

# A Study of the Use of Lean Manufacturing Techniques By Japanese Small and Medium Enterprises

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## 1. Introduction

The purpose of this paper is to report the results of a 2004 study of the use of lean manufacturing techniques (LMTs) by Japanese small and medium enterprises. The idea for this paper came from a report of a similar study by the Society of Manufacturing Engineers (SME) in America (*Reporting of the Lean*, undated). That study surveyed manufacturers in the Northeastern U.S. and found, among other things, “41% [of the respondents] are either not familiar with lean or have read about it but have not considered implementing lean principles” (p. 3 of the report). This gave me the idea to do a similar survey of Japanese manufacturers and see if my results would be comparable.

This paper is organized as follows:

1. Introduction
2. Lean manufacturing
3. The study
4. Results
5. Analysis and discussion of results
6. Limitations of the study
7. Recommendations for further investigation
8. Summary and conclusions

## 2. Lean Manufacturing

**Introduction.** Actually lean manufacturing is a subset of the more general area

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of lean enterprise. According to NIST's MEP<sup>1)</sup> Web site, "A Lean Enterprise produces more with existing resources by eliminating non-value added activities. Lean establishes a systematic approach to eliminating these wastes and creating flow throughout the whole company." So when we talk about lean manufacturing we are concentrating on the manufacturing part of the business but this doesn't mean that the principles of lean cannot be applied to any process or procedure within the company, be it how R&D is accomplished or how orders are processed. For the sake of keeping things relatively simple, this study concentrates on manufacturing.

Lean manufacturing/enterprise falls under the umbrella of what is usually called total quality management (TQM). Very generally speaking, TQM is simply managing a company in such a way that you seek to not only satisfy your customers but to continually go beyond their expectations by delivering quality products and services at reasonable prices. Despite what is often believed, delivering better quality does not necessarily mean spending more money. In fact, as a company seriously studies how to make its products and services better it usually results in a more streamlined operation that saves money, savings that can be passed on to the customer.

There are many things a company can do to improve its quality such as using statistical process control (SPC) to monitor its processes and find ways to not only eliminate episodic problems such as a production machine getting out of adjustment, but to make general improvements to the process based on improving the "inputs." For example, if a process is producing some product and the yield of good product is only 50%, a study can be undertaken of the effect of

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1) The National Institute of Standards and Technology (NIST) is part of the U.S. Department of Commerce. Its Manufacturing Extension Partnership (MEP) is a network of some 400 not-for-profit help-centers who assist small- and medium-size businesses. For more information see: <http://www.mep.nist.gov/>.

changing various inputs to process. This could be done off-line so as to not disrupt the existing schedule. Let's say one of the inputs to the process is some sort of raw material. The company could buy a small amount of higher quality raw material and statistically check if this has improved the yield. This can be done for other "inputs" such as the type of machine used or the level of training given the operators. If the off-line experiment reveals a significant improvement due to some change, then it is implemented on a full-scale basis. This sort of careful study of a process often results in major improvements in both quality and cost savings.

This example is just one way TQM ideas can be applied. Another way to look at TQM is as a philosophy that permeates a company's whole way of thinking. Perhaps one of the most famous set of quality philosophical principles are those set forth by American Dr. W. Edwards Deming. Dr. Deming died in 1993 at the age of 90. He was active in the quality movement almost right up to the time of his death. He found fame in Japan long before he was discovered in America and is often credited with playing a significant role in Japan becoming an economic powerhouse. Deming advised the Japanese in the early 1950s about things like SPC and not accepting bad supplies or material if they wanted to produce quality products. His influence was so strong that Japan's prestigious national quality award was named the Deming Prize. It was not until the 1980s when Japan was taking over many of America's markets with better and less expensive products that Deming and his ideas came to light in America. Although begun back in the 1950s, Deming's approach to quality became embodied in his famous 14 Points (see Appendix A).

In short TQM can be thought of as a philosophical view of quality such as expressed by Deming's 14 Points coupled with specific methods that concretely implement that philosophy. Some of these concrete methods are design of experiment, quality function deployment, training of your people in the principles and

techniques of quality and how to apply those in their specific situations.

As already implied one of the main goals of TQM is to eliminate defects. A highly popular approach to this is Six Sigma, a rather well developed set of actions to bring the defect rate down to essentially zero. On top of all this philosophy and these methods is an important standard that has become important for “bragging rights” if not always causing true changes in an organization: ISO 9001. This standard is published by the International Organization for Standardization (ISO). Headquartered in Geneva, Switzerland, ISO is a non-profit organization made up of the national standards bodies of some 140 countries. ISO 9001 specifically sets forth criteria a company must meet to show it has in place a good quality management system. Once validated by a certified inspector, the company may advertise its ISO 9001 compliance to improve its quality image in the eyes of its customers.

**Waste (Muda<sup>2</sup>)** Before describing the specific lean enterprise techniques, it will be well to review the types of waste that these techniques are meant to eliminate. The following brief rundown on the seven commonly accepted types of waste is excerpted from Austenfeld (2004); see Austenfeld (2003) for a more detailed description of these. The seven types are: over production, defects, motion, transportation, inventory, over processing, waiting, and people.

*Overproduction.* Overproduction simply means making more of some part or product than the demand for it. In the ideal “lean enterprise” situation, the amount produced would be exactly what is demanded at that time by the next downstream operation. This is also call a “pull” system in that it is that next downstream operation—and ultimately the customer—that sets the pace for production by “pulling” from the upstream operation. Overproduction can easily result in a lot of capital being tied up in work-in-process (WIP) and other inventory. Fur-

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2) *Muda* is the Japanese word for waste.

thermore, it may even necessitate scrapping product that is no longer marketable due to, say, obsolescence.

*Defects.* This is perhaps the most classic waste in TQM and has been the target of much research on how to prevent it. The idea is to make your processes so good they hardly ever produce a defective part or product. Deming, and his mentor Walter A. Shewhart<sup>3)</sup>, were some of the first to push for process improvement through the use of statistics.

*Motion.* This may be one of the most overlooked wastes in an organization because we tend to get into the habit of doing something a certain way and never think of “is there a better way?” For example, a worker may always go to supply point A to get part B and it never occurs to anyone that maybe supply point A could be moved right next to the worker and save countless amounts of time and energy. Just arranging one’s tools in a way to make them quickly accessible for the job can often eliminate a great deal of wasted motion.

*Transportation.* The saying now is “follow the forklift”—to see just how much redundancy there is in how things are moved about an organization. This waste is similar to motion waste but on a larger scale. This waste is concerned with how material and product is moved about an organization; for example, are optimum lot sizes used or does the transporter simply keep going back and forth with onesity? This waste could also extend beyond the organization in terms of how material is grouped for movement from suppliers and to distributors/customers. This waste includes that associated with movement of information too.

*Inventory.* This waste is closely related to over production in that over production results in excessive buildup of WIP and finished goods. However, it also

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3) Shewhart, a statistician working at Bell Laboratories in New York, did pioneering work in statistical process control; that is the systematic use of data about a process to determine its capability for producing a defect-free product. Deming subsequently popularized this technique.

Papers of the Research Society of Commerce and Economics, Vol. XXXXVI No. 1  
applies to how much capital the company has tied up in incoming and waiting-to-be-used material and in goods in the distribution system.

*Overprocessing.* Whereas overproduction is making too many, overprocessing is making the product “too much.” That is, giving the product more features—bells and whistles, if you will—than the customer really wants. In Austenfeld (2003) I gave the example of Microsoft’s over-featured Word word processing software as opposed to Corel’s relatively simple WordPerfect. The answer to this waste is, of course, to get to know your customer’s real wants and needs.

*Waiting.* How often have we seen and experienced this waste; e.g., waiting in line at a supermarket checkout or for service as at post office (especially in America!). And it is common within organizations too. An example cited in Austenfeld (2003) showed how the time actually spent processing a loan application within a bank was only 15 minutes with the rest of the 26 days (on average) spent waiting for the next operation in the process!

*People.* Although not as easy to quantify as the others, the potential of an organization’s human resources can be, and often is, greatly underestimated and used. A case history of the Delphi Saginaw Steering Systems (DSSS) company described by Woolson & Husar (1998) shows dramatically how this human potential can be tapped. The case history tells how through close cooperation with the union and a rigorous training program, one of DSSS’s six plants (Plant 6) became a model for cultural change with remarkable improvements in quality, output, and employee participation.

Now that we’ve discussed some of the most common types of waste let’s begin looking at some examples of lean techniques for minimizing and eliminating this waste. Examples of the following ten lean manufacturing techniques will be given<sup>4</sup>:

- 5S

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4) This information is mostly taken from Austenfeld (2003).

- Visual controls
- Total productive maintenance (TPM)
- Standardization and best practice deployment
- Single-minute exchange of die (SMED)
- Error-proofing (*poka-yoke*)<sup>5)</sup>
- Value-stream mapping
- Just-in-time (*kanban*)
- Cellular workplace layout
- *Kaizen* blitz

***The ten lean manufacturing techniques (LMTs).***

5S. Perhaps one of the easiest lean techniques to implement with a potentially big payback is 5S. One way to describe 5S is to call it good housekeeping. The five S's are: sort, set in order, shine, standardize, and sustain<sup>6)</sup>.

- *Sort*. Sort means to sort what you need for your job from what is not needed and get rid of the latter.
- *Set in order*. Set in order means to take everything that is required to do the job (what's left after the "sort" step) and designate a place for it. It is applying the old saying of "a place for everything and everything in its place." For example, having a tool board with the place for each tool clearly marked. Or, having all the dies needed for a particular tool each in a clearly designated place for that die.
- *Shine*. Perhaps a better word is "clean" but it doesn't start with "S."<sup>7)</sup> This

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5) On the English version of the study questionnaire, this LMT is called "Failsafe device."

6) Sometimes 5S goes by the acronym CANDO: Clearing up, Arranging, Neatness, Discipline, and Ongoing improvement.

7) The 5S idea apparently came from Japan where, according to the 5S definition in Womack & Jones (1996), the Japanese equivalents are: *Seiri*, *Seiton*, *Seiso*, *Seiketsu*, and *Shituske* (p. 306).

is another very simple but important lean practice. Having a very clean workplace can yield a number of benefits such as better functioning tools and a way to quickly detect any leaks from pipes or machinery since they will show up quickly in a clean environment.

- *Standardize*. Once the workplace is organized and clean the next “S” is to ensure it stays that way. To do this appropriate standard operating procedures (SOPs), inspection checklists, etc. should be written and followed.
- *Sustain*. There is a natural tendency for even the best 5S programs to lapse without consistent follow-up that ensures the SOPs, checklists, etc. are being followed. Also management should be constantly seeking ways of improving on the program including ideas the workers might have for this.

*Visual controls*. The use of visual controls is another important lean technique. A visual control can be relatively inexpensive to implement but make a big difference. For example simply designating traffic lanes on the floor for forklifts can streamline forklift movement and increase worker safety. And there are many, many other ways visual controls can be used. Some of these are:

- To show where tools should be kept when not being used (part of 5S).
- To show the status of a particular production operation using andon lights<sup>8)</sup>.
- To color-code tools or parts.
- To color-code pipes according to what they are carrying (water, steam, some chemical, etc.).
- To show the results of defect reduction efforts with large, easy-to-read charts.

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8) Andon lights could be set up like a traffic signal or on a large board above the production area. Typically they will have three colors: green signifying the operation is running as it should, amber signifying a potential problem or that the operation is undergoing maintenance, and red signifying that the operation has stopped and requires attention. Additional details can be conveyed with the use of flashing lights.

- To show where a stock replenishment box should be located.
- To warn employees of some danger such as high-voltage or steam discharge.
- To display job aids or SOPs at the point of use.
- To show production goals and extent of achievement.
- To provide motivational messages (e.g., “well done!”) or announce upcoming employee events (e.g., “all-hands meeting this Thursday”).

The list goes on and on. Actually only one’s imagination limits the ways visual controls can be used.

*Total productive maintenance (TPM)*. TPM is yet another very straightforward concept that, once setup, can pay rich dividends. All we mean by TPM is having a system for ensuring our production equipment is in the best possible condition at all times. One of the goals of lean is to promote continuous-flow production. This means, among other things, that equipment uptime is maximized. There are a some other important reasons for keeping equipment in tip-top condition: (1) equipment that is worn or gets out of adjustment can begin producing defects, (2) small problems, not corrected, can lead to catastrophic failures and long downtimes, and (3) well-maintained equipment will last longer.

In the traditional way of thinking there is often a disconnect between the operator and maintenance personnel, with the former believing their job is to run the equipment, not worry about its maintenance. On the other hand, the maintainers believe their job is to take care of the equipment only once someone tells them there is a problem. With TPM, there is a close relationship between these two groups: the operators assume responsibility for scheduled basic maintenance and for notifying maintenance personnel anytime there is a problem with the equipment, the maintainers assume responsibility not only for their usual higher-level maintenance, but for educating the operators on how to perform the basic maintenance. In fact, the maintainers should educate the operators on mat-

ters unique to the machinery they are operating such as where to look for a potential leak or what sound to listen for as an indication of some potential problem.

Feld (2001) makes another point with regard to TPM: when purchasing equipment, take into consideration ease of maintenance. Even if you must pay more for this convenience, it will pay off over the life cycle of the equipment. Equipment that is difficult to maintain—e.g., hard-to-reach fluid level indicators or lube points—will tend to discourage both operators and maintainers in doing complete preventive maintenance.

A final point with regard to TPM: *every* machine stoppage should be recorded and investigated. There may be an operator habit of simply performing some simple reset operation to clear a stoppage. Although this gets the machine back on line quickly, it is not getting at the reason for that stoppage.

*Standardization and best practice deployment.* Standard operating procedures (also known as SOPs or just plain “procedures”) are a way to remove non-value-added work from the production process—one of lean’s primary goals. The idea is to find the best way to accomplish a task and then make that a standard practice throughout the company. Although the latest version of ISO 9001<sup>9)</sup> has reduced the mandatory requirement for documenting all procedures, most quality professionals believe it is still a good idea.

It is also often a good idea to look outside the organization for best practices. This technique is called benchmarking<sup>10)</sup>. A formal benchmarking effort can often produce big gains in terms of streamlining processes. The only requirement is that the company from whom the best practice ideas are obtained should have

9) Previously mentioned, ISO 9001 is a set of standards for implementing an excellent quality management system. Once an authorized registrar certifies the system, that certification can be publicized as an indicator of the company’s commitment to quality excellence. Austenfeld (2002) provides a detailed description of this standard.

10) One of the best references on benchmarking is Camp, 1995.

a similar process even if it produces something entirely different.

*Single-minute exchange of die (SMED)*. This idea is primarily attributed to Shingo Shigeo, one of the masterminds behind the Toyota Production System. Actually SMED—doing the changeover in only one minute—would in most cases be an ideal and probably unrealizable goal. However the idea is to do whatever is possible to minimize changeover times. This can be accomplished by both just doing the existing method smarter or coming up with “out-of-the-box” ideas.

For example, when simply trying to streamline the existing method, an important consideration is how much of the changeover work can be accomplished “external” to the time during which the changeover is actually taking place. This means doing things like staging whatever material or equipment is required at the handiest place beforehand. Levinson & Rerick, (2002) cite many examples of where “out-of-the-box” thinking has also improved changeover times. For example, if exchanging the die on a machine tool requires that one or more bolts be turned, something called a “split-thread bolt” could be used. The “threaded” part of this type of bolt is divided up into six 60-degree alternating threaded and unthreaded sections. The female threads are also divided up this way. This means only one-sixth of a turn is required to tighten it much like the way the breech of an artillery piece is secured.

