

Lean Manufacturing in Small- and Medium- Sized Printers

By
Sandra Rothenberg, Ph.D.
Professor, College of Business

Frank Cost
Associate Dean,
College of Imaging Arts and Sciences
Rochester Institute of Technology

A Research Monograph of the
Printing Industry Center at RIT

December 2004

No. PICRM-2004-04

Lean Manufacturing in Small- and Medium-Sized Printers

By
Sandra Rothenberg, Ph.D.
Professor, College of Business

Frank Cost
Associate Dean,
College of Imaging Arts and Sciences

Rochester Institute of Technology



A Research Monograph of the
Printing Industry Center at RIT
Rochester, NY
December 2004

With Thanks

The research agenda of the Printing Industry Center at RIT and the publication of research findings are supported by the following organizations:



creo

RR DONNELLEY

HEIDELBERG



MeadWestvaco

NEXPRESS
A Kodak Company



Standard Register



Weyerhaeuser

THE DOCUMENT COMPANY
XEROX

Table of Contents

Abstract.....	2
Introduction.....	3
Lean Production and SMEs.....	3
What is Lean?.....	3
Lean and SMEs	4
Lean in the Printing Industry.....	4
Methods.....	5
Findings	7
Discussion and Conclusions.....	9
References	11

Abstract

Large manufacturing organizations have been achieving productivity improvements for decades using what is commonly known as lean production. Less is known about the extent to which small- and medium-sized firms (SMEs) have also benefited from the adoption of lean practices. The purpose of this paper is to investigate how small and large printers differ in their adoption of lean management practices. We find that while both small and large printers view lean production as an important contributor to future profits, small- and medium-sized printers are lagging in their adoption of a range of lean practices. In addition, we found that smaller printers used significantly fewer printing units, while producing a significantly higher range of print products. We argue that this operational configuration may place some smaller printers at a particular disadvantage when it comes to implementing lean systems. We discuss how small printers may wish to approach lean production given these operational constraints.

Introduction

Many printers, especially smaller printers, are struggling to reconcile two critical needs that are equally important to their long-term prosperity, but that often work against one another. They must offer their customers continuously improving and innovative services, while simultaneously improving the efficiencies of the underlying manufacturing operations. Within the printing industry, small firms are moving quickly to the adoption of service-based business models. Less is known, however, regarding how they compare to larger printers in terms of making advances in the area of productivity improvement.

Large manufacturing organizations have been achieving productivity improvements for decades using what is most commonly known as lean production. Through the adoption of lean practices they have been able to reduce waste, reduce inventories, improve quality, and reduce lead times. These improvements have been substantial. Some firms have enjoyed up to 90% reduction in inventory investment, 75% reduction in rework, and 90% reduction in manufacturing lead times (Ettkin, Raiszadehn, & Hunt, 1990). Given the potential advantages of lean production, the purpose of this paper is to investigate how small and large printers differ in their adoption of lean management practices. We will look at this question in the context of the printing industry, in which approximately 95% of firms have fewer than 100 employees (Romano & Soom, 2003).

We first offer an overview of lean production, lean practices in small- and medium-sized firms (SMEs), and the unique aspects of the printing industry that may influence the adoption and execution of lean production. Next, we review our survey methodology and discuss our survey findings. Finally, we discuss the implications of

our findings for management and offer some suggestions as to how small printers might follow a path to lean production suited to their unique constraints.

LEAN PRODUCTION AND SMEs

What is Lean?

There are multiple ways to operationalize the concept of lean production. Often, lean is thought of primarily as a way to reduce buffers. In this paper, however, we will be using a more multifaceted approach to operationalizing lean production. As discussed by MacDuffie (1995), the success of lean manufacturing stems from a combination of practices, policies, and philosophies – a combination that can be divided into three primary areas: buffer minimization, work systems, and human resource management. Research suggests that all three of these factors are important to the continuous improvement of performance at lean plants (Rothenberg, Pil & Maxwell, 1999; Ichniowski & Shaw, 1995; MacDuffie, 1995; Pil & MacDuffie, 1996).

The first element of lean production is the focus on what is most commonly thought of as “just-in-time” management. Lean production utilizes a specific set of factory practices that facilitate small lot production with minimal buffers and a corresponding rapid feedback process when there are problems. As such, lean facilities typically have very small end-of-process rework areas compared to non-lean plants. Workers “pull” materials and components throughout the production system. Material is delivered just-in-time, minimizing work in process, reducing the likelihood of large batches of faulty materials, and reducing in-process waste (Cusumano, 1985).

