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Corporate IT Systems and Continuous Improvement

Abstract

The focus of this research is in the area of Lean production and corporate IT systems. Essentially it studies the effects of IT systems on a fundamental aspect of Lean production; continuous improvement. This is important because the increasingly common corporate IT systems lock processes into inflexible patterns while continuous improvement require processes to be flexible; they are thus contradictory. Few studies have covered this. The research approach is an exploratory case study of a European Lean production pioneer, operating within machinery manufacturing. The findings provide evidence that IT systems designed to facilitate a normal state in production are effectively facilitating continuous improvement, while IT systems designed to directly support continuous improvement can be ineffective, counterproductive, and negative for worker motivation. It is also found that in-house development of IT systems is not the solution for making IT fit for continuous improvement. The thesis recommends companies to carefully consider the negative effects from IT systems directly supporting continuous improvement. Also it recommends effective cross-functional management of IT development to facilitate rapid change of IT systems when that is required for continuous improvement efforts.

Key words: Lean production, IT system, continuous improvement, ERP, Kaizen.

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1. Introduction

This thesis studies the effects of corporate IT systems on continuous improvement. This is important for three main reasons. First, IT systems lock processes into inflexible patterns while continuous improvement requires processes to be flexible; they are thus contradictory and there should be some kind of clash. Second, corporate IT systems are becoming increasingly common and continuous improvement through Lean production is today one of the most embraced manufacturing management concepts. Third, very few studies have covered this specific area.

The increasingly competitive and globalized markets demand corporations to constantly improve the efficiency of operations. Both Lean production and corporate information technology (IT) systems are implemented to meet this challenge. Productivity improvement is a topic that became the centre of attention in management studies as the concepts of scientific management were introduced. Stemming from studies of the Toyota Production System (TPS), Lean production is now one of the most popular and endorsed management concepts for continuous efficiency and quality improvement with the use of recognized tools and techniques (Powell, 2011). At the same time over 60 percent of all multinational companies have implemented Enterprise Resource Planning (ERP) systems (Hitt, Wu, & Zhou, 2002) to generate performance improvements in several areas simultaneously through organizational integration (Powell, 2011). Lean production and corporate IT systems are thus two important parallel means for productivity improvements.

Several studies discuss the fit or no fit of Lean production and corporate IT systems. Many argue that they are philosophically misfit because IT systems stem from a top-down approach to management and have a push system of manufacturing control, while Lean production is pull-oriented and bottom-up managed. Furthermore, some argue that while Lean production is aiming to eliminate all waste in operations, IT systems add wasteful activities. There are however also studies claiming that the striving for an ideal Lean production system without defects and waste requires the help from sophisticated IT systems as the manufacturing operations are increasingly complex (e.g. Bell, 2006).

On this subject continuous improvement has received relatively limited attention. This is surprising because continuous improvement can be seen as the most fundamental aspect of Lean production (Spear & Bowen, 1999). In fact, only a handful of authors discuss the relation between IT systems and continuous improvement. Some of those outline a critical clash between the two phenomena; IT systems lock up processes in inflexible and rigid patterns that make them difficult to change and thus inhibit continuous improvement. A few discuss the possibility to use IT systems to facilitate better continuous improvement. However, not many empirical studies underpin these discussions. This thesis fills that gap by exploring how IT systems support and hinder continuous improvement.

One problem encountered in studying relationships between IT systems and continuous improvement is that while IT systems are readily observable, it is not easy to tell if and how continuous improvement is practiced in an organization due to the comprehensive nature of the concept. A company that supposedly implements Lean production might actually not be engaging in continuous improvement but instead just focuses on tools and methods of Lean production. In addressing this problem, this thesis studies a company that evidently put substantial effort into continuous improvement as part of Lean production implementation. Specifically, a European machinery manufacturer was chosen for the study on the ground of its long-term commitment to continuous improvement. The Company's production system (CPS) is a version of the Toyota Production System (TPS), and its ongoing initiative to utilize IT systems to further strengthen CPS and continuous improvement is the focus of this study.

Although most scholars are negative to the coexistence of Lean production and corporate IT systems, there are some facts about the Company that give reasons to assume it should work well. The Company is developing its IT systems in-house; a reason to expect it fits well to the continuous improvement. Furthermore, the Company publicly proclaims that it fully embraces the concept of continuous improvement; a reason to assume that it has put efforts in tuning the IT systems to fit continuous improvement efforts.

This thesis empirically contributes to the literature by mapping IT systems effects on continuous improvement and by introducing three interesting propositions. First, it is found that IT systems designed to facilitate a normal state in production positively support continuous improvement. Second, it is found that IT systems designed to directly support continuous improvement are ineffective and can even be counterproductive as there is a potential negative effect on worker motivation. Third, it found that in-house development of IT systems does not guarantee a fit to continuous improvement.

The thesis starts off by reviewing the existing literature on Lean production, Corporate IT systems and literature on those combined. From the theoretical background a research gap is identified, and based on the gap the research question is formulated in the research question and methodology section. The section also outlines the method that has been used for conducting the study and the limitations it implies. Subsequently the context of the case is given, followed by the findings of the case study. Finally in the discussion section the findings are discussed and propositions and managerial implications are given.

2. Theoretical Background

This section will explore the literature on IT systems and Lean production. Importantly, Lean production is a management concept and stands on principles, while the use of corporate IT systems is a management tool and does not have specific principles. The two can thus not be compared under the same conditions, but rather will the intended and actual effects of IT systems and Lean production be examined and compared.