*Error-proofing (poka-yoke)*<sup>11)</sup>. As the name says, this lean technique is to prevent errors from happening. A simple example is the common electrical plug in America. As a safety measure, these plugs now come with either one blade wider or with three prongs. The wider blade or third prong ensures the plug will be properly inserted into the outlet and, thus, be properly married to the grounding system. In the workplace, error-proofing can range all the way from using color-coded wiring to designing a part so it is impossible to assemble it the wrong way.

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11) *Poka-yoke* is the Japanese term.

Another example from Wader & Elfe (2003, p. 64) is the use of sensors to tell the operator she has done or not done something. In this example, the operator is a packer required to pick one item from six boxes to complete the packing. Each box has a sensor that detects when a part has been picked and turns off its light. If a light remains on at the end of the operation, the packer knows she has missed an item and also which box got missed. As with SMED, a little creative thinking is often required to come up with a solution to an error-proofing problem. The advantages from a lean point of view are obvious: less chance for a defect, less time lost in the operator trying to remember what to do and, perhaps most important, creating a safer environment. Think about how much time would be lost if a worker suffered a serious injury due to something a little error-proofing would have prevented. Also think about how this would affect morale.

*Value-stream mapping.* Often a starting point for making “lean” improvements, value-stream mapping is a way to see just how much non-value-adding activity is in some process. Typically we would pick some product whose entire process we wish to examine for possible improvements. This means starting with how orders are received and how raw material and vendor parts are handled and working our way through each step until the finished product is delivered. Wader & Elfe (2003, during tutorial) recommend laying out all the steps using butcher paper and Post-Its<sup>®</sup>. Information about each major subprocess can be written on the Post It’s and they can then be posted in the right place in the process on the butcher paper. Once the “present state” is determined, a new layout can be developed showing an ideal or, at least improved, “future state.”

The idea in developing an improved future state is to eliminate as much non-value-adding activity (waste) as possible. According to Wader & Elfe (2003, during tutorial) most activity—95 to 98 percent—is non-value-adding *in the eyes of the customer*. For example, the movement of materials, although necessary, is not a value-adding activity as far as the customer is concerned. However, assembling

those materials into a finished or partially finished product would be. Another example would be a stamping process. The time taken to make a die changeover is not “customer” value-adding but the actual stamping is. So it is this 95 to 98 percent of the activities that we want to minimize. We can do this by thinking about the seven sources of waste discussed above in this paper. For example, are we overproducing what’s needed or accumulating excessive inventory? What are the defect rates within the process? Are there motion, transportation, or waiting wastes that can be reduced or, better yet, eliminated? Perhaps a long tool changeover time can be greatly shortened or some unnecessary administrative step eliminated.

Wader & Elfe stress the importance of tracking the information flows of the process also. Perhaps things like how does the order information actually trigger the production process? Is there a tight relationship there so that soon after receipt of the order action is being taken to fill it or, conversely, must the order information go through a series of largely unnecessary bureaucratic steps before getting to someone who can actually “turn on” the production process?

Once the current and future states are considered sufficiently developed, an implementation plan should be made and executed.

*Just-in-time (kanban)*<sup>12)</sup>. The basic idea behind just-in-time (JIT) is to have material delivered just when it is needed. One of the major benefits of such a system is that inventory is reduced or, ideally, eliminated. This in turn, means less capital tied up and even more important, less chance for problems to go hiding. As a simple example let’s say workers are producing parts A and B that will then be combined at the next downstream step into assembly C. Suppose we have

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12) Strictly speaking, *kanban* means “card” in Japanese and one way JIT is implemented is by the movement of cards from where the parts/material is being used to the place from which they are drawn. The card signals that replenishment in some predetermined amount is required. However, *kanban* is often used synonymously with JIT.

a JIT system so that those parts are fed to the assembly person just when needed. If there is any problem with either part A or B it is much more likely to be immediately caught by the person making assembly C. Now let's take a look at what would probably happen when our system is operating with traditional inventories. The workers making parts A and B place them into a work-in-process (WIP) inventory from which the assembly person draws as needed. Suppose the assembly person draws a defective part A. Under pressure to produce as much as possible, he will most likely just grab another (good) part A and keep going. With any luck, eventually the defective part might come to someone's notice for corrective action but it is unlikely and, worse yet, the root cause of the problem may go undetected until some serious losses begin occurring. With JIT there is a real incentive to not produce defects and JIT usually goes hand-in-glove with source inspection where the person making the part (providing the service) is constantly self-checking that what is being passed along to the next step is OK. In a full-fledged JIT operation, workers are usually empowered to stop a production process when a problem occurs.

JIT is synonymous with "pull" in that the ideal JIT system is "pulling" from the upstream activities only what's required to fulfill the customer demand. This implies the need to establish a close relationship with our material and parts vendors so they deliver what's needed only when needed. However, even with such good relationships, the variability in transportation reliability can necessitate the need for some inventory. This idea of working closely with suppliers is one of Deming's Fourteen Points (see Appendix A): *Point 4: End the practice of awarding business on the basis of price tag. Instead minimize total cost. Move towards a single supplier for any one item, on a long-term relationship of loyalty and trust.*

*Cellular workplace layout.* Cellular workplace layout (or cellular manufacturing) is basically the opposite of traditional batch and queue manufacturing. In

batch and queue manufacturing, machines doing similar operations (grinding, plating, drilling, stamping, etc.) are grouped and (usually) large batches of that operation are completed at a time. This, of course results in a lot of inventory and the need for a complicated logistics system to transport, store, and retrieve the right material at the right time. With cellular manufacturing the workplace is designed around a particular part or product.

Although some say a certain shape is best for this type of workplace layout, Wader & Elfe (2003) say to use the one that fits your application, be it “U,” “V,” “L” or whatever. However Wader & Elfe (pp. 50–51) do specify certain requirements for an optimally arranged layout:

- It should be laid out in a way that optimizes the flow from materials/parts to finished product. This means a logical arrangement of machines and operators along this flow.
- There should be a designated primary work area that is closest at hand for handling the product.
- A little further away (18–24 inches) should be a designated secondary work area for all the tools and equipment the operator will be using.
- Material, parts, and tools should be available in front of the worker so he doesn’t have to twist or turn to use them.
- Containers for accepting anything that needs to be disposed of should also be in front of the operator.
- Work surface heights should be appropriate to the work being done with higher heights for more precise work.
- To the maximum extent possible, JIT techniques should be used. That is, the material and parts are used only as demanded by downstream processes so there is no WIP inventory buildup. This means using *kanban* techniques such as using a card to signal when a certain part or material is required, or having marks on supply bins showing when they should be

replenished.

Under a cellular workplace layout scheme the material handler becomes a key person, ensuring timely replenishment of whatever is needed by the operators to keep a steady flow of production going. At the same time, he/she is also making sure that only the material/parts required are on hand so as not to clutter up the workplace or have too much inventory.

*Kaizen blitz*. *Kaizen blitz*, as the name implies<sup>13)</sup>, is a rapid improvement project usually lasting a week. Once one understands the fundamentals of lean and realizes just how much waste is lying around and causing the production/service operation to suffer, it seems natural to carry out a *kaizen blitz*. This would normally be done on a single (but important) process such as assembling a product or making some part. Perhaps a particular work space would be a good target. The first step, after deciding on what to target, is to assemble a team of six to eight people. Wader & Elfe (2003, p. 70) recommend the team include operators, engineers, mid-level managers, quality people, and a person completely outside the process (to be looking at things from a fresh perspective). Of course one person should be designated as the facilitator and his/her role will be crucial to the success of the project. Some important points to remember are:

- The event should have an “action bias”; that is, no analyzing things to death but some quick data gathering, brainstorming and deciding on solutions, and implementing the solutions. We are not trying to do everything at once—looking for substantial improvement but not perfection.
- Upper management should be involved in deciding what to work on to ensure the project has that level of support.
- The process picked should be something fairly important to lend credibility to the project.

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13) *Kaizen* meaning improvement in Japanese and *blitz* meaning, in this case, a concentrated effort to get something done.

- Some clear objectives should be set such as reducing cycle time or inventory.
- The event should be looked upon as not only making a rapid improvement but the basis for further continuous improvement. That is, this intensive event should begin to engender a cultural change in those involved.
- The success of the first *kaizen* blitz should be well publicized to get everyone in the company thinking “lean.” Additional events should be scheduled.

In summary, a *kaizen* blitz can quickly improve a process with very little expenditure of resources. It will be a source of pride for those involved and will very likely inspire others to want to do something similar in their work areas. Ideally, a *kaizen* blitz can be the genesis of a complete cultural change for the company if handled properly.

Having discussed TQM in general and then the types of waste and the specific LMTs, it is time to look at the study.

### 3. The Study

***The sample.*** The sample of 500 companies was drawn from the database of a well-recognized database company in Tokyo. The specification for the sample was as follows:

- Type of company: manufacturer (any industry)
- Size of company: 300 or fewer regular employees
- Capitalization (per the definition of SMEs in Japan’s SME Basic Law): “capital stock of not in excess of ¥300 million”

This specification resulted in 171, 513 companies. The 500 companies were then drawn on a proportional basis from each of the 47 prefectures, Hokkaido to Okinawa. For example, if a prefecture had 10% of the 171,513 companies, 50 (10% of the sample) were randomly drawn from that prefecture. See Appendix B

for more details about when the questionnaire was sent out and where the responses came from.

Of the 500 questionnaires sent out, 66 (13.2%) were returned<sup>14)</sup>. These 66 companies can be characterized as follows:

- In general, *the type of company* (according to the choices presented on questionnaire):
  - a. Subcontractor, of a specific enterprise, that mainly produces and charges on a piece-by-piece basis: 13.6% (9 companies)
  - b. Subcontractor, of several enterprises, that mainly produces and charges on a piece-by-piece basis: 16.7% (11)
  - c. A manufacturer that mainly produces products as an OEM (original equipment manufacturer): 3.0% (2)
  - d. A manufacturer that produces a high ratio of its own products: 53.0% (35)<sup>15)</sup>
  - e. Subcontractor, of a specific enterprise, that not only manufactures for the contractor but also conducts joint research and development with the contractor: 4.5% (3)
  - f. Subcontractor, of several enterprises, that not only manufactures for the contractor but also conducts joint research and development with the contractor: 4.5% (3)
  - g. Other: 1.5% (1)<sup>16)</sup>

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14) Actually 67 companies responded but one company's understanding of LMTs seemed so different from that upon which the study/questionnaire was based that it was not used.

15) One company that marked "other" and "a manufacturer that produces 100% of its own products" was included here.

16) Although not completely clear to the translator, this company described itself as having two departments, one we believe would fit the "d" definition (produces a high ratio of own products) and the other the "e" definition (subcontractor that manufactures for and conducts joint R&D with the contractor).

h. No answer: 3.0% (2)

Figure A provides a more graphic indication of this information showing that by far most companies characterized themselves as “a manufacturer that produce a high ratio of its own products.” Another 30% (a and b) were subcontractors either for a specific enterprise (a) or for several enterprises (b) working on a piece-by-piece basis.

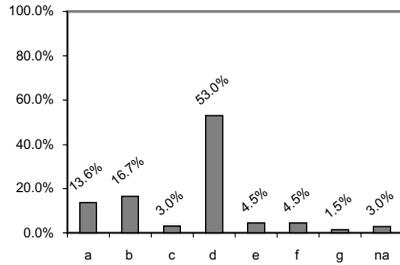


Figure A. Type of Company

- *The size of the company* (according to the choices presented on questionnaire):

- Less than 10 employees: 0.0%
- More than 10 employees but less than 50 employees: 0.0%
- More than 50 employees but less than 300 employees: 78.8% (52 companies)
- 300 or more employees: 19.7% (13)
- No answer: 1.5% (1).

Although the sample specification called for 300 or fewer employees, the results suggest that smaller companies were not included since no companies reported less than 50 employees. Also, 19.7% of the respondents were bigger than the specification called for ranging in size from 310 to approximately 1000 (one company<sup>17</sup>) with half in the 300’s. Figure B shows this surprising result graphically. I subsequently asked the company that supplied my sample of 500 SMEs about this. It turns out they selected companies from each prefecture in the order of annual sales. This means most of the companies in my specified sample were

17) This company reported 110 employees but since it is in the shipbuilding business and had marked “more than 300” I’ve assumed either a “1” or “0” was left off.

probably at the high end for annual sales and tended to have more employees. To get a more broadly representative sample I should have specified that the companies be selected without regard to annual sales (or, for that matter, any other attribute as long as they met the basic specification parameters).

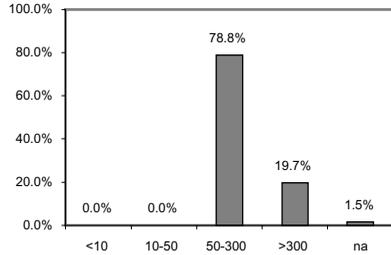


Figure B. Size of Company

• *The industry(ies)*<sup>18)</sup> for which the companies produce parts and/or products (according to the choices presented on questionnaire):

- a. Steel industry: 1.5% (1 company)<sup>19)</sup>
- b. Nonferrous metal manufacturing: 4.5% (3)
- c. Metal manufacturing: 4.5% (3)
- d. General machinery and appliances manufacturing: 4.5% (3)
- e. Electrical machinery and appliances manufacturing: 22.7% (15)
- f. Transportation equipment manufacturing (other than automobiles): 3.0% (2)
- g. Transportation equipment manufacturing (automobiles): 12.1% (8)
- h. Precision instruments manufacturing: 7.6% (5)
- i. Plastic products and/or rubber products manufacturing: 13.6% (9)
- j. Construction: 1.5% (1)
- k. Lumber/wooden products manufacturing: 1.5% (1)
- l. Other - food production: 19.7% (13); Other - other: 13.6% (9)

Figure C shows these percentages graphically. About one fifth of the companies

18) Six companies listed more than one industry (five listed two and one listed three).

These were added to the list for each type of industry when computing the percentages and, therefore, the total adds up to more than 100 percent (110.6%).

19) Actually this company is in the shipbuilding business.

are in the electrical machinery/appliances business (choice e) and about one fourth, evenly split, in the automobile (choice g) or plastic/rubber products (choice i) business. About eight percent (five companies) are in the precision instruments industry (choice h). One third of the

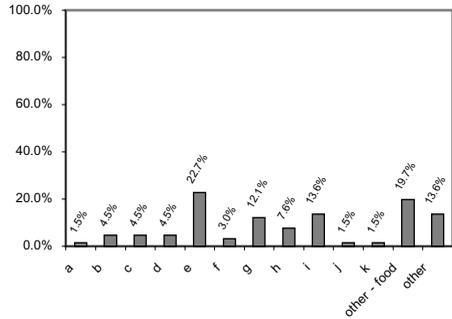


Figure C. Type of Industry

companies (22) reported being in an industry other than given as a choice on the questionnaire and 13 of these (almost one fifth of the total) are in the food production industry. This suggests that the questionnaire was not such an accurate reflection of the types of industries SMEs are in. Because of the large number of companies in the food production business, this industry is broken out separately from the other “others.”

To better understand the type of company, question 3B on the questionnaire asked for a brief description of the products the company makes. Appendix C lists all the industries reported including “others” and the products each company makes.

So a “typical” company in my sample might be a manufacturer who produces a high ratio of its own products<sup>20)</sup> and is in the electrical machinery, transportation equipment, or food production business with between 50 and 300 employees.

**The questionnaire.** The questionnaire was designed to elicit this information:

- To what extent do Japanese SME manufacturers use lean manufacturing techniques (LMTs)?
- For those not using LMTs, do they plan to use them?

20) As opposed to being a subcontractor.

- Of those not using them and not planning to use them, why not?
- For those using LMTs, when did they start using them and which ones do they use?
- For those using them, which LMTs are helping them the most?
- For those using them, what were the biggest problems when initially trying to adopt LMTs?