A firm's relationship with its suppliers is a critical part of this operational aspect of lean management systems (Stamm & Golhar, 1991; Helper, 1995). Lean manufacturers are abandoning sourcing based only on cost and instead look for longer-term contracts and building closer relationships with suppliers (Helper, 1995). These closer relationships contribute to the just-in-time aspect of lean production. They may also lead to decreased acquisition costs and increased labor productivity (Helper, 1995).

The second element of lean production is the work practices that support the fragile manufacturing system just described. In the lean model, work is based on the principle of continuous improvement, or "kaizen." Workers are responsible for identifying and analyzing quality problems found on the production line. To do this, workers are organized in teams to enhance multi-skilling. Workers also undergo training and job rotation. This is particularly important since assembly workers are given many of the responsibilities that would be assigned to specialists in mass production. Improvement suggestions are offered through a suggestion system or Quality Circles.

Human resource policies are the third component of lean production. In lean production, worker commitment, skill, and motivation are critical to operational success. Some of the means used to ensure this include highly restrictive worker selection emphasizing aptitude and ability to work in a cooperative fashion with others, compensation linked to performance, and efforts to reduce status barriers between managers and workers (Pil & MacDuffie, 1999).

Lean and SMEs

There is some evidence that smaller firms have adopted and benefited from some lean management practices. Ettkin et al. (1990) found in a survey of small manufacturers that approximately one third of the respondents indicated that they had lean-type management programs. The most common aspect of lean being adopted was employee involvement programs. Ettkin et al. also found, however, that most small firms did not actually understand what lean manage-

ment was, and that while they claimed that they were lean, they often did not adopt some of the major components of a lean management system. There are a number of reasons for lack of SME adoption of lean practices. Researchers have pointed to such factors as lack of top management commitment, limited financial resources, investment in specialized equipment, and a lack of perception that lean production is a simpler form of manufacturing control (Bowen & Inman, 1993).

Research also suggests that there are a large number of benefits that SMEs can attain from adopting lean practices. Stamm and Golhar (1990) found that small firms are able to achieve many of the benefits of lean that are enjoyed by larger firms. Benefits include smaller inventories, improved quality, shorter lead times, reduced waste and lower costs. In fact, some research suggests that SMEs may actually have more immediate success in starting lean manufacturing practices than larger firms. Smaller firms are often more flexible, have a greater amount of general purpose equipment, have a greater number of multifunctional workers, and have a management staff that is closer to operations and production (Winston & Heiko, 1990; Brown & Inman, 1993). All of these qualities can contribute to a lean system. Others argue, however, that SMEs are at a comparative disadvantage when adopting lean practices; they simply do not have the resources and the special knowledge needed to launch and sustain a lean manufacturing program.

Lean in the Printing Industry

In the printing industry, as products become more commoditized, firms are focusing to a much greater extent on the role of service. Unfortunately, the manufacturing operations of these firms often reflect a service-at-all-costs philosophy, even at the expense of increased productivity (Cost & Daly, 2003). In fact, lean printing shops are still not common in the printing industry (Faust, 2003). Instead, it is more common to find printing factories organized with large buffers in front of and behind all of the major manufacturing operations (Cost & Daly, 2003). The workforce is conditioned to respond to quick changes in the production schedule that reflect the frequent

need to expedite work for customers who have come to rely on the company to make up for shortfalls due to their own poor planning processes. The scheduling board shows a lot of back-and-forth movement over time as jobs jockey for position in the queues. A lot of effort is expended in the plant rearranging queues of work in progress. The values of inventories relative to sales volumes in the plant have been rising slowly (Cost & Daly, 2003).

More and more, however, printers are realizing that if their companies place the prime emphasis on service and neglect to take a disciplined approach to improving manufacturing efficiencies, their businesses will not be sustainable long term. As a result, some printers have embarked on a lean manufacturing program intended to systematically improve the efficiencies of manufacturing operations (Cost & Daly, 2003). The relative magnitude of potential benefits from the application of lean manufacturing practices depends on the exact nature of each printer's products and market. The printing industry is highly fragmented and diverse (Romano, 2003). Companies range in size from sole proprietorships to large multinational corporations employing tens of thousands of people. Companies also range in geographic reach from those strictly serving local markets to those with global customer bases. Companies throughout this spectrum also vary in the diversity of products and services offered. In particular, companies offering a greater diversity of products and services present more complexity to the implementation effort. Thus the cost of implementation increases.

