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Lean Production and the Internet

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In this paper the implications for lean production systems of the Internet are explored. Does the World Wide Web facilitate the implementation of Just-in-Time production systems, or alternatively, can it serve as a substitute for JIT? The possible effects on supply chains, production scheduling, inventory control, procurement, quality improvement, and the workforce are some of the issues addressed. Some case examples of use of the Internet for these purposes are presented. Constraints on the use of the Web to foster leanness are discussed and recommendations for integrating the Internet into production systems offered.

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Introduction

In the 1990's many manufacturing firms in the United States and Europe adopted *lean production* as a strategy to become more globally competitive. Some firms have made much progress in implementing lean production in their factories while others have found it to be very difficult and are still struggling with implementation, or in some cases, given up the attempt. Some of the companies that have been successful in converting their manufacturing facilities to lean production have begun to spread lean principles to other business activities (e.g. product design, payments processing, order taking) or into their supply chains. They are attempting to move beyond lean manufacturing to become *lean enterprises.* Since the advent of the concept of lean production, which itself is derived from the *Just-In-Time* system developed by Toyota beginning back in the 1960's, there have been many advances in information technology, particularly the widespread deployment of the World Wide Web and the Internet. Almost every firm and business function has been impacted by the Internet in the last few years and whole new industries have arisen because of the technology. Of course, lean production systems are not immune from the effects of the Internet. But what are these effects likely to be? Will they allow lean production concepts to be more fully applied or, on the other hand, might they serve as an alternative way to increase operational efficiency? In fact some have seen an inherent conflict between lean principles and information technology (IT) such as the Internet (Piszczalski, 2000). It is argued that lean production emphasizes reducing variety and flexibility to achieve greater efficiency whereas one of the benefits of IT is its ability to provide more flexibility and product variety. Also many proponents of lean production believe simple visual systems (such as *kanban*) are sufficient to control a pull system and that computer systems tend to shift production control from a line to a staff function, which is undesirable in lean thinking. Furthermore, computer systems can be expensive and difficult to implement and may distract attention from continuous process improvement. In this paper I will discuss the ways in which the Internet is already having an impact on firms using lean production methods and its potential for deepening and broadening these effects. I will argue that the Internet is a facilitator to the implementation of lean production and lean enterprises and, in fact, a synergy exists between the two. In other words, if appropriately applied, the Internet can help make production systems leaner, and even more significantly, make the entire supply chain leaner.

In the first section of the paper, the principles of lean production will be examined and how theoretically the Internet might affect the implementation of these principles. In the second section some examples of how firms have actually used the Internet to make their lean production operations more effective are discussed. The third section examines some constraints and barriers to integration of the Internet into lean enterprises. The fourth section draws conclusions and presents some guidelines for using the Internet to make the firm and its supply chain leaner, or *e-lean*, as it has been called (Piszczalski, 2000).

How Lean Production Systems Might Use the Internet

To identify ways in which the Internet might be useful to firms using lean production approaches it is helpful to first define what a lean production system is and its key characteristics. The term *lean production* was used by the authors of the International Motor Vehicle Project (carried out by MIT in the 1980's) to describe the approach originally developed in the Japanese auto manufacturing industry that they contrasted with the mass production approach common in the United States and Europe at the time. This approach is often called *Just-In-Time* (JIT) but the authors Womack, Jones, and Roos of the book which summarized the MIT study (The Machine That Changed the World, 1990) believe that leanness goes beyond JIT and more accurately describes the production systems used in the Japanese auto industry at the time and now in much of the world. Their definition is: "Lean production is 'lean' because it uses less of everything compared to mass production—half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products." (Womack, Jones, Roos, 1990). In examining this definition, one can see that there is a strong emphasis on reducing the use of *all* resources, not only in the factory but also in activities extending beyond the shop floor such as product development and supplier relations. They subsequently broadened the concept of lean production to include the entire firm and called this *the lean enterprise* (Womack and Jones, 1996). Although many use the terms JIT and lean production interchangeably, Womack, Jones, and Roos clearly believed that leanness is more descriptive of how pervasive the organizational change must be to fully benefit from a JIT approach. The key parameters are the same in the two concepts, but lean systems apply them more comprehensively throughout the firm to activities beyond the factory floor (some have called lean production *big JIT*). In fact, the greatest potential for the Internet in lean enterprises may be that it will allow leanness to be applied throughout the supply chain and beyond in a way that could not have been conceived of ten years ago. In this section I will examine that potential.