As an additional bit of information that may be useful for those interested in the LMT experience, companies using LMTs were asked to give examples of how specific LMTs helped their business. Also, those using LMTs were asked to comment on their experience and *all* companies, whether using LMTs or not, were asked if they had “any other comments.” A copy of the questionnaire is at Appendix D and its English translation is at Appendix E.

#### 4. The Results

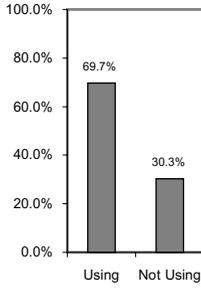
As just stated, the purpose of this study was, very simply, to determine the following:

- To what extent do Japanese SME manufacturers use LMTs?
- For those not using LMTs, do they plan to use them?
- Of those not using them and not planning to use them, why not?
- For those using LMTs, when did they start using them and which ones do they use?
- For those using them, which LMTs are helping them the most?
- For those using them, what were the biggest problems when initially trying to adopt LMTs?

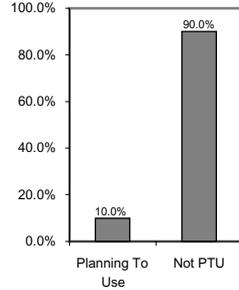
This section will present the results and the next section will present an analysis of and commentary on these results.

*To what extent do Japanese SME manufacturers use LMTs?* Figure D shows the percentage using LMTs: 69.7% (46 of the 66 companies responding).

*For those not using LMTs, do they plan to use them?* Figure E shows the percentage of those who said they didn't use LMTs (20 of the 66 total) but were planning to. Surprisingly this was only 10% (2 companies). In the next section we'll briefly



**Figure D.** Percentage Using/Not Using



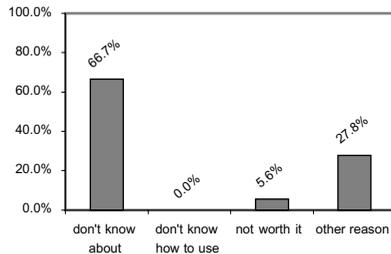
**Figure E.** Of Co's Not Using, Percgt Planning/Not Planning To Use

look at these two companies in terms of which LMTs they plan to use and when.

*Of those not using them and not planning to use them, why not?* Here are the "reason" percentages for the 18 companies that are both not using LMTs and are not planning to per the questionnaire choices.

- a. We don't know much about Lean Manufacturing Techniques: 66.7% (12 companies)
- b. We know about Lean Manufacturing Techniques but we don't know how to use them: 0.0%
- c. We think adopting Lean Manufacturing Techniques would not be worth the effort: 5.6% (1)
- d. Other reason(s): 27.8% (5).

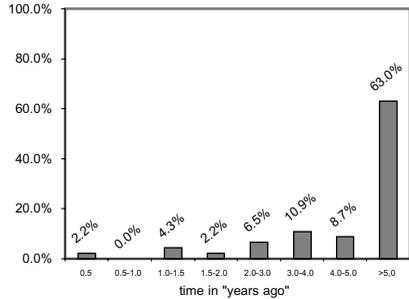
Figure F shows these percentages graphically. The "other" reasons of the five companies marking choice "d" will be discussed in the next section.



**Figure F.** Reason Not Planning To Use LMTs

***For those using LMTs, when did they start using them and which ones do they use?*** Of the 46 companies responding and using LMTs, the first question I was interested in was generally how long had they been doing so. These are the choices given on the questionnaire along with percentages of those responding to each:

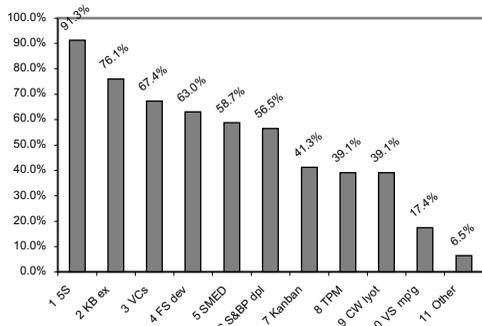
- a. About half a year ago:  
2.2% (1 company)
- b. Between half a year and a year ago: 0.0%
- c. Between a year and one and a half years ago:  
4.3% (2)
- d. Between one and a half years and two years ago:  
2.2% (1)
- e. Between two and three years ago: 6.5% (3)
- f. Between three and four years ago: 10.9% (5)
- g. Between four and five years ago: 8.7% (4)
- h. More than five years ago: 63.0% (29)
- i. No answer: 2.2% (1)



**Figure G.** When Started To Use

Obviously most of the companies using LMTs have been doing so for a long time (at least five years) as Figure G dramatically illustrates.

As to the LMTs being used, the ten described in



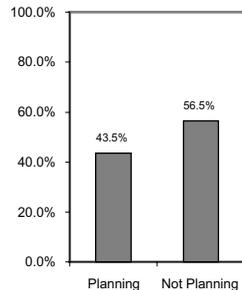
**Figure H.** Percentage of Companies Using Each LMT

section 2 were listed on the questionnaire in no particular order<sup>21</sup>). After calculating the percentages of companies using these ten plus other (marked by three of the 46), I reordered the LMTs according to these percentages as follows (letters are questionnaire designators):

1. a. 5S: 91.3% (42 companies)
2. j. *Kaizen* blitz exercise: 76.1% (35)
3. b. Visual controls: 67.4% (31)
4. f. Failsafe device: 63.0% (29)
5. e. Reduction of set-up time (SMED): 58.7% (27)
6. d. Standardization and best practice deployment: 56.5% (26)
7. h. *Kanban* system (Just-in-time manufacturing): 41.3% (19)
8. c. Total productive maintenance (TPM): 39.1% (18)
9. i. Cellular workplace layout: 39.1% (18)
10. g. Value-stream mapping: 17.4% (8)
11. k. Other<sup>22</sup>: 6.5% (3)

The average number of LMTs used by these 46 companies was 5.6. Figure H graphically displays these use percentages.

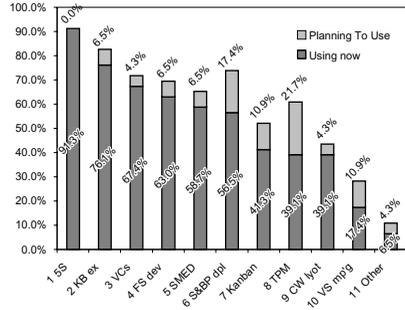
To provide a more complete picture of those using LMTs, I also asked if they planned to use any more and when they might do this. This would be of particular interest for some company that had perhaps just started using them and was using only a few. Figure I shows that of the 46 companies,



**Figure I.** Of Co's USING, Perctg Planning/ Not Planning To Use More

- 21) Actually the order used in the questionnaire was that used in Austenfeld (2003/2004) and generally is goes from relatively simple to implement to harder to implement.
- 22) The responses given by three companies as "other" and presently being used are: (1) Improvement proposal system, (2) Performance management, and (3) HACCP (a system to control food safety hazards)—see also Figure S on p. 37.

43.5% (20) said yes. Figure J shows which additional LMTs are being planned for use by these 20 companies. However, the percentages are based on all 46 companies presently using LMTs to facilitate a meaningful comparison. Accordingly Figure J shows, for each LMT, the percentage of all 46 companies that are presently using it and the percentage of all 46 companies that are planning to use it<sup>23</sup>.



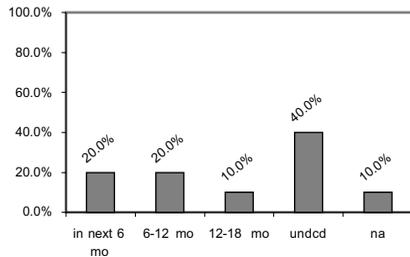
**Figure J.** For Each LMT, Percentage Using Now and Percentage Planning to Use In Future

As to when these 20 companies are planning to start using these additional LMTs, these are percentages for each choice on the questionnaire:

- a. Within 6 months: 20.0% (4 companies)
- b. After 6 to 12 months: 20.0% (4)
- c. After 12 to 18 months: 10% (2)
- d. Other time or “undecided”:  
40% (8)<sup>24</sup>
- e. No answer: 10.0% (2)

Figure K shows this graphically.

For the 26 companies answering “no” to the question of if they were planning to use any more LMTs, I asked for the reason. The choices



**Figure K.** For Those Co’s Planning To Use More LMTs, When They Will Do It

23) For the companies planning to use more LMTs, two came under “other” (see Figure S on p. 37). There was one “no answer.”

24) Seven “undecided” and one “after 24 months.”

along with the percentage making this choice were<sup>25)</sup>:

- a. Because we don't know much about the Lean Manufacturing Techniques that the company has not yet used: 23.1% (6 companies)
- b. Because we think the other Lean Manufacturing Techniques are not suitable for this company: 34.6% (9)
- c. Because we don't think we can expect enough returns by using any of the other Lean Manufacturing Techniques: 23.1% (6)
- d. Other reason(s): 26.9% (7)

See Figure L for the graphical display of these percentages. Almost all the "other" reasons of the seven companies marking choice "d" were to the effect that they wished to wait and see how the LMTs they are presently using work out and concentrate on improving those LMTs.

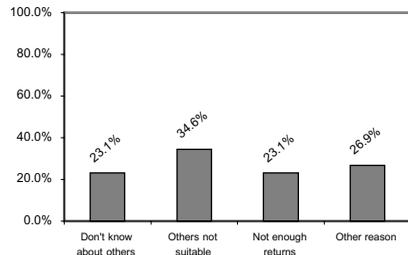


Figure L. For Co's Using LMTs, Reason(s) for Not Using Any More

***For those using them, which LMTs are helping them the most?*** The question was: "Which Lean Manufacturing Techniques have helped (or are helping) you the most; that is, have saved (or are saving) you the most money, time, number of workers, etc.?" Of the 46 companies using LMTs, two did not answer this question. Also, only one company listed a LMT other than one of the ten listed on the questionnaire as "helping the most" (along with two other LMTs). Therefore for simplification purposes besides dropping the two who did not answer I have disregarded that one "other" LMT.

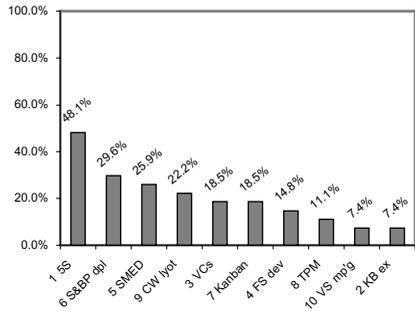
The results for this question are divided into two parts: (1) for each LMT, the percentage of companies that listed it as one of the LMTs that helped it the most

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25) These are the percentages of the 26 companies making these choices. Since two companies made two choices each, the total adds up to 107.7%.

1 5S	6 S&BP dpl	2 KB ex	5 SMED	9 CW lyot	4 FS dev	3 VCs	8 TPM	7 Kanban	10 VS mp'g
61.4%	29.5%	29.5%	27.3%	27.3%	25.0%	18.2%	18.2%	18.2%	4.5%
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
<b>Figure M. Part 1: Helped Most Percentages for All Companies Reporting (44)</b>									
1 5S	6 S&BP dpl	5 SMED	9 CW lyot	3 VCs	7 Kanban	4 FS dev	8 TPM	10 VS mp'g	2 KB ex
48.1%	29.6%	25.9%	22.2%	18.5%	18.5%	14.8%	11.1%	7.4%	7.4%
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
<b>Figure M. Part 2: Helped Most Percentages for Companies Reporting 50% or less of those used (26)</b>									

for “all” companies (44), and (2) the same thing but only for companies that chose not more than 50% of the number of LMTs they are using (26 companies). Figure M shows the percentages for each part ranked first to tenth from left to right. The number preceding the LMT’s name is where it ranked with respect to number of companies reporting using it. Note that for a couple of the LMTs—*Kaizen* blitz exercise and *Kanban* system (Just-in-time manufacturing)—there is a significant shift in ranking. The second set of results (Part 2) is probably more meaningful since to mark that all the LMTs you’re using helped you doesn’t really tell us much in terms of which ones helped/are helping the *most*. The cutoff of 50% or less was an arbitrarily chosen number. These Part 2 values will be used in commenting on these results in the next section. Figure N graphically shows these Part 2 percentages.



**Figure N.** For Each LMT, Percentage of Co’s Including It As One That Helped Most (for Co’s Choosing 50% or Less of Those Used-26 Co’s)

**For those using them, what were the biggest problems when initially trying to adopt LMTs?** To get this information, the question was: “What were the biggest problems your company faced when trying to adopt Lean Manufacturing Techniques?” Since three companies did not answer this question, they were

eliminated. For the remaining 43 companies, the choices along with the percentage of companies making each choice are as follows:

- a. The workers couldn't see any merit in adopting Lean Manufacturing Techniques and had to be convinced: 72.1% (31 companies)
- b. Couldn't get enough support from outside to receive the resources necessary to adopt Lean Manufacturing Techniques: 11.6% (5)
- c. Integrating Lean Manufacturing Techniques into the old conventional production system: 27.9% (12)
- d. Other problem(s): 11.6% (5)

And Figure O shows this graphically.

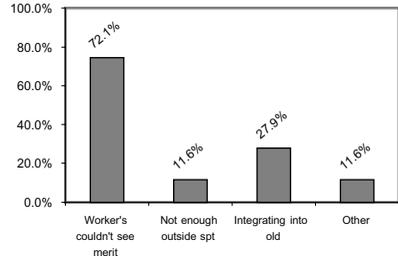
The average number of problems reported by the 43 companies answering this question was 1.26. The five

companies that reported "Other problem(s)" will be discussed in the next section.

This concludes the results for the primary questions this survey was attempted to answer. The next section will do some analysis and commentary on each question in light of the results just presented. Besides the results reported so far, the questionnaire sought to get three additional types of information:

- Examples of improvements gained through the use of LMTs.
- Open-ended comments by those adopting and using LMTs on that experience.
- Open-ended comments by any respondent (whether they use LMTs or not) on anything they wish to say.

The results of these responses will also be discussed and summarized in the next section of this report.



**Figure O.** Perctg of Co's Rpt'g These Problems When Trying to Adopt LMTs

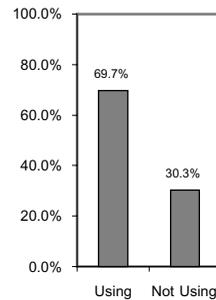
## 5. Analysis and Discussion of Results

The analysis will follow the same order as the results were presented:

- To what extent do Japanese SME manufacturers use LMTs?
- For those not using LMTs, do they plan to use them?
- Of those not using them and not planning to use them, why not?
- For those using LMTs, when did they start using them and which ones do they use?
- For those using them, which LMTs are helping them the most?
- For those using them, what were the biggest problems when initially trying to adopt LMTs?

The figures used in the results section will be repeated here as needed.