Large companies serving global markets with low product diversity stand to see the highest return from a lean manufacturing program. This is because the relative simplicity of the manufacturing process yields relatively simple manufacturing value streams. Given the advantages of lower product diversity, small companies serving local or global markets with highly focused products and services are also good candidates for lean programs. For example, companies manufacturing uniform products such as labels or packages for specific markets often employ a single linear workflow in the factory. It is relatively easy to create the value stream map for these kinds of operations.

The small improvements in efficiency can easily justify the efforts to implement lean.

Within the printing industry, however, these types of specialized small firms are more the exception than the norm. Most small companies serving local markets offer a high diversity of products and services, and as a result stand to benefit least from formalized application of lean manufacturing disciplines. These companies must operate as custom service providers for customers willing to pay for creative effort and innovative thinking in order to be profitable. The effort required to implement formal lean manufacturing programs may not be justified because each new job would require its own individual value stream analysis. The cost of doing this analysis may not be recovered on a per-job basis.

METHODS

Data for this study come from a survey panel of 565 printers who volunteered to participate in a series of on-line surveys administered by a university based printing research center. The panel was created by inviting a sample of 10,500 printers and packagers—selected from the Dunn and Bradstreet database—to participate in a survey program. The sample was chosen to represent a random sample of printing technologies and a variety of firm sizes. Participants were offered incentives, such as early access to results, written material, and a free on-line class. Out of the 565 plants in the panel, 103 printing plants participated in this particular survey. This 18% response rate is somewhat low, given that firms had already agreed to participate in the survey effort. On the other hand, the population has a greater number of smaller firms than many other industries. In addition, the survey was administered during a period of great economic uncertainty and turbulence. Therefore, with potential issues of response bias in mind, we felt that this was an acceptable response rate.

Survey respondents replied to the survey via the Internet, through a survey designed with SPSS Data Entry Builder software. The advantage of this method was that data was entered directly into an SPSS database, avoiding data entry error by the researcher (but not by the respondent).

Introduction

The survey questions discussed in this paper were created with input from several printers.

For this analysis, firms were separated into two groups, those with less than 100 employees and those with 100 or more employees. This number was chosen because the Small Business Administration defines a small business as one

employing fewer than 100 or 500 employees (Brown & Inman, 1993). Because of the large number of small firms in the printing industry, we chose the former number as the defining point for a small firm. The study included some exploratory analysis, and a series of T-tests to compare responses between the groups of small firms versus those of larger firms.

Findings

Overall, there were no significant differences among smaller and larger firms regarding the types of printing technology used (i.e., screen, digital, etc). Larger firms tended to use a significantly greater number of printing units and a larger variety of printing technologies. There were some differences in the types of products produced and customers served. As may be expected, small firms tended to engage in more quick printing than larger firms. Perhaps more important, although they owned a lower variety of printing units, small firms provided a significantly larger range of products to their customers. As discussed above, this suggests that small printers will face greater challenges capturing the benefits of lean production.

Both small and large firms reported that there were opportunities for improved efficiencies throughout the printing process. On average, there was a slightly larger opportunity in the pre-press area. There were no significant differences, however, across firm size. There were also few significant differences across firm size regarding how different activities had contributed to increased productivity over the past three years. The exception to this was waste reduction, an integral part of lean production. Larger firms were significantly more likely to have found productivity improvements through waste reduction than firms with less than 100 employees.

With regard to lean production in particular, there was no difference in how firms reported their own knowledge of lean production and the high importance they gave to lean practices to the future profitability of their firm. In terms of actual practices, however, smaller firms reported to be undertaking lean practices to a lesser extent than larger firms. One of the areas we were interested in was the degree to which plants monitored key measures of waste in the

printing process. As can be seen in Table 1, for all indicators, large firms tended to measure process waste more often than smaller firms. This difference was statistically significant for all of the indicators but paper waste.

Also critical in the lean process is the degree to which employees are trained to use process data in order to identify and solve process inefficiencies. Again, as seen in Table 2, we found that larger firms tended to train more of their employees on common lean analytic techniques like statistical process control, quality assurance, and root-cause analysis. This is consistent with the findings of Dreyfus, Gulbro, and Shonesy (1999), who reported that employees in larger firms received more structured quality training.