To begin it is useful to outline the characteristics of a lean production system. As the definition presented above indicates, there is a strong emphasis on reducing the use of all resources in a firm—labor, capital, materials, space, time. Lean enterprises are always looking for ways to cut the use of any of these resources anywhere in the firm. JIT methods are at the heart of these efforts and include:

Pull approach and *kanban* production control
Inventory reduction
Quick setups and orders
Quality at the source (*jidoka*)
Supplier networks
Teamwork and participation
Continuous improvement (*kaizen*)

For each of these methods one can consider how the Internet might help to implement the lean approach. For example JIT uses a pull approach to production scheduling versus the more traditional push method that is based on forecasts of demand, rather than actual demand. In the past JIT could be implemented in a single factory using *kanbans* (cards) to alert upstream workstations to produce more of an item. This worked well on the shop floor but was difficult to transfer outside the factory to suppliers who often delivered large batches infrequently because it was not easy to link their production schedules to that of the customer. Some supplier firms overcame this problem by locating their factories in close proximity to the customer, assigned their own employees to work at the customer's plant, or used EDI (Electronic Data Interchange). The Internet provides a much better way of linking members of a supply chain. EDI, which connects the computer systems of different firms through software protocols, is a closed system, which requires substantial investment in software and hardware, and thus is not widely deployed, especially among smaller firms. Nor is it interactive in the way that the Internet is. Consequently the open and inexpensive nature of the Internet has much potential to link a supply chain together and allow pull production planning and scheduling to be more effectively employed. The collaborative nature of the Internet is particularly useful for the production planning function for it will allow quick notification throughout the supply chain of any disruptions to existing schedules; for example, quality problems, capacity or material constraints, and machine breakdowns. The members of the supply chain can then quickly and collaboratively adjust their production plans.

The pull principle of production planning ultimately begins with the last link in the supply chain, the final customer of the product or service. By using the Internet to transmit point-of-sale transactions and orders back through the supply chain, the member firms can keep their production in line with final demand, reducing inventories throughout the chain and avoiding the "bull whip effect". Of course, much process development work has to be done by each member of the supply chain to make their internal systems truly JIT responsive, but the Internet makes it feasible to link the entire supply chain into one long pull pipeline.

A key principle of JIT is reducing inventories to the bare minimum, and the effort to do so turns out to be powerful in finding waste and inefficiencies throughout a production process. How might the Internet facilitate the inventory reduction effort? One obvious way, as explained above, is to more closely coordinate the supply chain in order that each participant is only producing what is actually being used as the next stage, not what they expect to use. The result is small lot sizes and frequent deliveries meaning low levels of inventory throughout the supply chain. In some situations, of course, lead times and production cycles are too lengthy to fully apply the pull principle, but where applicable, the Internet will allow firms to achieve greater coordination and collaboration in their supply chain resulting in substantial inventory reduction. Another benefit is that *mass customization* will become feasible for some products and services as the supply chain becomes shorter and faster. Dell Computer Corp. is a good example of a firm that makes most of its products to customer specification resulting in little or no finished goods inventories.

To be able to deliver mass customization of a service or product, the supply chain must be very fast and responsive. This requires quick setups for production and rapid turnaround on orders from suppliers. The Internet will facilitate this aspect of JIT as

well. As lot and order sizes come down due to the closer coordination of production schedules, firms will be forced to develop faster and more efficient ways of setting up runs of products and order delivery to customers. The Internet permits closer coordination of production schedules and faster adjustment to changes in demand while facilitating information transmittal internally within the firm, and externally throughout the supply chain.

The ongoing trend towards outsourcing of manufacture and service activities that are not considered core competencies also is fostered by the Internet. Outsourcing requires close cooperation and intensive information sharing among supply chain participants, and these aspects the Internet can facilitate. In a few cases, supply chains are moving towards becoming a *virtual corporation* where all the participants are so closely linked that they, in effect, operate as one entity. Cisco Systems is an example of a firm that has moved strongly in that direction. Cisco receives 80 % of its orders from customers over the Internet and contracts out most of their manufacturing activities to Celestica, Solectron, and other ESM (Electronic Service Manufacturers). In many cases from order to delivery, Cisco employees never physically touch the product. There are many benefits to virtual manufacturing, but it would not be practical without the Internet to link the supply chain together.