*To what extent do Japanese SME manufacturers use LMTs?* As already seen the extent to which Japanese SME manufacturers use LMTs is quite high: 69.7% (Figure D). Although not completely comparable, the study mentioned in the Introduction to this paper by the Society of Manufacturing Engineers (SME) found that 41% of their respondents were “either not familiar with lean or have read about it but have not considered implementing [it].” An additional 34% “either recognized the need for [it] or would like to implement [it] but are not sure how to go about it” (*Reporting of the Lean*, undated, p. 3). In fact, according to the details of this study, only 17% of the respondents answered that they “have one or more ‘Lean’ systems in place” (*SME*<sup>26</sup>) *2002 Lean*, undated, p. 6). These figures are probably fairly rep-



**Figure D.** Percentage Using/Not Using

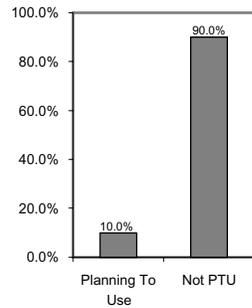
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26) Here “SME” stands for Society of Manufacturing Engineers.

representative of all U.S. manufacturers.<sup>27)</sup> Accordingly it would appear there is a big difference between the use of LMTs in Japan and in America.<sup>28)</sup>

I would speculate that this is because Japan has been at the forefront of the TQM movement and, in fact, most of the LMTs probably derive directly from the Toyota Production System (TPS). For example it was the contributions of Toyota people like Taiichi Ohno who is famous for recognizing the importance of a “pull” system and Shigeo Shingo, famous for SMED, that laid the foundations for the TPS and lean manufacturing (Austenfeld, 2003, p. 49). Whittaker (1997) also recognizes the part large firms in Japan have played in “providing global models for ‘lean production,’ *kaizen*, and so on” (p. 211). This is all to say that the chance for a SME to be exposed to information on LMTs has probably been much higher in Japan and this might well explain the apparently much higher usage of LMTs by Japanese manufacturers.

***For those not using LMTs, do they plan to use them?*** As shown by Figure E, only two (10%) of the 20 companies not presently using LMTs plan to use them. This would suggest that most companies not



**Figure E.** Of Co’s Not Using, Percgt Planning/ Not Planning To Use

	1 5S	2 KB ex	3 VCs	4 FS dev	5 SMED	6 S&BP dpl	7 Kanban	8 TPM	9 CW lyot	10 VS mp’g
Co. #1	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>
Co. #2	<input type="checkbox"/>		<input type="checkbox"/>					<input type="checkbox"/>		

**Figure P.** LMTs Being Planned for Use by the Two Companies Not Using LMTs But Planning To

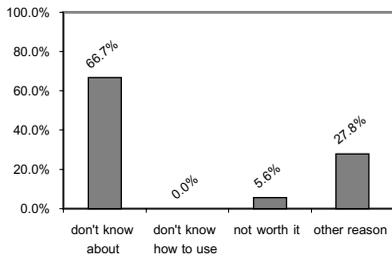
27) According to a December 17, 2004 email from the person who was responsible for the SME study: “... we believe (at least when the study was conducted) that our sample was fairly representative of the entire US.”

28) This comment should be qualified in that over the last two years since the Society of Manufacturing Engineers study more U.S. manufacturers have probably adopted LMTs to some degree.

using LMTs probably won't. And, from an examination of the reasons given for not planning to use them (Figure F below), it would seem not really knowing what LMTs are is the reason for this.

For the two companies planning to use LMTs Figure P shows the LMTs they plan to use (listed in the order of most used to least used). As for when they were planning to start using these LMTs, one company was undecided and the other did not answer.

*Of those not using them and not planning to use them, why not?* The reasons given by the 18 companies not planning to use LMTs are shown in Figure F. No company chose “we know about LMTs but we don't know how to use them” and only one company (5.6%) chose “we think



**Figure F.** Reason Not Planning To Use LMTs

adopting LMTs would not be worth the effort.” Twelve companies (66.7%) chose “we don't know much about LMTs” as their reason and five companies (27.8%) marked “other reason(s).” Figure Q breaks out these other reasons. The following comments apply to these reasons:

Co #1	“Because of the Hazard Analysis and Critical Control Point (HACCP) system.”
Co #2	“We use other manufacturing techniques.”
Co #3	“We use other manufacturing techniques similar to LMTs.”
Co #4	“All manufacturers use these things naturally.”
Co #5	“We adopt other manufacturing methods.”

**Figure Q.** For Companies Not Using LMTs, Reasons Given When “Other” Was marked

- Company #1 (dairy products): “HACCP, a preventative system that is used to identify, evaluate and control food safety hazards, is becoming a worldwide norm for food safety” (*HACCP*, 2004). The reason given seems specious since one would think the use of LMTs would contribute to a better-run food production operation.
- Companies #2, #3, and #5 (various products): It would be interesting to know what these “other” techniques/methods are. If they really are similar to LMTs then these companies could have listed them at the question asking which “LMTs” they used under the choice “other.”
- Company #4 (pachinko machines): I would question this “reason” since to truly implement an LMT takes a lot of effort and stick-to-itiveness.

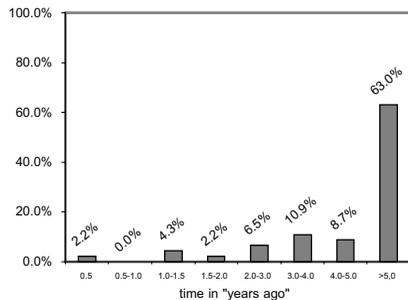
In sum, the five reasons given suggest a lack of understanding about LMTs. If we combine these five companies with those who answered “we don’t know much about LMTs” (totals 94.5%) we can reasonably conclude that the reason companies don’t plan on using LMTs is that *they don’t really know much about them*.

Finally, returning to the previous study question “For those not using LMTs, do they plan to use them?” the answer from these results is, as mentioned, probably not and the reason for this is their lack of knowledge about LMTs (and what they might do for them).

***For those using LMTs, when did they start using them and which ones do they use?***

*When did they start using them?*

Figure G shows when the respondents using LMTs started using them. It is obvious that for most companies (63.0%), LMTs have

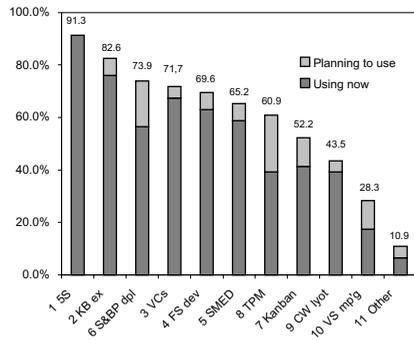


**Figure G.** When Started To Use

been a part of their way of operating for a long time, at least five years. If we include those who have been using them for three or more years the percentage rises to 82.6%. If I were to conduct this survey again, I would have made the choices less precise and going back perhaps 15 or so years. The data shown by Figure G supports that shown in Figure D which showed approximately 70% of those responding *do* use LMTs. In other words, LMTs are used by a majority of SME manufacturers and have been for a long time.

*Which ones do they use?* To answer this question completely I felt it was necessary to get information on not only the LMTs they're using now but also any they are planning to use. If we add the percentage of those presently using each LMT to the percentage of those planning to use that LMT, as we did with Figure

J above, we get the picture shown in Figure R. Figure R differs from Figure J by showing total percentages for both LMTs being used and LMTs being planned for use. It also reorders *these* total percentages most to least.<sup>29)</sup> Figure R is probably a more accurate indication of which LMTs are the most popular for SME manufacturers in Japan.



**Figure R.** For Each LMT, Total Percentages Using Now and Planning to Use In Future

What is interesting about Figure R is the relatively uniform use of all ten LMTs provided as choices in the questionnaire. In fact, the percentage of companies using the eight most used LMTs do so at a level of more than 50%. That is to say, all LMTs are being used or planned for use and, with a few excep-

29) Again, the number associated with the name of each LMT is where it ranked according to the number of companies *presently* using it.

tions<sup>30)</sup>, to a considerable extent. The average of these percentages including the “Other” category is 59.1% and the average number of LMTs used by each company is 6.5.

What can we say about the differences in these percentages?:

- 5S (91.3%). That 5S is the most used is not surprising since it is easy to understand and relatively easy to implement—just takes a strong management effort to convince workers that it is in their best interests to keep the workplace clean and orderly followed by good execution and follow-up.
- *Kaizen blitz exercise* (82.6%). Given the difficulty of organizing and carrying out a good *kaizen* blitz exercise, I was surprised that its percentage is so high. This could be for reasons such as the respondent was confusing this LMT with the more general concept of *kaizen* meaning “continuous improvement.”<sup>31)</sup> To the extent those completing the questionnaire did properly understand and cite this LMT the large percentage may also be a reflection of the importance this LMT has gained recently as a quick and effective means of rapid improvement.
- *Standardization and best practice deployment* (73.9%). Although important, this LMT is not that easy to implement and maintain since it involves writing down how something is done and ensuring that the procedure is always followed. It also involves keeping the written procedure up to date, usually a chronic problem when we are always too busy “putting out today’s fires.” Therefore, I was surprised at the relatively high percentage. If it is true it reflects well on the companies doing it and planning to do it.
- *Visual controls* (71.7%). Similar to 5S, visual controls need not be a major

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30) Cellular workplace layout and Value-stream mapping of the ten listed are the only two below 50%.

31) Although the cover letter did include a very brief description of each LMT, there is no guarantee that it was read or used when completing the questionnaire.

effort since such controls can be as simple as a large sign made of cardboard or a handmade chart showing daily or weekly production goals and achievements. Once their value is realized, it is easy to understand why visual controls would be employed.

- *Failsafe device* (69.6%). Also known as *poke-yoke*, the large percentage may be explained by the importance this LMT can play in reducing rework and scrap, not to mention safety. And, again, with a little ingenuity, many failsafe devices can be implemented rather easily.
- *Reduction of set-up time (SMED)* (65.2%). Another LMT that could be fairly difficult to implement since it requires studying just how you presently do your machine set-ups and devising ways to do more things “off-line” from the actual change over. Accordingly, it is interesting and good that so many companies are using this LMT.
- *Total productive maintenance (TPM)* (60.9%). Again, I was surprised at the high use of the LMT, which in its fully implemented form demands a coordinated effort between the operators and the maintenance personnel. It could be that a looser interpretation of this LMT—just having a good preventive maintenance program for example—contributed to the high percentage.
- *Kanban system (just-in-time manufacturing)* (52.2%). Because to set up a good just-in-time system requires considerable effort in terms of studying the whole production operation it is reasonable that the number of SMEs using this LMT is about 50%.
- *Cellular workplace layout* (43.5%). To establish a good cellular workplace layout usually requires considerable study, realignment of equipment, and retraining of personnel. Also, every manufacturer’s operation may not lend itself to such a layout. The percentage seems reasonable.
- *Value-stream mapping* (28.3%). Similar to cellular workplace layout, value-

stream mapping involves a thorough study of your present operation and then decisions about how to change it, often in major ways. Due to the effort required it is not surprising that this is the least used of the ten LMTs.

- *Other* (10.9%). See Figure S. Of the 46 companies presently using LMTs three listed something under “other” for LMTs they are presently using and two listed something under “other” for LMTs they plan to use. As Figure S shows, company #2 listed something under both. Let’s look at these “other” LMTs:

	Using Now	Plan To Use
Co. #1	Improvement Proposal System	
		Planned Production System, Stock Planning/Mgt System,
Co. #2	Performance Management	Cost Mgt System
Co. #3	HACCP	
Co. #4		Self-Directed Work Team

**Figure S.** The "Other" LMTs

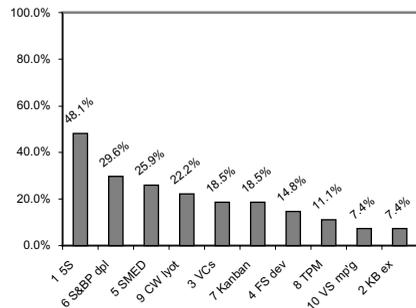
- *Improvement Proposal System.* One of the wastes mentioned in section 2 was “people.” One way to take advantage of the great potential of your people and increase their participation and ownership in the manufacturing process is having means by which they can recommend improvements. It is often the person closest to that process that will have the best ideas for making it better. Toyota Motor Co. is famous for its proposal system which is well run with most suggestions being implemented (Austenfeld, 2003, p. 63).
- *Performance Management.* This “LMT” is described as monitoring the efficiency of an operation and where a loss in efficiency is detected, eliminating the cause of that loss. Although more information would be needed to fully understand this system, generically it fits the definition of “lean” since its goal is to eliminate waste.
- *HACCP (Hazard Analysis and Critical Control Point).* As already

described, this is a preventive system to control food safety hazards. It would seem it is not per se a technique for eliminating waste. However, to the extent that it eliminates defective food product it could be considered an LMT.

- *Planned Production System, Stock Planning/Management System, Cost Management System.* These three systems seem to be more standard planning and control systems versus techniques for eliminating waste but, again, to the extent they do would qualify as LMTs.
- *Self-Directed Work Team.* Although not usually considered an LMT, similar to the improvement proposal system, this is taking advantage of the potential of your employees. In fact this is probably the ultimate means of doing this since such teams are truly self-managing with all that implies (pride of work, loyalty to the company, high morale, striving to do better, etc.). For more on self-directed work teams see Austenfeld, 2000.

This has been a quick assessment of the LMTs the 46 companies reported. A further insight into why some LMTs are more popular than others may be gained when we examine the results of which LMTs help the most and some of the examples of improvements due to specific LMTs.

***For those using them, which LMTs are helping them the most?*** Figure N is repeated here to show the LMTs that were reported as helping the companies the most. As already mentioned in the “results” section, to provide a more meaningful indication of



**Figure N.** For Each LMT, Percentage of Co’s Including It As One That Helped Most (for Co’s Choosing 50% or Less of Those Used-26 Co’s)

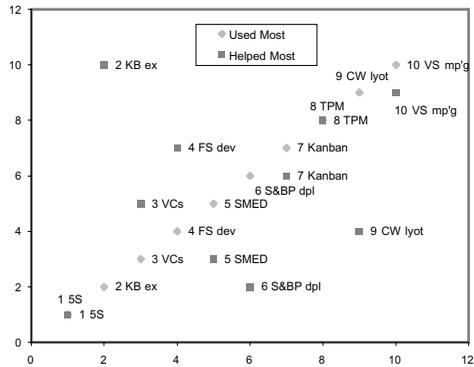
which LMTs a company thought were *most* helpful, Figure N shows only the choices made by companies reporting 50% or less of the LMTs being used (26 companies). After all, if a company simply reports 100% of the LMTs being used as “helping the most” it doesn’t tell us much.

So what can we say about the respondents’ choices regarding which LMTs have most helped? First note that the number associated with the name of each LMT is that of the order in which the LMT ranked for *percentage of use*; i.e., 5S is the most used, *Kaizen* blitz exercise the second most used, etc. (Figure H). It is obvious that the LMTs used most are not necessarily the ones that are the most helpful in the collective opinions of the respondents. Figure T shows how the

Rank	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Used Most	1 5S	2 KB ex	3 VCs	4 FS dev	5 SMED	6 S&BP dpl	7 Kanban	8 TPM	9 CW lyot	10 VS mp/g
Helped Most	1 5S	6 S&BP dpl	5 SMED	9 CW lyot	3 VCs	7 Kanban	4 FS dev	8 TPM	10 VS mp/g	2 KB ex

**Figure T.** Comparing Rankings of "Used Most" LMTs with "Helped Most" LMTs

rankings changed between “used most” and “helped most.” For example Standardization and best practice deployment went from a “used most” 6th place to “helped most” 6th place to “helped most” 2nd place. These results are interesting since they show that it was important to ask the companies in the sample which LMTs help the



**Figure U.** Scatter Diagram of “Used Most” and “Helped Most” Rankings

most versus simply going by the ones most used. It would be interesting to somehow quantify this difference. Perhaps the easiest way is to simply see how well the two rankings correlate. Figure U shows this. The correlation is only 0.25. Fig-

ure V is another way to show the information on Figure U32). Again this chart compares the two rankings (“used most” with “helped most”) showing how each LMT changed its ranking and the extent of that change. For example, 5S’s ranking didn’t change yet Kaizen blitz exercise went from a “used most” 2nd place to a “helped most” 10th place, a difference of  $-8$ . So on the “negative” side of the ledger the data suggests that the following LMTs were not that much help despite being used a *lot*:

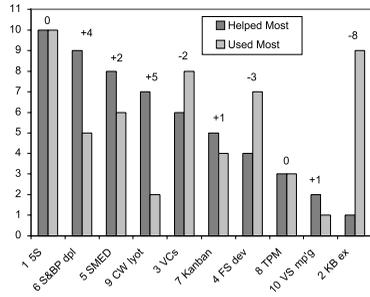
- Kaizen blitz exercise ( $-8$ )
- Visual controls ( $-2$ )
- Failsafe device ( $-3$ )

And, on the “positive” side (generally helped more despite not being used that much):

- SMED ( $+2$ )
- Standardization and best practice deployment ( $+4$ )
- Kanban ( $+1$ )
- Cellular workplace layout ( $+5$ )
- Value-stream mapping ( $+1$ )

And those “neutral” (no change in ranking):

- 5S
- TPM



**Figure V.** Rankings for Helped Most LMTs (26 Co’s) Compared With Those for Used Most (46 Co’s)

32) For graphical depiction purposes, the LMT that ranked first was given a value of 10, the one ranking second, a score of 9, etc. The numbers at the top of the columns are the difference between the “Helped Most” value and the “Used Most” value.