	Paper Waste	Ink Waste**	Press Productivity**	Value of Inventory**
Employees ≥ 100	3.96	2.94	3.76	2.07
Employees <100	3.43	2.13	3.26	2.30

* Scale of 1 = never, 2 = monthly, 3 = weekly, 4 = daily, 5 = per job

** Indicates a significant difference in means.

Table 1. Measurement of Waste Indicators*

	Statistical Process Control**	Quality Assurance**	Root-Cause Analysis or Similar**
Employees ≥ 100	1.94	2.48	2.08
Employees <100	1.51	2.09	1.53

* Scale of 1 = none, 2 = some, 3 = most, 4 = all

** Indicates a significant difference in means.

Table 2. Training of Employees on Common Lean Practices*

Findings

As discussed earlier, the just-in-time aspect of the lean system is highly reliant on how firms relate to their suppliers. Lean firms are more likely to have long-term relationships with their suppliers; suppliers are not just picked based on cost, but on flexibility, trust, and their ability to provide not just the product, but the service needed for efficient use of their product (Helper, 1995). In addition, in order to facilitate just-in-time operation, location can also be a criteria for selecting suppliers. In our

survey, there were similarities and differences across firm size with regard to how firms chose their suppliers. For more basic criteria, such as cost and quality, there was no difference across firm size. Large firms, however, were more likely to use criteria typical of lean firms, such as trust, flexibility location, and service, for choosing a supplier. As can be seen in Table 3, these differences were significant for all variables except service.

	Trust**	Flexibility**	Location**	Service
Employees ≥ 100	4.84	4.40	3.60	4.40
Employees <100	4.58	4.10	3.18	4.21

* Scale of 1-5 with 1 = not important and 5 = very important

** Indicates a significant difference in means.

Table 3. Criteria for Choosing Suppliers*

Discussion and Conclusions

In this paper we looked at the extent to which small and large printers differed in their adoption of a variety of lean management practices. We found that both large and small firms saw the potential advantages of lean production, and thought that it could contribute to the future profitability of their firm. For most measures, however, small firms were still lagging in the implementation of lean practices. First, small firms were less likely to have reported waste reduction as having contributed to recent increases in productivity. Second, small firms measured common waste indicators less often than larger firms. Third, smaller firms trained fewer employees in critical lean analysis tools. Lastly, smaller firms were less likely to use criteria common for lean firms (trust, flexibility location, and service) when choosing a supplier.

There are a number of limitations of this study. First, the data is self-reported. Second, the study focuses on one industry. As we point out, this industry is unique in its demographics, product, and market environment. Third, the survey was limited in the range of lean practices investigated. Therefore, future research is clearly needed. While small firms are a large contributor to the national economy, still relatively little is known regarding their success in achieving productivity improvements and adopting state-of-the-art manufacturing practices. There is a great deal of room to collect a wider range of survey and performance data in future research.

Despite these study limitations, there are some lessons to be drawn from this study. The survey clearly indicated that although trailing in the adoption of lean practices, smaller firms saw the importance of lean manufacturing to their future success, and were interested in adopting lean systems. Prior research also suggests that there are benefits for most small

firms from adopting lean management practices. Therefore, small firms stand to benefit immensely from a working knowledge of how these lean manufacturing practices can be put to work in a print-manufacturing context.

Small firms face challenges in obtaining this working knowledge. As in other industries, small- and medium-sized printers are less likely to have the special knowledge and resource base needed to launch and sustain lean efforts that will eventually yield results. In addition, the exact nature of the printing industry may place some SMEs at a particular disadvantage when it comes to implementing lean systems. We found that small- and medium-sized printers tended to offer a greater diversity of products and services with more generalized manufacturing facilities. Therefore, there are some challenges particular to small firms trying to survive in the printing industry.

Given these challenges, it is likely that the path small printers take to lean will not mimic the path of their larger counterparts. Given their operational and resource limitations, it is likely that these companies will need to take a less encompassing approach to improving productivity, undertaking those aspects of lean management that are likely to provide the greatest return.