Another key JIT principle is *jidoka*, or quality at the source. The Internet can aid in the implementation of quality improvement in a lean enterprise in several ways. First, internally, it can allow rapid transmittal of information about quality problems throughout the firm, such as when line or machine stoppages occur. A feature of jidoka that makes it effective is the highlighting of quality deficiencies so that everyone is aware of them and deals with them. *Andon boards* and *line-stop authority* are common methods to accomplish jidoka, and the Internet should broader awareness of quality problems throughout the firm (one, after all, has to be able to see a andon board or a stopped assembly line) and perhaps elicits wider participation in solving them. But perhaps, the greater benefit will be spreading jidoka along the supply chain. If other firms are immediately notified via the Internet of a quality issue of a member of the supply chain, they not only can adjust their production schedules but also may be able to help out in resolving the problem. For example, they may be able to send engineering personnel or contact another supplier who has had a similar problem to provide assistance. Additionally, another supplier may be able to provide the item until the quality problem is resolved.

As mentioned in the Cisco case, supply chains are becoming more closely linked where the lines blur between separate corporate entities (the virtual corporation). This would not be feasible or effective without the Internet. The tremendous amount of information transmittal and cooperation possible over the Internet allows firms to link more closely with their supply chain partners. Supplier partnerships are another important feature of effective JIT systems. The Internet alone cannot create these partnerships for trust and experience are also are required which require the development of personal relationships, but it makes it more practical to link to supply chain members in production scheduling, inventory control, quality improvement, and new product development in a way that could not even be conceived of when JIT production systems were first developed in the 1960's. In fact, it is no coincidence that *supply chain*

management has become an important operations management topic only in recent years for its advent closely parallels the development of the Internet.

Just-In-Time production systems call for teamwork and participation of everyone to make them effective. As lean thinking spreads throughout the firm creating the lean enterprise, and along the supply chain creating the virtual firm, even greater teamwork and participation will be necessary. The Internet will facilitate this as virtual meetings become more widespread and much more information is available to everyone within and outside the firm. As Deming and others have pointed out, good management decisions are based on data and careful analysis of data, and the information capabilities of the Internet can disseminate the data. There are many types of information that will allow for better problem resolution and production planning, as have been discussed above, which the Internet can quickly and cheaply transmit. If firms allow their employees to actively use this wealth of data, and to work collaboratively with employees in other firms in the supply chain, the result should be superior and faster decision-making because of broader participation and more rapid information transmittal. An example of this benefit is in ever speedier and better product design as assemblers link with their suppliers and customers via design teams (both physical and virtual). The Internet provides the mechanism for such close coordination and cooperation, especially when the supply chain and the customer base are global.

The final characteristic of JIT to be discussed is the emphasis on *kaizen* or continuous improvement processes. Kaizen is a natural consequence of the other characteristics, previously considered, in particular, jidoka, kanban, and teamwork and participation. The philosophy of leanness and lean thinking encourage all employees to continually search for better ways of doing things to improve quality, efficiency, and speed. The concepts of *zero defects* and *zero inventories*, although unattainable in many cases, are motivating and further improvement is almost always possible. How can the Internet help the kaizen effort? Probably the largest contribution that the Internet can make to kaizen is in its ability to rapidly disseminate all type of data (e.g. demand, production schedules, quality performance) that are essential to effective process improvement. Many firms have capable internal kaizen programs so where the Internet can really make a contribution is by spreading these throughout the supply chain and allowing mutual learning. As supply chains cooperate more closely, each participant can contribute to efforts of other supply chain members to improve. If the firms in the supply chain accept their partnership role in the chain, they will then see the benefits of contributing to other's continuous improvement efforts. Toyota, Motorola, and others have long realized that if they can help their supplier improve quality or lower costs, they also benefit. The Internet will allow each firm to know what others in the supply chain are doing, problem areas can be highlighted, performance criteria can be shared, and the entire supply chain can work as a team toward continuous improvement. Of course, this will not come automatically as trust will need to be developed among firms and expertise developed in process analysis and problem solving, but as the realization spreads that each firm is increasingly a virtual corporation, kaizen should intensify along the supply chain.

In summary, we have seen that for many of the characteristics of Just-in-Time production systems, and the application of these methods outside of production activities into other business functions in the lean enterprise expands, the Internet becomes a potent

facilitator to make each of these factors more effective, and even more importantly, to spread leanness throughout a supply chain. Only a few firms have fully realized the potential to become *e-lean* and even fewer have begun implementing it, but there are a few examples of firms moving in that direction. In the next section I will feature two of these, Dell Computer Corporation and Cisco Systems Corporation, and mention several others firms using the Internet in their efforts to become e-lean.

How Firms Are Using the Internet to Become Leaner

Not many firms have yet learned how to use the Internet in implementing lean production principles, but a few examples will be discussed to illustrate successful applications. Two such examples are Dell Computer Corporation and Cisco Systems, which have both widely deployed the Internet in managing their supply chains. I will also cite several more specialized applications by other firms.