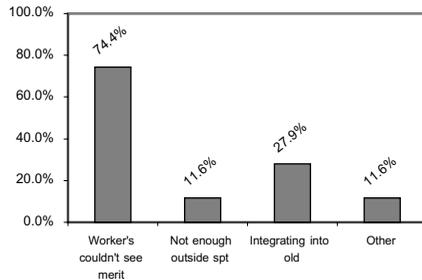
In general this seems to tell us that certain LMTs might be “overused,” that is, used more than their benefits warrant (those with the negative numbers) and others “underused,” that is, their use doesn’t accord with their perceived benefit (those with the + numbers). For *example*, Kaizen blitz exercise, as just mentioned, ranked high in use but low in “helped most”; does this mean it really is “overused”? Probably not since it is hard to imagine any LMT being “overused.” More probably it reflects a misunderstanding of just *what a* Kaizen blitz exercise is. It is possible its high usage percentage is because some respondents reported something other than a *pure* Kaizen blitz exercise as such; e.g., simply doing “continuous improvement” which is *what* “kaizen” means. If we *eliminate* Kaizen blitz exercise from the results shown in Figures U and V, the only other really significant aberrations are Cellular workplace layout (+5) and Standardization and best practice deployment (+4) whose positive numbers suggest perhaps they aren’t used enough according their perceived benefits. This may well be true since both require a considerable effort to fully implement. Note that another LMT that requires a lot of effort to implement is Value-stream mapping but it’s “used most”/“helped most” correlates well as shown in Figures U and V.

Having tried to make some sense out of the differences between where a LMT ranked use-wise vs. “helped most”-

wise, let’s move on to the last question: For those using them, what were the biggest problem(s) they encountered?

***For those using them, what were the biggest problems when initially trying to adopt LMTs?***

Figure O, repeated here, shows



**Figure O.** Perctg of Co’s Rpt’g These Problems When Trying to Adopt LMTs

that by far the biggest problem was that the workers couldn't see any merit in adopting LMTs and had to be convinced. This is not surprising and is the reason I chose to list it as the first choice for this question. To make the change from traditional methods to LMTs requires considerable effort in not just requiring your workers to use them but to convince them of the merit in doing so. As a case in point, Woolson & Husar (1998) describe the efforts of a manager to convert a General Motors plant making steering systems from traditional methods to lean methods. To do this a special "communications" model was used that emphasized not only providing information about LMTs but, before expecting full implementation, went through the "understanding" and "commitment" steps. Such a model might well serve any major change effort, and surely going from traditional methods to lean methods is a major change.

The other significant problem cited (see Figure O) was integrating LMTs into the old conventional production system. Notwithstanding the comments just made about becoming a "complete" lean manufacturer, many companies will not elect to do this but pick and choose only those LMTs best suited for their situation. Therefore they will, in effect, be running a hybrid operation. Therefore this, by its very nature, will present problems since some parts of the operation will continue as before while others will change, often in radical ways, as they become "lean."

Figure W shows the "other" problems reported by five of the companies. To provide a better perspective of these responses, I've shown whether they also gave any other reasons (from the left in Figure O: a (workers couldn't see merit), b (not enough outside support), or c (integrating into the old [system])). Where it seemed appropriate I commented on their response to suggest better what the person was trying to say.

Company #1's response by the Factory Chief for a subcontractor that makes aluminum alloy apparently didn't have any problems worth mentioning, the

	"Other"(d) Problem Reported	Any Other Problems Reported?
Co #1	"Nothing special"	No, only d
Co #2	"We can't use them fully." <i>Comment: maybe he means expand usage or use "better."</i>	Yes, a
Co #3	"Reforming the employees' feelings." <i>Comment: so they constantly think about doing it this way?</i>	No, only d
Co #4	"How to accommodate LMTs to many kinds of production situations; e.g., small batches, many different kinds"	Yes, a & c
Co #5	"LMTs are not so effective if they are introduced only by our company; we need the cooperation of our related manufacturers."	No, only d

**Figure W.** Biggest "Other" Problems Faced When Trying to Adopt LMTs

only company not reporting any.

Company #2's response was not clear but, as I commented, maybe he is saying they simply haven't been able to implement their LMTs (seven were listed) as fast and fully as desired. In fact, in making general comments about their LMT experience, this manager commented to the effect that to try for too much "efficiency" (equals fully implementing lean?) can actually cause a decline in worker morale and quality. I would suggest that he might be simply saying how difficult it is to effect a cultural change which is basically what reason "a" (workers couldn't see merit) is about.

The response by company #3 would also seem to fall into this category; i.e., essentially saying how difficult it is to get the workers to accept LMTs.

Company #4's response was in addition to citing reasons "a" and "c" and provides another perspective on the difficulty in implementing lean techniques. However, by its very nature, the lean approach to manufacturing is meant to make it easier to go to a small batch operation; i.e., from a traditional large batch and queue operation to a small, even one product/assembly at a time, operation with the concomitant reduction in inventory.

Finally, company #5's response was by the Production Planning Manager of a subcontractor making car seat assemblies. His comment is right on the mark and in line with one of Deming's 14 Points<sup>33</sup>: *Point 4: End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.* In other words, work with your suppliers and be sure they are practicing good quality management too.

As promised the rest of this section will be devoted to the other information gathered by the survey:

- Examples of improvements gained through the use of LMTs.
- Open-ended comments by those adopting and using LMTs on this experience.
- Open-ended comments by any respondent (whether they use LMTs or not) on anything they wish *to say*.

***Examples of improvements gained through the use of LMTs.*** Although not a primary purpose of the study, I decided to ask the sample to list improvements they've gained by using LMTs. This was Question 16 on the questionnaire and included an example of what I wanted. Of the 46 companies responding as using LMTs, 37 (80.4%) provided examples of improvements<sup>34</sup>, a very good response indeed. The average number of "improvement examples" provided was 3.1. For those interested, the complete list as best translated by my translator and understood by both of us is at Appendix F. For the ten specific LMTs listed in the questionnaire, there were 110 examples given. Appendix F also shows the percentage of examples given for each LMT.

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33) See Appendix A for a list of all 14 points.

34) Actually there were 38 responses but one company's examples didn't seem to fit the concept of what a LMT is. Another company did not cite specific LMTs but made a general comment. And one company gave an example for one of the "other" LMTs (Performance management). For completeness all these are listed in Appendix F.

*Open-ended comments by those adopting and using LMTs on this experience.* This was Question 19 on the questionnaire. The question: “Is there anything else you would like to tell me about your experiences related to adopting or using Lean Manufacturing Techniques?” Of the 46 companies responding as using LMTs, 16 (34.8%) made comments. Their comments are at Appendix G. In my opinion, some of the more significant comments were these (italics are my annotations):

- “No matter what the *condition is (difficult or not?)*, I think it is important to continue steady training and practice.”
- “As I think can be said of everything, the key is to take the initiative and with patience thoroughly see the effort through to completion.”
- “(1) The will to ‘do it!’ is important, (2) we *should (always?)* consider our relationship with those with whom we’re *connected (suppliers, customers, etc.?)*.”
- “Introducing LMTs isn’t a goal, we have to continue improving them or they will become ‘*outdated*’ (*my word*) and we will be left behind.”
- “I think the most important thing is if we can develop the workers’ drive and *understanding*.”

*Open-ended comments by any respondent (whether they use LMTs or not) on anything they wish* to say. This was Question 20 on the questionnaire. The question: “If you have any other comments please write them here.” All respondents were welcome to comment here whether they used LMTs or not. The page of the questionnaire on which this “question” was presented (p. 5) was missing from one response<sup>35)</sup> so the number of companies responding for the purpose of this question was 65 (vs. 66). Of these 65 companies only 14 (21.5%) made substantive comments; the rest either made no comment (43 companies) or com-

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35) This page was probably missing from the questionnaire when it was sent out.

Papers of the Research Society of Commerce and Economics, Vol. XXXXVI No. 1  
mented “nothing” or “nothing special” (8 companies). These comments are at  
Appendix H. The type of business, if they are using LMTs, and the position of  
the person making the comments are included.

## 6. Limitations of the study

I believe these were the primary limitations of the study:

- No responses from companies with less than 50 employees.
- My lack of fluency in Japanese.
- The question of just how representative the sample was of all Japanese SME manufacturers.
- Did the respondents fully understand the LMTs.

*No responses from companies with less than 50 employees.* Although the specification called for the random sample to be taken from all Japanese manufacturing companies employing 300 or less, for some reason none of the respondent companies were less than 50 employees. As explained on pages 19 and 20, this was probably due to the way the sample was drawn in that companies were selected from each prefecture in the order of annual sales. This means most of the companies in my specified sample were probably at the high end for annual sales and tended to have more employees. To get a more broadly representative sample I should have specified that the companies be selected without regard to annual sales (or, for that matter, any other attribute as long as they met the basic specification parameters).

*My lack of fluency in Japanese.* This limitation made it much more difficult to (1) create a good questionnaire and cover letter and (2) to get a good understanding of many of the responses to the questionnaire. I was fortunate to have the help of both two colleagues at Shudo University and two people at Sophia University (where the study took place) in developing a good translation of the questionnaire (see Appendixes D and E). I might add that these people not only

helped me translate these documents but made many useful suggestions for their improvement; it was truly a “joint” effort. Without their help I would have been stymied from the start. They are gratefully recognized in the Acknowledgements.

Many of the questions on the questionnaire were multiple choice and required no translation of the responses. However, there was also a lot of what I called “text” material such as the “other” choices, the “improvements” examples (Question 16) and the “comment” questions (Questions 19 and 20). For these I was (again) fortunate to find a Sophia University student who was quite fluent in both English and Japanese. On the other hand, this student was not a “business major” so had some difficulty fully understanding some of the “business” words. Where possible I tried to get further clarification from business-knowledgeable people at Sophia University.

*The question of just how representative the sample was of all Japanese SME manufacturers.* As mentioned at the beginning of section 3 of this report, the sample was drawn from the database of a well-recognized database company in Tokyo. Unfortunately I was not able to get a response from that company regarding this question. It is conjectured that, given the probable huge size of that company’s database, the sample was fairly representative. However, offsetting this would be the fact that the sample contained no companies with less than 50 employees (see first limitation above).

*Did the respondents fully understand the LMTs?* The results of this study assume that when a respondent said the company used, for example, *Kaizen* blitz exercise, they understood it in the sense described in section 2 of this report. However, I felt that this was not always the case. I mention *Kaizen* blitz exercise because of the high percentage of use reported (76.1%) for this relatively difficult to implement LMT. In another case, a respondent essentially equated LMTs with JIT (just-in-time) when JIT is only one LMT.

## 7. Recommendations for Further Investigation

I would suggest the following as areas for further investigation:

- Survey the companies with less than 50 employees.
- Verify the company's understanding of LMTs.
- Conduct some case studies of the actual experience of some companies.

*Survey the companies with less than 50 employees.* See first limitation above (“No responses from companies with less than 50 employees”).

*Verify the company's understanding of LMTs.* Conduct a similar study but check the company's understanding of LMTs by asking for their definition. This would accomplish at least two things: (1) make the results more credible (see the “Did the respondents fully understand the LMTs” limitation above) and (2) would provide a greater understanding of just how well lean techniques are understood and, therefore, effectively applied.

*Conduct some case studies of the actual experiences of some companies.* Similar to what Liker (1998) did, get the “inside story” on how one or more companies came to realize the need for using lean techniques and then went about doing so. What problems did they face and what benefits did they gain? Although this study attempted to get this sort of information about problems and benefits an in-depth case study would reveal much more and be of much value for others in the process of implementing LMTs or planning to do so.

## 8. Summary and Conclusions

The purpose of this paper is to report the results of a 2004 study of the use of lean manufacturing techniques by Japanese small and medium enterprises (SMEs). A questionnaire was sent to 500 randomly selected manufacturers to answer the following questions:

- To what extent do Japanese SME manufacturers use LMTs?

- For those not using LMTs, do they plan to use them?
- Of those not using them and not planning to use them, why not?
- For those using LMTs, when did they start using them and which ones do they use?
- For those using them, which LMTs are helping them the most?
- For those using them, what were the biggest problems when initially trying to adopt LMTs?

Of the 66 companies responding<sup>36)</sup> (13.2%), about half characterized themselves as “A manufacturer that produces a high ratio of its own products”; the remaining companies were distributed fairly evenly across the other five “type” categories. The vast majority of the companies was at or above the high end of being a SME; that is, were between 50 and 300 employees (78.8%) or over 300 (19.7%). About 20% of the companies were in the electrical machinery/appliances business, one third were in “other” industries, mostly food, and the rest more or less evenly distributed across the other ten categories. (Appendix C lists all industries reported along with the products reported.)

Based on the questions listed above we can draw the following conclusions from the results of this study:

***To what extent do Japanese SME manufacturers use LMTs?*** As shown in Figure D (page 23) about 70 percent use LMTs. This compares with only 17% found in the SME study conducted with U.S. companies in 2002 (*SME 2002 Lean*, undated, p. 6).

***For those not using LMTs, do they plan to use them?*** The short answer is “no” since only 10% of the 20 companies not using LMTs plan to use them (see Figure E, page 23).

***Of those not using them and not planning to use them, why not?*** Figure F

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36) As mentioned in a footnote in section 3, there were actually 67 companies responding but one was not used.

(page 23) shows that a full two-thirds of those not planning to use LMTs gave the reason “we don’t know much about LMTs.” However an analysis of the companies giving an “other” reason suggests that these companies also don’t know too much about LMTs. When these two groups are combined it adds up to a total of 94.5%. This suggests that anything that contributes to a better understanding of LMTs would be very beneficial to these companies, for example the publication of this study.

*For those using LMTs, when did they start using them and which ones do they use?* Figure G (page 24) shows that the vast majority (63.0%) of the companies have been using LMTs for at least five years. And Figure R (page 34), showing company percentages for both current and planned usage for each LMT, indicates being used/planned to be used percentages ranging from 91.3% for 5S to 10.9% for the “other” category. The average for these eleven LMTs (the ten I listed plus the “other” category) is 59.1%. If we exclude the relatively small “other” category, this average jumps to 63.9%. The conclusion we can draw from this is not only are most companies using LMTs they are using them to a significant degree across the whole range of LMTs and have been for some time.