As an example, some companies with high product diversity and modest volumes have succeeded in applying lean ideas by using a concept called “configuring” (Parr, 2003). In configuring, firms structure their products and the way they are presented to the market to create better flow. The result is that the firm can use lean “pull” (or kan ban) methods for specific segments of their business. In another example, Manoochchri (1988) argues that due to the relatively weaker bargaining power

Discussion and Conclusions

of small firms with their suppliers, they may chose to start their engagement with lean by actually buffering themselves from the outside world with larger inventories and focus on process waste reduction. This more incremental approach to lean production is also likely to lead to “quick wins,” which will encourage small firms to move forward with additional lean initiatives.

The focus of lean efforts at small firms, however, should not just include operational changes, such as the implementation of kan ban or value-stream mapping for waste reduction. As

discussed earlier, prior research suggests that human resource practices, work practices, and supplier relations are just as critical to lean production as the operational aspects, and in fact support the flexible and somewhat fragile lean operations. Our research suggests that SMEs are lagging in the adoption of some of these practices, such as employee training and the adoption of a broader range of criteria for supplier selection. Unlike other aspects of lean, these practices may not lead to an immediate payback. They are likely, however, to increase the long-term sustainability of the firm by increasing its flexibility and long-term productivity.

References

- Brown, K., & Inman, A. R. (1993). Small business and JIT: A Managerial Overview. *International Journal of Operations and Production Management*, 13(3), 57- 66.
- Cost, F., & Daly, B. (2003). *Digital integration and lean manufacturing practices of U.S. printing firms* (Research Monograph No. PICRM-2003-09). Rochester, NY: Rochester Institute of Technology, Printing Industry Center.
- Cusumano, M. (1985). *The Japanese automobile industry: Technology & management at Nissan & Toyota*. Cambridge, MA: Council of East Asia Studies.
- Dreyfus, P., Gulbro, R. D., & Shonesy, L. (1999). Quality in manufacturing: Does firm size matter? *Journal of Business & Entrepreneurship*, 11(1), 75-84.
- Ertkin, L. P., Raiszadehn, F. M. E., & Hunt, H. R. (1990). Just-in-time: A timely opportunity for small manufacturers. *Industrial Management*, 32(1), 16-18.
- Faust, C. (2003, April 1). Think lean. *Paper, Film & Foil Converter*. Retrieved from http://advertisers.pffc-online.com/ar/paper_think_lean/
- Helper, S. (1995). Supplier relations in Japan and the United States: Are they converging? *Sloan Management Review*, 36(3), 77-84.
- Ichniowski, C., & Shaw, K. (1995). Old dogs and new tricks: Determinants of the adoption of productivity-enhancing work practices. *Brookings Papers on Economic Activity: 1995 Special Issue on Microeconomics*, 1-65.
- MacDuffie, J. P. (1995). Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry. *Industrial and Labor Relations Review*, 48(2),197.
- Manoochehri, G. H. (1988). JIT for small manufacturers. *Journal of Small Business Management*, 26(4), 22-30.
- Par, B. (2003). Can lean be successfully applied in a high mix operation? *TheManufacturer.com*. Retrieved from http://www.themanufacturer.com/us/detail.html?contents_id=1198
- Pil, F. K., & MacDuffie, J. P. (1996). The adoption of high-involvement work practices. *Industrial Relations*, 35(3), 423-455.
- Pil, F. K., & MacDuffie, J. P. (1999). What makes transplants thrive: Managing the transfer of best practice at Japanese auto plants in North America. *Journal of World Business*, 34(4), 372-393.

References

- Romano, F., & Soom, M. (2003). *An investigation into printing industry demographics* (Research Monograph No. PICRM-2003-01). Rochester, NY: Rochester Institute of Technology, Printing Industry Center.
- Rothenberg, S., Pil, F., & Maxwell, J. (2001). Lean, green and the quest for superior performance. *Journal of Production and Operations Management*, 10(3), 2001.
- Stamm, C., & Golhar, D. (1990). Can small manufacturing firms successfully implement JIT? *Proceedings of the Annual Conference of the Decision Science Institute*, 1655-7.
- Stamm, C., & Golhar, D. (1991). Customer and supplier linkages for small JIT manufacturing firms. *Journal of Small Business Management*, 29(3), 43-49.
- Winston, R., & Heiko, L. (1990). Just-in-time and small business evolution. *Entrepreneurship Theory and Practice*, 14(4), 50-64.



Rochester Institute of Technology
College of Imaging Arts and Sciences
55 Lomb Memorial Drive
Rochester, NY 14623
Phone: (585) 475-2733
<http://print.rit.edu>