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Constraints and Obstacles to e-Leanness

The examples cited above of firms using the Internet to become leaner are illustrative of the possibilities of the Web. However, there remain many potential obstacles and constraints to achieving e-leanness. Many of these are typical organizational change constraints, but some are unique to production systems and supply chain management. In this section I will discuss some of these constraints and offer suggestions on how managers may overcome them.

One common problem is linking to supply chain partners is the incompatibility of internal computer systems with other firms' systems and the Internet. Many companies in recent years have implemented Enterprise Resource Planning (ERP) systems to coordinate internal financial, marketing, and human resource data. However, most ERP systems are not linked to shop floor production scheduling, inventory, and quality control data (Vijayan, 2000). This type of information is essential to collaborative production planning and inventory management throughout the supply chain as well as making build-to-order production feasible. There exists software to provide the links; for example, Manufacturing Execution System (MES) or Advanced Planning System (APS), but many firms are loath to invest in additional software since they have made substantial investments in their ERP systems and may still be working out the bugs. In any case, for those firms that go ahead and invest in MES or APS there will be the usual implementation problems and lags to make these systems operational, thus slowing down their supply chain Internet efforts.

Another potential problem is the sharing of information that has been considered proprietary with supply chain members. Many companies are still struggling with the transition from seeing their suppliers as opportunistic opponents to partners. Asked to open up their internal financial, production, and marketing data to supply chain members,

many firms may balk. Additionally, some suppliers are concerned that any information they provide to their customers might be used against them to force down prices or the customer or other suppliers may expropriate their technology. These concerns are heightened with online auction sites. More broadly many firms are concerned about access of others including competitors to their internal data systems, and are unlikely to fully participate in Web systems until adequate firewalls are developed. So not only must there be confidence in the technology along the supply chain, but there also must be sufficient trust developed in the other chain members.

Another concern, especially among companies that have developed lean production systems, is that the Internet may transform close, personal relationships with supply chain members into arms-length, virtual relationships. The best lean companies have extensive linkages to their supply chain partners, developed over the years, with frequent meetings and plant visits and, in some cases, the training of other firms' personnel in process improvement and quality methods. Much of the transfer of lean principles and techniques occur through these personnel exchanges and, over time, trust and confidence in supply chain partners is developed. Will the Internet replace these relationships? It could but certainly need not do so. Firms can continue to maintain personal relationships with partners and use the Internet to transmit the additional production scheduling and performance data that could make these relationships more productive. With global partners where close personnel relationships may not be possible in any case due to physical distance, the Internet can at least create virtual relationships where none may currently exist. However, some proponents of lean methods may continue to be skeptical of what the Internet may do to the relations between supply chain partners.

Other problems include finding personnel such as Web site developers and training of the employees involved in implementing and operating the Internet systems. However, as the potential of the Internet to increase the efficiency and efficacy of the supply chain and allow more make-to-order processing, firms will likely find the resources and the willingness to overcome these constraints and obstacles.

Conclusions and a Look Ahead

As was discussed above there are many reasons why the Internet can facilitate the movement to lean production systems, and a few firms have made tentative efforts in that direction. Most of the applications have been in supply chain management, which is a logical target for a lean approach. Lean thinking has slowly spread from the factory floor (*lean production*) to activities such as order processing, billing, and product development the *lean enterprise*). Now some firms are thinking of the virtual corporation where many of their processes are linked to their customers and suppliers. Once they begin thinking in this way, they soon understand that to fully realize leanness they will need to apply the concept of pull production to their customers and suppliers in one *virtual supply chain* (the *lean supply chain).* The benefits of doing this will be so compelling that firms will increasingly move in that direction. The Internet is a perfect tool for accomplishing the lean supply chain with its open, easy, and cheap access. Previous attempts to

computerize the supply chain using ERP and EDI have been limited by the closed, proprietary and costly nature of those systems. There are, of course, many obstacles to accomplishing the virtual supply chain, but none of these is insurmountable.

Another force that will drive the movement to an Internet-linked supply chain is the increasing globalization of business. There are very few companies that do not have some international customers and suppliers, and they will increasingly find that they need to improve communications and coordinate planning with these global supply chain partners. Although nothing can substitute for face-to-face contact for many types of business dealings, the Internet can supplement direct with virtual contacts allowing much more information transmittal globally, in real time. Coordination of new product development, production planning, and inventory management will be more feasible with greater possibilities for driving inventory out of the system, a key goal of lean production. Some of the disadvantages of global supply networks will become less formidable as collaboration increases because of the Web. There is huge potential to benefit from being *e-lean* in global supply chains.

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