*For those using them, which LMTs are helping them the most?* To get a more meaningful result I used the responses to this question of only those companies reporting 50% or less of the LMTs being used. Although arbitrary, this 50% figure seemed reasonable to weed out cases where a company reported most or all LMTs as helping most—an answer not very useful. This reduced the number of companies from 46 to 26 but is still considered large enough for credible results. Figure N (page 28) shows these percentages for each LMT. However, perhaps more interesting is how the rankings for these “Helped Most” percentages compared with those for the “Used Most” percentages of Figure H (page 24); this is shown in Figure V (page 40). Surprisingly there were some significant differences between these respective rankings; especially for these LMTs:

*Kaizen* blitz exercise, Cellular workplace layout, and Standardization and best practice deployment. We can conclude that for some reason companies don't recognize the value of some of the most helpful LMTs or, in some cases, a LMT was wrongly reported as being used due to the person not fully understanding what it is.

***For those using them, what were the biggest problems when initially trying to adopt LMTs?*** According to the data shown in Figure O (page 29), the biggest problem was “the workers couldn't see the merit in adopting LMTs” (72.1%). One of the five “other” problems reported would seem to fall in this category also. Therefore we can conclude that this is, indeed, the biggest problem. Considering the significant change a sincere effort to adopt LMTs involves, this is not surprising since we are talking about nothing less than a wholesale cultural transformation.

## Final Remarks

I owe many people thanks for their support while I was doing this study. I have attempted to acknowledge this support in Appendix I.

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**Appendix A** (page 1 of 2)

**Deming's 14 Points**

(Deming, 1986, pp. 23–24)

- Point 1: Create constancy of purpose towards improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
- Point 2: Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.
- Point 3: Cease reliance on mass inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
- Point 4: End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.
- Point 5: Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
- Point 6: Institute training on the job.
- Point 7: Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.
- Point 8: Drive out fear, so that everyone may work effectively for the company.
- Point 9: Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

**Appendix A** (page 2 of 2)

**Deming's 14 Points** (continued)

(Deming, 1986, pp. 23–24)

- Point 10: Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, since the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.
- Point 11a: Eliminate work standards (quotas) on the factory floor. Substitute leadership.
- Point 11b: Eliminate management by objectives. Eliminate management by the numbers, numerical goals. Substitute leadership.
- Point 12a: Remove barriers that rob the hourly workers of their right to pride of workmanship. The responsibility of supervisors must be changed from mere numbers to quality.
- Point 12b: Remove barriers that rob people in management and in engineering of their right to pride of workmanship.
- Point 13: Institute a vigorous program of education and self-improvement.
- Point 14: Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

**Appendix B** (page 1 of 2)

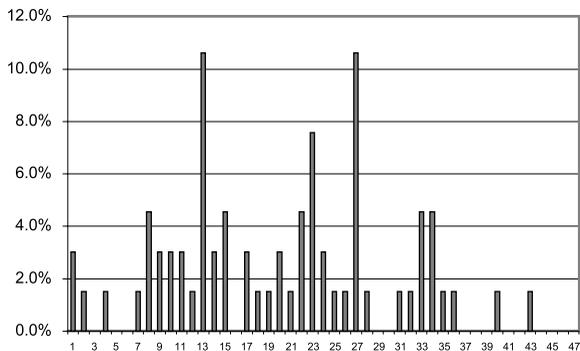
**Study Details**

1. Number of questionnaires sent out: 500 on or about October 7, 2004.
2. Number of (usable\*) questionnaires received back: 66 (13.2%).
3. When questionnaires received back: Between October 14 and December 6, 2004 with 80% received by October 22. The requested “send back” date in the cover letter was October 29.
4. Distribution of responses by prefecture: see Figures 1 and 2 below. As might be expected, the most responses came from Tokyo and Osaka. Aichi had the third most (7.6%).
5. Distribution of responses by Region: see Figure 3 below.

\* One was not usable.

1	Hokkaido	2	3.0%	13	Tokyo	7	10.6%	25	Shiga	1	1.5%	37	Kagawa	0	0.0%
2	Aomori	1	1.5%	14	Kanagawa	2	3.0%	26	Kyoto	1	1.5%	38	Ehime	0	0.0%
3	Iwate	0	0.0%	15	Niigata	3	4.5%	27	Osaka	7	10.6%	39	Kochi	0	0.0%
4	Miyagi	1	1.5%	16	Toyama	0	0.0%	28	Hyogo	1	1.5%	40	Fukuoka	1	1.5%
5	Akita	0	0.0%	17	Ishikawa	2	3.0%	29	Nara	0	0.0%	41	Saga	0	0.0%
6	Yamagata	0	0.0%	18	Fukui	1	1.5%	30	Wakayama	0	0.0%	42	Nagasaki	0	0.0%
7	Fukushima	1	1.5%	19	Yamanashi	1	1.5%	31	Tottori	1	1.5%	43	Kumamoto	1	1.5%
8	Ibaraki	3	4.5%	20	Nagano	2	3.0%	32	Shimane	1	1.5%	44	Oita	0	0.0%
9	Tochigi	2	3.0%	21	Gifu	1	1.5%	33	Okayama	3	4.5%	45	Miyazaki	0	0.0%
10	Gumma	2	3.0%	22	Shizuoka	3	4.5%	34	Hiroshima	3	4.5%	46	Kagoshima	0	0.0%
11	Saitama	2	3.0%	23	Aichi	5	7.6%	35	Yamaguchi	1	1.5%	47	Okinawa	0	0.0%
12	Chiba	1	1.5%	24	Mie	2	3.0%	36	Tokushima	1	1.5%				

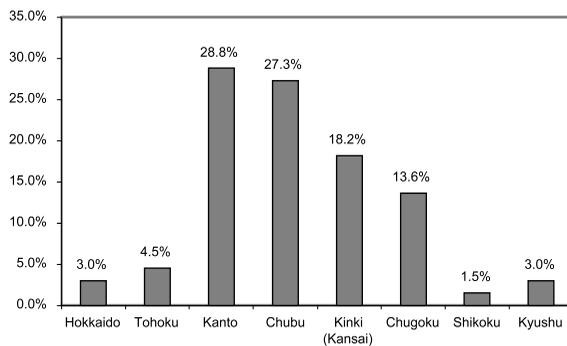
**Figure 1.** Responses Received From Each Prefecture



**Figure 2.** Distribution of Responses By Prefecture

**Appendix B** (page 2 of 2)

**Study Details** (continued)



**Figure 3.** Distribution of Responses By Region

## Appendix C (page 1 of 2)

### Industries and Products Reported

My annotations are in italics.

Questionnaire Choice	Name of Industry	Co	Products
a	Steel industry (1.5%)	1	refrigerator, container, and multipurpose ships; repairs small ships
b	Nonferrous metal manufacturing (4.5%)	2	aluminum alloy
		3	additive for aluminum products
		4	aluminum alloy for both die-casting and casting
c	Metal manufacturing (4.5%)	5	zinc iron plate, colored-zinc iron plate, wire
		6	steel processed goods (mainly for cars), polished ( <i>steel?</i> ) bars
		7	cast iron parts for automobiles, diesel engines, and agricultural machines/implements
d	General machinery and appliances manufacturing (4.5%)	8	processing auto parts ( <i>perhaps putting finishing touches on them</i> )
d, h	d & h	9	1. semiconductors, vacuum pump for making LCDs, 2. snow machine, and 3. ski lift
d, e, g	d, e, & g	10	mainly frames for automobiles
e	Electrical machinery and appliances manufacturing (22.7%)	11	mechanism and exterior parts for car audio and navigation systems
		12	ventilators, air cleaners, compost makers
		13	home kitchen goods
		14	car radio assembly and packing
		15	assembly of liquid crystal displays for cell phones
		16	1. human machine interfaced (HMI) liquid crystal display and touch panel, 2. control board for industrial machines
		17	blenders, laser printers (+ <i>two others: light pickup &amp; micro-"fore"??</i> )
		18	magnetic tape devices, the development and production of precise assembly devices (?), processing PT boards (?)
		19	( <i>circuit?</i> ) breakers, connectors, taillights
		20	<i>pachinko</i> and slot machine parts and modules
		21	home healthcare equipment (e.g., scales)
		22	home solar heating systems
		23	portable car navigation systems, machine ( <i>components?</i> ) used for car navigation systems
e, i	e & i	24	optical instruments and micro-lens units
f	Transportation equipment manufacturing (other than automobiles) (3.0%)	25	automobile parts ( <i>probably should have classified "g"</i> )
f, g	f & g	26	makes(?) and assembles parts for engines for two- and four-wheel vehicles
g	Transportation equipment manufacturing (automobiles) (12.1%)	27	1. (mainly) automobile parts to Honda, Daihatsu, etc. (console boxes, spoilers, wiring harnesses, etc.), 2. motor scooter parts for Yamaha (wiring harnesses, cords, etc.)
		28	iron plates for car frames (press weld, etc.)
		29	engine parts
		30	seat assemblies for cars
		31	automobile seat covers
g, i	g & i	32	seats and doors for cars, urethane products, packing material

**Appendix C (page 2 of 2)**  
**Industries and Products Reported (continued)**

Questionnaire Choice	Name of Industry	Co	Products
h	Precision instruments manufacturing (7.6%)	33	color page printer
		34	vacuum thin film making machine
		35	medical equipment ( <i>not clear if precision or just simple things</i> )
		36	cell phones, audio equipment (e.g., stereos)
i	Plastic products and/or rubber products manufacturing (13.6%)	37	resin compound product, OPS sheet, CPS sheet, PS resin
		38	various plastic utensils (?), sticky carpet cleaner, etc.
		39	plastics forming, coloring, and secondary processing
		40	dry coating product (using vacuum process) and wet coating product (using "painting" process [ <i>best guess</i> ]).
		41	light diffusion sheet for LCD tail lamps
		42	industrial resin products
i, j	i, j (j: Construction [1.5%])	43	fiberglass reinforced plastic (FRP) septic tanks, sewage disposal facilities
k	Lumber/wooden products manufacturing (1.5%)	44	( <i>wooden?</i> ) uprights, foundations (?), beams for houses
l	Other - food production (19.7%)	45	condensed milk, powdered milk, milk, yogurt, butter, cheese
		46	butter, powdered milk, condensed milk, etc.
		47	dairy products, yoghurt, 100% juice (orange, etc.)
		48	powdered and liquid seasoning, frozen and dried vegetables, quick food pouch (heat in microwave), frozen food
		49	laver (seaweed) processing, <i>ochazuke, furikake</i>
		50	sake
		51	boiled rice and barley, dried noodles, flour, barley tea
		52	colza oil, corn oil, lecithin
		53	coffee, syrup
		54	seasonings, alcoholic drinks
		55	frozen sea foods
		56	dairy products (milk, ice cream, [ <i>other?</i> ] beverages, yoghurt)
		57	<i>mentaiko</i> (spicy cod roe)
l*	Other - amusements	58	<i>pachinko</i> machines
		59	<i>pachinko</i> and slot machines
	Other - chemical production	60	chemicals used in the production of foods and medicines; e.g., glucide made from starch, etc.
		61	inorganic chemicals
	Other - electronic machine parts	62	color filter (put on liquid crystal display for color)
	Other - house unit assemblages	63	iron and wooden prefab framework (?)
	Other - printing	64	planning, designing, and production of commercial printing
	Other - processing of elect. fittings, glass surface treatment	65	light bulb and bottle processing, sheet glass surface processing ( <i>maybe polishing</i> )
Other - stock breeding and food production	66	Chicken	

\*The percentage for these "non-food production" other industries is 13.6%

## Appendix D (page 1 of 5)

### The Questionnaire (Japanese)

#### 調査の目的

本調査の目的は以下の3つを調査することにあります。

- ① リーン生産手法が日本の中小製造業でどのくらい利用されているか。
- ② リーン生産手法の利用によりもたらされる利点とはどんなものなのか。
- ③ リーン生産手法を最初に導入する際どのような問題があったか。

リーン生産とは、製造業者が資源の利用をより有効に行うことを助ける方法です。リーン生産手法として知られるこれらの方法は、不良品、過剰生産、労働者や原材料の無駄な動き、過剰在庫や不必要な待ち時間などによる無駄を認識し排除することにより、資源を有効利用を実現します。これらの手法の多くは、初めてトヨタ自動車により実践され、後に多くの日本国内および欧米の製造業者により取り入れられました。本アンケートに添付の“調査協力の依頼”文書の2ページ目に、リーン生産手法の最も一般的なものの概略を明記いたしました。

#### 第1部 一般的質問事項

- 質問1 あなたの会社についておたずねします。以下のa～gの中で、あなたの会社はどれに該当しますか？最も適切と思われるものに○をつけてください。
- a. 特定企業1社からの下請加工が主である。
  - b. 特定企業数社からの下請加工が主である。
  - c. OEM供給業者としての製造が主である。
  - d. 自社製品比率が高い製造業者である。
  - e. 特定企業1社との共同研究開発なども伴った下請取引が主である。
  - f. 特定企業数社との共同研究開発なども伴った下請取引が主である。
  - g. その他 ( )
- 質問2 あなたの会社の規模についてお尋ねします。以下のa～dの中で、あなたの会社はどれに該当しますか？該当するものに○をつけてください。
- a. 従業員10人未満
  - b. 従業員10人以上50人未満
  - c. 従業員50人以上300人未満
  - d. 従業員300人以上の場合、従業員数を明記してください。約 ( ) 人
- 質問3A あなたの会社で製造する部品や製品は、どの業界に該当しますか？以下のa～lの中で、該当するものすべてに○をつけてください。
- a. 鉄鋼業
  - b. 非鉄金属製造業
  - c. 金属製品製造業
  - d. 一般機械・器具製造業
  - e. 電機機械・器具製造業
  - f. 輸送用機械・器具製造業（自動車以外）
  - g. 輸送用機械・器具製造業（自動車）
  - h. 精密機械器具製造業
  - i. プラスチック製品、ゴム製品製造業
  - j. 建設・建築関連製造業
  - k. 木材・木製品製造業
  - l. その他 ( )

質問3B 貴社で生産している製品について簡単に説明してください。

( )

紙面が足りない場合は、このページの裏面をご利用ください。

## Appendix D (page 2 of 5)

### The Questionnaire (Japanese) (continued)

- 質問4 本調査に回答していただく方の地位や肩書きを教えてください

( )

#### 第2部 リーン生産手法の利用に関する質問

※該当するものに○をつけてください。

- 質問5 あなたの会社では、製造工程を改善するためリーン生産手法を利用していますか？（リーン生産手法については本アンケート用紙の1ページをご覧ください。）

- a. はい
- b. いいえ

（回答が“はい”の場合は質問10へ，“いいえ”の場合は質問6へお進みください）

- 質問6 あなたの会社ではリーン生産手法を今後利用することを考えていますか？

- a. はい
- b. いいえ

（回答が“はい”の場合は質問8へ，“いいえ”の場合は質問7へお進みください）

- 質問7 質問6で“いいえ”と回答されましたが、その理由についてお聞きします。

以下のa～dの中で、該当するものに○をつけてください。

- a. リーン生産手法についてあまり詳しく知らないから。
- b. リーン生産手法について知っているが、どのように導入していいかわからないから。
- c. リーン生産手法を導入する価値がないと思われるから。
- d. その他の理由 ( )

紙面が足りない場合は、このページの裏面をご利用ください。

（質問7を回答後、質問20に進んでください。）

- 質問8 あなたは質問6で“はい”と回答されましたが、だいたいいつ頃からリーン生産手法を利用することを検討していますか？以下のa～eの中で、該当するものに○をつけてください。

- a. 今後半年の間
- b. 今後半年から1年の間
- c. 今後1年から1年半の間
- d. 今後1年半から2年の間
- e. その他、おおよその時期がおわかりでしたら、その時期をお書きください。時期が不明の場合は不明とお書きください。( )

- 質問9 貴社では将来どのリーン生産手法を採用する予定ですか？以下のa～kの中で、該当するものすべてに○をつけてください。

- a. 5S
- b. ビジュアル・コントロール
- c. トータル・プロダクティブ・メンテナンス (TPM)
- d. 標準化/バスト・プラクティス
- e. 段取り時間の短縮 (SMED)
- f. ボカよけ
- g. バリユーマッピング
- h. カンバン方式 (ジャストインタイム生産)
- i. セル生産方式
- j. カイゼン運動
- k. その他 (具体的に )

紙面が足りない場合は、このページの裏面もご利用ください。

（質問9を回答後、質問20に進んでください。）

Appendix D (page 3 of 5)

The Questionnaire (Japanese) (continued)

■質問10 質問5で“はい”と回答されましたが、貴社ではいつ頃からリーン生産手法を利用していますか？以下の a～h の中で、該当するものに○をつけてください。

- a. 約半年
- b. 半年から1年前
- c. 1年から1年半前
- d. 1年半から2年前
- e. 2年から3年前
- f. 3年から4年前
- g. 4年から5年前
- h. 5年以上前

■質問11 貴社では現在どのリーン生産手法を利用していますか？以下の a～k の中で、該当するものすべてに○をつけてください。

- a. 5S
- b. ビジュアル・コントロール
- c. トータル・プロダクティブ・メンテナンス (TPM)
- d. 標準化/ベスト・プラクティス
- e. 段取り時間の短縮 (SMED)
- f. ボカよけ
- g. バリューマッピング
- h. カンバン方式 (ジャストインタイム生産)
- i. セル生産方式
- j. カイゼン運動
- k. その他 (具体的に \_\_\_\_\_)

紙面が足りない場合は、このページの裏面もご利用ください。

■質問12 貴社では、質問11で回答された現在使用しているリーン生産手法以外のリーン生産手法の利用を考えていますか？該当するものに○をつけてください。

- a. はい
- b. いいえ

(回答が“はい”の場合は質問14へ、“いいえ”の場合は質問13へお進みください)

■質問13 あなたは質問12で“いいえ”と回答されましたが、以下の a～d の中で、その理由として該当するものに○をつけてください。

- a. 貴社がまだ導入していないリーン生産手法についてはあまりよく知らないから。
- b. 他のリーン生産手法が貴社に適合するとは思えないから。
- c. 他のリーン生産手法を導入しても見返りが十分得られるとは思えないから。
- d. その他 (具体的に \_\_\_\_\_)

紙面が足りない場合は、このページの裏面もご利用ください。

(質問13を回答後、質問16へ進んでください。)

■質問14 あなたは質問12に“はい”と回答されましたが、以下の a～k の中で、将来、貴社で利用することを考えているリーン生産手法に該当するものすべてに○をつけてください。

- a. 5S
- b. ビジュアル・コントロール
- c. トータル・プロダクティブ・メンテナンス (TPM)
- d. 標準化/ベスト・プラクティス
- e. 段取り時間の短縮 (SMED)
- f. ボカよけ
- g. バリューマッピング
- h. カンバン方式 (ジャストインタイム生産)
- i. セル生産方式
- j. カイゼン運動
- k. その他 (具体的に \_\_\_\_\_)

紙面が足りない場合は、このページの裏面もご利用ください。

Appendix D (page 4 of 5)

The Questionnaire (Japanese) (continued)

- 質問15 今後だいたいいつ頃から、他のリーン生産手法を利用することを考えていますか？
- 今から6ヶ月の間
  - 6-12ヶ月後
  - 12-18ヶ月後
  - その他、上記以外の利用開始予定の時期、あるいは時期が決まっていなかった場合は決まっていな  
いと明記してください。( )

- 質問16 あなたの会社では、リーン生産手法の導入により、どのような改善が図られましたか？以下の(例)にならって、(回答欄)に詳細をお書きください。

(例)

LMTの項目	改善点
ポカよけ	サークル・タイムの改善、やり直しの減少

(回答欄)

LMTの項目	改善点

- 質問17 貴社がこれまで導入した(または現在利用している)リーン生産手法の中で、最も利用価値が高かった(または高い)ものは何ですか？以下のa~kの中で、該当するすべてのものに○をつけてください。
- 5S
  - ビジュアル・コントロール
  - トータル・プロダクティブ・メンテナンス(TPM)
  - 標準化/ベスト・プラクティス
  - 段取り時間の短縮(SMED)
  - ポカよけ
  - バリューマッピング
  - カンバン方式(ジャストインタイム生産)
  - セル生産方式
  - カイゼン運動
  - その他(具体的に \_\_\_\_\_)
- 紙面が足りない場合は、このページの裏面もご利用ください。

- 質問18 貴社で、リーン生産手法を導入するうえでの大きな問題点は、どのようなものでしたか？以下のa~dの中で、該当するすべてのものに○をつけてください。
- リーン生産手法を導入することのメリットを理解できない従業員に納得してもらおうための努力。
  - リーン生産手法の利用に不可欠な資源を得るための外部からのサポートが不十分。
  - リーン生産手法を伝統的な生産方式に統合すること。
  - その他(具体的に \_\_\_\_\_)
- 紙面が足りない場合は、このページの裏面もご利用ください。

Appendix D (page 5 of 5)

The Questionnaire (Japanese) (continued)

- 質問19 リーン生産の実施に関しての貴社のその他の経験についてなにかあれば教えてください。

[ ]

紙面が足りない場合は、このページの裏面をご利用ください。

- 質問20 この質問票についても含め、何かご意見・ご感想があればお書きください。

[ ]

紙面が足りない場合は、このページの裏面をご利用ください。

- 質問21 あなたは、本アンケートの結果を受け取りたいですか？該当するものに○をつけてください。  
a. はい  
b. いいえ

以上で質問は終わりです。回答後は本アンケート用紙を添付の封筒で返送していただければ幸いです。ご協力ありがとうございました。

**Appendix E** (page 1 of 9)  
**The Questionnaire (English)**

Purpose of this questionnaire

The following three objectives are the purpose of this questionnaire:

1. To research how many small and medium-sized manufacturers in Japan are using Lean Manufacturing Techniques.
2. To research what are the benefits of using Lean Manufacturing Techniques.
3. To research what are the problems encountered when a company first started using Lean Manufacturing Techniques.

Lean manufacturing means using methods that help manufacturers get more from their resources. These methods, known as Lean Manufacturing Techniques, do this by identifying and eliminating waste caused by such things as defects, over production, unnecessary movements of people or material, excessive inventory, and unnecessary waiting. Many of these techniques were first used by the Toyota Motor Co. and later adopted by other Japanese and Western manufacturers. Some of the most common Lean Manufacturing Techniques are briefly described on page 2 of the cover letter.

**PART 1: GENERAL QUESTIONS**

Question 1 Please tell me about your company. Please choose and circle the letter, "a-g" below, that best describes your company.

- a. Subcontractor, of a specific enterprise, that mainly produces and charges on a piece-by-piece basis.
- b. Subcontractor, of several enterprises, that mainly produces and charges on a piece-by-piece basis.
- c. A manufacturer that mainly produces products as an OEM (original equipment manufacturer).
- d. A manufacturer that produces a high ratio of its own products.
- e. Subcontractor, of a specific enterprise, that not only manufactures for the contractor but also conducts joint research and development with the contractor.
- f. Subcontractor, of several enterprises, not only manufactures for the contractor but also conducts joint research and development with the contractor.
- g. Other ( )



**Appendix E** (page 3 of 9)

**The Questionnaire (English)** (continued)

Question 4 Please specify the work position and/or title of the person who is filling out this questionnaire.

**PART 2: QUESTIONS CONCERNING THE USE OF LEAN MANUFACTURING TECHNIQUES**

Note: Please circle the letter next to the answer(s) that apply to your company

Question 5 Has your company been using any Lean Manufacturing Techniques to improve your manufacturing processes? (Please refer to the description of Lean Manufacturing in the box on page 1 of this questionnaire.)

- a. Yes
- b. No

**(If you answered “Yes” please go to Question 10; if you answered “No” please go to Question 6.)**

Question 6 Is your company planning to use Lean Manufacturing Techniques in the future?

- a. Yes
- b. No

**(If you answered “Yes” please go to Question 8; if you answered “No” please go to Question 7.)**

Question 7 You answered “No” to Question 6. Please circle the reason for this answer from the following “a-d.” **(After answering Question 7, please go to Question 20.)**

- a. We don’t know much about Lean Manufacturing Techniques.
- b. We know about Lean Manufacturing Techniques but we don’t know how to use them.
- c. We think adopting Lean Manufacturing Techniques would not be worth the effort.
- d. Other reason(s) ( \_\_\_\_\_ )

Please use the back of this paper if more space is needed.

**(After answering Question 7, please go to Question 20.)**

**Appendix E** (page 4 of 9)

**The Questionnaire (English)** (continued)

Question 8 You answered “Yes” to Question 6. About when are you planning to start using Lean Manufacturing Techniques?

- a. Within half a year.
- b. After half a year to one year.
- c. After a year to one and a half years.
- d. After one and a half years to two years.
- e. Other. Please indicate approximate time if known; otherwise indicate “unknown” or “undecided.”

( \_\_\_\_\_ )

Question 9 Which Lean Manufacturing Techniques is your company planning to use in the **future**? From “a-k” below, please circle all that apply.

- a. 5S
- b. Visual controls
- c. Total productive maintenance (TPM)
- d. Standardization and best practice deployment
- e. Reduction of set-up time (SMED)
- f. Failsafe device
- g. Value-stream mapping
- h. Kanban system (Just-in-time manufacturing)
- i. Cellular workplace layout
- j. Kaizen blitz exercise
- k. Other (please specify: \_\_\_\_\_)

Please use the back of this paper if more space is needed.

**(After answering Question 9, please go to Question 20.)**

**Appendix E** (page 5 of 9)

**The Questionnaire (English)** (continued)

Question 10 You answered “Yes” to Question 5. When did your company start to use Lean Manufacturing Techniques? From “a-h” below, please circle the letter that applies.

- a. About half a year ago
- b. Between half a year and a year ago
- c. Between a year and one and a half years ago
- d. Between one and a half years and two years ago
- e. Between two and three years ago
- f. Between three and four years ago
- g. Between four and five years ago
- h. More than five years ago

Question 11 Which Lean Manufacturing Techniques is your company **currently** using? From “a-k” below, please circle all that apply.

- a. 5S
- b. Visual controls
- c. Total productive maintenance (TPM)
- d. Standardization and best practice deployment
- e. Reduction of set-up time (SMED)
- f. Failsafe device
- g. Value-stream mapping
- h. Kanban system (Just-in-time manufacturing)
- i. Cellular workplace layout
- j. Kaizen blitz exercise
- k. Other (please specify: \_\_\_\_\_)

Please use the back of this paper if more space is needed.

**Appendix E** (page 6 of 9)

**The Questionnaire (English)** (continued)

Question 12 Is your company planning to use any Lean Manufacturing Techniques other than the one(s) you marked under Question 11?

- a. Yes
- b. No

**(If you answered “Yes” please go to Question 14; if you answered “No” please go to Question 13.)**

Question 13 You answered “No” to Question 12. Please circle the reason for this answer from the following “a-d.” **(After answering Question 13, please go to Question 16.)**

- a. Because we don’t know much about the Lean Manufacturing Techniques that the company has not yet used.
- b. Because we think the other Lean Manufacturing Techniques are not suitable for this company.
- c. Because we don’t think we can expect enough returns by using any of the other Lean Manufacturing Techniques.
- d. Other reason(s) ( \_\_\_\_\_ )

Please use the back of this paper if more space is needed.

**(After answering Question 13, please go to Question 16.)**

Question 14 You answered “Yes” to Question 12. Which Lean Manufacturing Techniques is your company planning to use in the **future**? From “a-k” below, please circle all that apply.

- a. 5S
- b. Visual controls
- c. Total productive maintenance (TPM)
- d. Standardization and best practice deployment
- e. Reduction of set-up time (SMED)
- f. Failsafe device
- g. Value-stream mapping
- h. Kanban system (Just-in-time manufacturing)

**Appendix E** (page 7 of 9)

**The Questionnaire (English)** (continued)

- i. Cellular workplace layout
- j. Kaizen blitz exercise
- k. Other (please specify: \_\_\_\_\_ )

Please use the back of this paper if more space is needed.

Question 15 About when is your company planning to start using these other Lean Manufacturing Techniques from now?

- a. Within 6 months
- b. After 6 to 12 months
- c. After 12 to 18 months
- d. Please specify other time if it falls other than as above or specify “undecided” if it is not decided yet. ( \_\_\_\_\_ )

Question 16 What improvements have you gained by using Lean Manufacturing Techniques?

Example:

<b>Item of LMT</b>	<b>Improvement</b>
Failsafe device	Improvement in cycle time and a decrease in rework

Answer columns:

<b>Item of LMT</b>	<b>mprovement</b>

**Appendix E** (page 8 of 9)

**The Questionnaire (English)** (continued)

Question 17 Which Lean Manufacturing Techniques have helped (or are helping) you the most; that is, have saved (or are saving) you the most money, time, number of workers, etc.? From “a-k” below, please circle all that apply.

- a. 5S
- b. Visual controls
- c. Total productive maintenance (TPM)
- d. Standardization and best practice deployment
- e. Reduction of set-up time (SMED)
- f. Failsafe device
- g. Value-stream mapping
- h. Kanban system (Just-in-time manufacturing)
- i. Cellular workplace layout
- j. Kaizen blitz exercise
- k. Other (please specify: \_\_\_\_\_)

Please use the back of this paper if more space is needed.

Question 18 What were the biggest problems your company faced when trying to adopt Lean Manufacturing Techniques? From “a-d” below, please circle all that apply.

- a. The workers couldn’t see any merit in adopting Lean Manufacturing Techniques and had to be convinced.
- b. Couldn’t get enough support from outside to receive the resources necessary to adopt Lean Manufacturing Techniques.
- c. Integrating Lean Manufacturing Techniques into the old conventional production system.
- d. Other problems ( \_\_\_\_\_ )

Please use the back of this paper if more space is needed.

**Appendix E** (page 9 of 9)

**The Questionnaire (English)** (continued)

Question 19 Is there anything else you would like to tell me about your experiences related to adopting or using Lean Manufacturing Techniques. Please use the back of this paper if more space is needed.

Question 20 If you have any other comments please write them here. Please use the back of this paper if more space is needed.

Question 21 would you like a copy of the results of this survey?

- a. Yes
- b. No

You have completed this questionnaire. It would be appreciated if you could return this questionnaire in the envelope provided. Thank you very much for your cooperation.

Appendix F (page 1 of 4)

Examples of Improvements Gained Through the Use of LMTs

Lean Manufacturing Technique	No. of Examples	Percentage
5S	24	21.80%
Cellular workplace layout	10	9.10%
Failsafe device	12	10.90%
<i>Kaizen</i> blitz exercise	12	10.90%
<i>Kanban</i> system (Just-in-time manufacturing)	9	8.20%
Standardization and best practice deployment	8	7.30%
Reduction of set-up time (SMED)	14	12.70%
Total productive maintenance (TPM)	10	9.10%
Value-stream mapping	1	0.90%
Visual controls	10	9.10%
In general		
Performance management		
Clarify*		
Evaluation*		
Training workers*		

\* True LMT?

Note: My annotations are in italics.

	<b>5S</b>
1	Time to do work shortened and decrease in modifications ( <i>rework?</i> ).
2	Has promoted factory cleanup, discipline, and working improvements.
3	Cleanly-consciousness improved.
4	Hygiene improved ( <i>cleaner workplace?</i> ).
5	Defective products decreased, efficiency improved.
6	Helps us distinguish good product from half-finished/defective product (?).
7	Finding and making improvements regarding unnecessary work/material. Cost reduced.
8	Employees' consciousness ( <i>of use of quality methods?</i> ) improved, ( <i>also</i> ) quality, working time ( <i>shortened?</i> ), and environment improved.
9	Has improved morale.
10	Production efficiency improved.
11	Cleaning time was reduced.
12	Efficiency improved, more effective use of space, problems have become clearer.
13	With 5S for our machines and floor, our troubles have decreased and safety has improved.
14	Labor accidents reduced.
15	Factory has become clean.
16	Tool reduction ( <i>maybe reduction in number of tools needed since now have good accountability</i> ).
17	Better arrangement of things in the factory.
18	Working process shortened, bad "system" reduced (?).
19	Able to reject ( <i>get rid of?</i> ) what is unnecessary, more effective use of space.
20	We were successful in finding where the dirt comes from.
21	Troubles (injuries, etc.) reduced.
22	Quality improved (with cleanliness).
23	Were able to throw out useless stock.
24	Has resulted in a reduction in defective product. Problems have become clearer.

**Appendix F** (page 2 of 4)

**Examples of Improvements Gained Through the Use of LMTs** (continued)

	<b>Cellular workplace layout</b>
1	Productivity improved.
2	Were able to remove a four-stage conveyor system ( <i>replacing it with something more efficient?</i> ).
3	The efficiency of making many kinds of products improved.
4	We ( <i>seek a?</i> ) higher goal of ( <i>production?</i> ) numbers each day.
5	Stock reduction, motivation improved, can react ( <i>better?</i> ) to changing demand, quality improved.
6	Working time reduced by attention to "critical path" ( <i>my guess</i> ).
7	We train our people in a way to develop their multiple abilities.
8	The number of defective products decreased.
9	Has improved the efficient use of our space.
10	Stock reduced, lead-time shortened.

	<b>Failsafe device</b>
1	Has resulted in a reduction in defective product.
2	Working process ( <i>time?</i> ) decreased, quality improved.
3	Defective products decreased.
4	We could reduce errors and defective products.
5	We make a "repairing" tool ( <i>perhaps a device to ensure alignment</i> ) and ( <i>use?</i> ) visual management ( <i>techniques?</i> ).
6	Failsafe device is essential and we have introduced it completely.
7	Let's us prevent defective product from reaching the market.
8	Has improved their "step-stopping" process ( <i>maybe a process for preventing defects</i> ).
9	Has resulted in a reduction in having to start all over again ( <i>sounds significant</i> ).
10	Injuries reduced, quality improved.
11	Complaints decreased.
12	Our checking system became efficient (e.g., the place we put the CCD camera [?]).

	<b>Kaizen blitz exercise</b>
1	Have gotten improvement proposals from the workers.
2	Defective products decreased, machine errors decreased.
3	We have an "encouraging system" ( <i>to have our people do good kaizen blitzes?</i> ).
4	Employees' consciousness ( <i>of use of quality methods?</i> ) improved.
5	Working process ( <i>time?</i> ) decreased, quality improved. workers' spirits lifted.
6	Workers' spirits lifted ( <i>morale improved?</i> ).
7	Has resulted in improvements in quality and productivity.
8	Has resulted in cost reductions and improvement in employees' work (with annual recognition of this improvement).
9	Quality and efficiency improved.
10	Big improvement in results by ( <i>use of</i> ) QC circle ( <i>maybe not really KBE</i> ).
11	Defective products and machine errors decreased.
12	Efficiency improved, personnel costs cut.

Appendix F (page 3 of 4)

Examples of Improvements Gained Through the Use of LMTs (continued)

<b>Kanban system (Just-in-time manufacturing)</b>	
1	Tool loss and defective products decreased.
2	Freshness improved ( <i>food company</i> ), losses decreased, and defective production became zero.
3	Stock reduction and space required reduced.
4	Has resulted in reduced stocks ( <i>inventory?</i> ).
5	Stock reduced.
6	Stock reduced and now know where all our stock is.
7	Number of defective products decreased.
8	Has helped us develop a close relationship with our customers ( <i>and suppliers?</i> ).
9	Stock reduced.

<b>Standardization and best practice deployment</b>	
1	Personnel ( <i>required?</i> ) reduced, efficiency improved, working method improved.
2	Production time shortened.
3	Defective products decreased, efficiency improved, development time ( <i>for new products?</i> ) shortened.
4	Has helped us improve and maintain our quality system based on the ISO standard.
5	Working process ( <i>time?</i> ) decreased, quality improved.
6	Production efficiency improved.
7	Dissolving time shortened ( <i>maybe this relates to the production of aluminum alloy</i> ).
8	Cleaning time was reduced.

<b>Reduction of set-up time (SMED)</b>	
1	We are challenged ( <i>using SMED?</i> ) to make our set-up time simpler, faster, easier ( <i>loosely translated</i> ).
2	Aiming for "single" time ( <i>one minute?</i> ), we prepare whatever we can outside the line.
3	Stock reduction, efficiency improved.
4	Working process ( <i>time?</i> ) decreased, quality improved.
5	Machine efficiency improved.
6	Better, more effective production planning.
7	Production time reduced, better able to meet appointed date of delivery.
8	Processing time cut in half.
9	Costs reduced.
10	Caused us to review our working process ( <i>improvement?</i> ).
11	Production increased.
12	Efficiency improved.
13	Productivity improved.
14	( <i>Able to better handle</i> ) small lots, reserve force ( <i>inventory?</i> ) improved ( <i>reduced?</i> ), standardization of works ( <i>operations?</i> ).

**Appendix F** (page 4 of 4)

**Examples of Improvements Gained Through the Use of LMTs** (continued)

	<b>Total productive maintenance (TPM)</b>
1	Efficiency improved, safety consciousness elevated, modification (?) costs reduced, etc.
2	Trouble ( <i>down?</i> ) time decreased.
3	Machine troubles decreased.
4	We use ISO 9001 and regular checks to keep a measure of our accuracy ( <i>of TPM?</i> ) ( <i>improvement?</i> ).
5	Has improved the activity in each department ( <i>I wonder how?</i> ).
6	Defective products decreased.
7	Checking process ( <i>time?</i> ) reduced, quality improved.
8	Not T (total), only PM ( <i>preventive maintenance</i> ) ( <i>interesting comment—but may still qualify as a start on TPM</i> ).
9	Has resulted in a reduction in machine troubles and improved productivity.
10	Our ( <i>machine?</i> ) troubles became zero.

	<b>Value-stream mapping</b>
1	Efficiency improved, standard times became shorter.

	<b>Visual controls</b>
1	Mistakes decreased.
2	Efficiency improved, quality improved, stock reduction.
3	Helps us distinguish copyright goods ( <i>?—a printing company</i> ) and makes the whereabouts of tools clear.
4	Mistakes reduced, skills improved.
5	Working time shortened, mistakes decreased, safety improved.
6	Our business ( <i>operation?</i> ) became more active and more efficient.
7	Production efficiency improved.
8	Tool loss reduced.
9	Have made it easier to put things on and off in manufacturing process ( <i>best guess</i> ).
10	Safety improved, more effective use of space, efficiency improved.

	<b>In general and "other"</b>
In general	Factory sorted and set in order ( <i>thanks to 5S?</i> ), management has become easier, people more "active" ( <i>productive, better motivated?</i> ), and profits have improved.
Performance management	Efficiency improved, better compliance with rules, reserve force ( <i>inventory?</i> ) improved ( <i>reduced?</i> ).
Clarify*	We can make problems clearer.
Evaluation*	We can see what is wrong.
Training workers*	Workers show great enterprise when working.

\* Although listed here, these three don't really fit the usual concept of a LMT.

## Appendix G

### Comments By Those Adopting and Using LMTs on This Experience

Note: My annotations are italicized.

1	(1) We determine our present condition and set a goal of making a 30% improvement in six months. (2) We have a full-time improvement person. (3) We discuss how we're doing at a meeting held once a month. By repeating ( <i>doing</i> ) these three things we've stepped up ( <i>improved</i> ).
2	No matter what the condition is ( <i>difficult or not?</i> ), I think it is important to continue steady training and practice ( <i>good comment</i> ).
3	We also make much of training.
4	As I think can be said of everything, the key is to take the initiative and with patience thoroughly see the effort through to completion ( <i>good comment</i> ).
5	We started with 5S but keeping it is not so easy because: (1) we have lots of different parts because we accept a lot of individual orders and (2) our production quantities change very much each month as do our personnel so it is difficult to keep everything in order. Measures ( <i>of how well we're doing?</i> ): (1) how well we standardize our parts and (2) how well we subdivide groups ( <i>make teams?</i> ) and improve workers' responsibility.
6	We shouldn't introduce JIT until the stream from order acceptance to shipment is smooth. To do so before this would cause troubles (?) and waste labor. And when we introduce it executives (?) will need patience and "practical power" ( <i>a good understand of the LMT?</i> ).
7	It's difficult to make sure ( <i>the workers?</i> ) obey the rules ( <i>for doing LMTs?</i> ). The difficulty of being taken over as DNA (??). It's difficult to make the problems clear (= <i>just what are the problems??</i> ). <i>What is DNA here?</i>
8	(1) The will to "do it" is important, (2) we should ( <i>always?</i> ) consider our relationship with those with whom we're connected ( <i>suppliers, customers, etc.?</i> ), (3) it is more effective and easier to promote and introduce LMT when production is on the increase ( <i>maybe when morale is high</i> ), and (4) we need an outside "instructor" ( <i>consultant?</i> ).
9	It is essential to use LMTs perfectly to achieve the aim of LMTs.
10	The products we produce continue to progress ( <i>change?</i> ) and the requirements imposed on the producer (e.g., quality, quantity, delivery times, and costs) are becoming severer. To satisfy these requirements we need to develop the "contents" of LMTs. Introducing LMTs isn't a goal, we have to continue improving them or they will become "outdated" ( <i>my word</i> ) and we will be left behind. On the other hand, I ( <i>also?</i> ) feel strongly that SE ( <i>systems engineering?</i> ) activity is very important. (SE is [ <i>I am not sure of translation here</i> ] changing the product's design to improve it and make it easier to produce. <i>I think these are some good comments</i> ).
11	We don't use the term "Lean Manufacturing Techniques," we use the name for each item. In addition to TPM, 5S, and <i>kaizen</i> blitz exercise, we do QC activity to improve our quality.
12	Based on an Improvement Proposal System, we introduced 5S, standardization and best practice deployment, and failsafe device. The have affected us well.
13	We have a "check" meeting and achievement report once a week or month to sustain our improvement activity. And, in line with that, we use brainstorming as part of this effort.
14	I think LMTs are not things we are told but that which we learn by ourselves. We can improve everything by practice, wisdom, and knowledge.
15	We manage by measurement. Administrators' mgt skills ( <i>have?</i> ) improved. Workers' morale and eagerness decline with too much pursuit of efficiency. Some people misunderstand that( <i>too much?</i> ) efficiency pursuit can ( <i>actually?</i> ) cause a decline in quality and many troubles. <i>He may be saying you can't change things too fast.</i>
16	I think the most important thing is if we can develop the workers' drive and understanding ( <i>good comment!</i> ). So we continue <i>kaizen</i> blitz activities and use outside consultants.

Appendix H (page 1 of 2)

Open-Ended Comments By Any Respondent (Whether They Use LMTs or Not)

Note: My annotations are in italics.

Type of Business	Using LMTs?	Position of Person Making Comment	No.	Comment
color filters (put on liquid crystal display for color)	No	Manufacturing Techniques Mgr	1	I've heard of LMTs but our company has not authorized or promoted them yet. But I think we have need of them.
1. ( <i>mainly</i> ) automobile parts (console boxes, spoilers, wiring harnesses, etc.), 2. motor scooter parts (wiring harnesses, cords, etc.)	Yes	Production Managing Dept SPS* Manager	2	We don't use the word "LMT," but we do the same kind of activity ("improve activity" or "efficiency improvement activity").
planning, designing, and production of commercial printing	Yes	President	3	I'm happy if my answers will help your study ( <i>how nice!</i> ). Our company is composed of five firms so I answered this questionnaire for the entire group.
sake	Yes	Production Mgr	4	5S, TPM, etc. are discussed as ( <i>separate?</i> ) manufacturing techniques but "Toyota Manufacturing Techniques" is a system which synthesizes these techniques. So we can't really talk about adopting or not adopting with respect to each LMT. The ( <i>real?</i> ) power in the field of production is the power ( <i>ability?</i> ) to synthesize. From that point of view, our company has 1/100 the power of Toyota.
automobile parts	Yes	President	5	<i>Kanban (kaizen?) blitz exercise and "just-in-time" are not equal. "Just-in-time" is one step before Kanban (?) blitz exercise. "Just-in-time" is (the most?) important (thing?) and main point. Kanban is just a means which is effective only when "just-in-time" is done. Comment: I wonder if he means "kanban" when he says "kanban blitz exercise"? I think his point: Kanban is a way for implementing JIT.</i>
pachinko and slot machine parts and modules	Yes	Production Dept Mgr	6	This is a good questionnaire, easy to answer. But not enough to grasp the real situation. I wonder how persuasive its ( <i>data will be</i> ) when you make a report from it. I think you need to do some fact-finding on the spot. <i>Very good comment.</i>

\*SPS is a section that promotes improvement activity.

Appendix H (page 2 of 2)

Open-Ended Comments By Any Respondent (Whether They Use LMTs or Not)  
(continued)

Type of Business	Using LMTs?	Position of Person Making Comment	No.	Comment
pachinko machines	No	Production Dept Vice-Mgr	7	I didn't know the term "Lean Manufacturing Techniques" but its contents have been widely accepted for a long time. All manufacturers make an effort to do those things more or less. The difference is whether they use the term "LMT" or not.
colza oil, corn oil, lecithin	No	Project Mgt Dept Mgr	8	We got ( <i>need?</i> ) a chance to study LMTs and cellular workplace layout.
automobile seat covers	No	General Mgr	9	Our company exploits (uses) the Toyota manufacturing system ( <i>but that's what LMTs essentially are - ??</i> ).
coffee, syrup	No	General Affairs Dept Section Chief	10	I don't know about LMTs in detail but we have introduced 5S, visual controls, TPM, and standardization. <i>Comment: Yet this person marked questionnaire as not using LMTs.</i>
portable car navigation systems, machine ( <i>components?</i> ) used for car navigation systems	Yes	President	11	Rather than worry about "difficult" theory, we make the most of what is practically useful to survive ( <i>interesting comment</i> ).
dairy products (milk, ice cream, [ <i>other?</i> ] beverages, yoghurt)	Yes	Business Mgr	12	Our company doesn't make automobile parts or something like that. But we always ( <i>have?</i> ) introduced 5S and VC ( <i>and others? [because others were marked on the questionnaire]</i> ) as a food maker. Now we practice HACCP mainly. I don't know well about LMT but we ( <i>have?</i> ) introduced 5S, VC and ( <i>?SP</i> ).
refrigerator, container, and multipurpose ships; repairs small ships	No	Engineering mgr	13	I'm sorry I don't know about LMT well but I have thought about introducing it partially before. I want to know more about it.
makes(?) and assembles parts for engines for two- and four-wheel vehicles	No	Chief, Mgt Dept Planning Section	14	Our company employs many seriously disabled people. Therefore, it is not so easy to introduce general theory ( <i>not clear why not?</i> ). Can we use these techniques?

## Appendix I (page 1 of 2)

### Thanks

I wish to acknowledge the support I received on this sabbatical project by many people both at Sophia University (Tokyo), where the Institute of Comparative Culture (ICC) hosted me, and Hiroshima Shudo University, my university.

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Robert B. Austenfeld, Jr.: A Study of the Use of Lean Manufacturing Techniques By  
Japanese Small and Medium Enterprises

**Appendix I** (page 2 of 2)

**Thanks** (continued)

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Robert B. Austenfeld, Jr.

February 15, 2005