Corporate IT Systems

The early approach to corporate IT systems, Material Requirements Planning (MRP) emerged as a computerized system for ordering material at the right time and quantity depending on inventory levels and scheduled production. MRP needed to reschedule frequently in unstable business environments. It did not cover important design parameters like lead time offsets, bill of material structure, safety stock management etc. This compromised the quality of the underlying data and limited the effectiveness and the consequence was that the industries limited their use of the systems for administrative purposes. By connecting several planning mechanisms, control was taken over lead times and the enhanced management system was named 'closed loop' MRP. By also adding several financial modules an integrated approach towards the management of resources was achieved and this system was termed MRPII. In 1990 the MRPII had been extended to cover almost all of organizations' functions, adding functions used for product design, HR, communications etc. The system was named Enterprise Resource Planning (ERP) (Hicks, Riezebos, & Klingenberg, 2009).

The users of the system are collectively feeding it with large amounts of information that is automatically combined, analyzed and disseminated throughout the whole organization, enabling management to take decisions and actions upon the information (Hitt et al., 2002). The desire for improved reporting and decision making is a strong motivation (Robey, Ross, & Boudreau, 2002). Hitt et al. (2002) report that by implementing an ERP system the company can automate operations from supply chain management, increase control over inventory, manufacturing scheduling and production, sales support, customer relationship management, financial and cost accounting, human resources. Buckhout, Frey and Nemec (1999) argue that ERP systems are implemented for two reasons; reducing costs and achieving improved capabilities. The cost savings are based on reduced legacy IT system costs, labor costs and inventory costs, while the improved capabilities include more efficient processes, tighter control and reduced cycle times. The interoperability, process automation and information dissemination prospects (Hitt et al., 2002), as well as reducing the complexity inherent with using multiple data sources are often appealing motives (Buckhout et al., 1999). The initiative is often part of a reengineering initiative and integration of disparate sites or operations as the company seek to implement standard processes across global sites (Robey et al., 2002), enabling the firm to adapt and standardize the processes to best practice (Hicks et al., 2009). Robey et al. (2002) found that among the most common motivations for implementing an ERP system was to replace legacy systems. Before the change of millennium, the installation was also driven by the need to solve "year 2000" compliance problems (Buckhout et al., 1999).

Around 60 percent of all multinational companies (Hitt et al., 2002) and almost 19 percent of all organizations across all industries have implemented ERP systems, and the manufacturing sector is leading the trend (Robey et al., 2002). An average implementation costs around $15 million (Hitt et al., 2002), but it is not uncommon that companies spend more than $100 million on an implementation with multiple modules across multiple divisions (Robey et al., 2002).

Successful adopters have higher sales per employee and higher profit margins, and financial markets reward the implementations with rising stock values although implementers achieve lower return on equity (Hitt et al., 2002). Several companies are benefiting from their ERP systems; Chevron Corp. cut its costs by 15% and Autodesk Inc. saved enough from inventory reduction alone to pay for the whole implementation (Buckhout et al., 1999).

Lean Production

The Toyota Production System (TPS) is widely discussed and different names are used for describing the concepts, techniques and tools drawn from it; Lean production, continuous improvement, Just in Time (JIT) etc. There are divergent perceptions of what they imply and what their differences are, if there are any. New (2007) argues that the problem of deciphering the TPS stems from Toyota's "annoying habit of ceaselessly developing and improving its own practice" (p. 3547).

Lean production can be contrasted with craft production and mass production, where Lean production combines the advantages of both while avoiding the high costs of the former and the inflexibility of the latter. Lean production pushes responsibility and control down the organizational hierarchy, making every worker more productive. A "truly Lean plant" transfers the maximum amount of responsibilities to workers that add value and has in place a system for detecting defects that quickly traces the problem to its root cause. In mass production defects have traditionally been fixed by special repairmen remote from the production line, while at Lean production companies the workers are instructed to stop the whole assembly line immediately if a problem could not be fixed. The whole team comes over to find the root cause and institute a permanent fix for the problem. The original Lean production company Toyota has practically no rework and delivers cars with among the lowest number of defects, while mass-production plants devote 25 percent of total working hours to fix mistakes. The pursuit of optimizing production does not stop by the gates of Toyota's plants. By maintaining collaborative relationships and being a minority owner in main suppliers, Toyota has managed to integrate them into a just-in-time build-to-order system, minimizing defects and inventory levels – thus part of the continuous improvement efforts. The result is a production system that "use half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours" (Womack, Jones, & Roos, 1990, pp. 12-14, 55-62, 67, 99).

Developing business practices to make them more efficient and better fit for given conditions is a concern for most organizations. Imai (1986) states that improvement efforts can be separated into innovations and "Kaizen", where the former is drastic improvements of the status quo and the latter signifies small improvements made in the status quo. Kaizen, or continuous improvement as it is also known in recent literature, means ongoing improvements involving both managers and workers. The philosophy assumes that not only business, but the way of life deserves to be constantly improved. Imai further argues that Japan's postwar economic miracle is a product of the country's deeply rooted culture of Kaizen. It is materialized by constantly changing and standardizing working procedures to higher standards (pp. 3-6). Continuous improvement is a general phenomenon, but is strongly associated with the Toyota Production System as the company is often depicted the master of Kaizen. The chairman of Toyota Motor Corporation Fujio Cho has stated that "The soul of the Toyota Production System is a principle called kaizen" (Liker & Hoseus, 2008, pp. 149-152).

Many companies have tried to imitate Toyota, but the attempts have often been unsuccessful because their focus has been on tools and techniques rather than the culture, in which continuous improvement and respect for people are fundamental (Liker, 2004, pp. 7, 52). The world is dynamic and complex and thus an attentive culture of constantly improving and adapting to the environment throughout the organization is critical. The first step for any new worker is to learn to perform the job according to the standards with high quality. But at Toyota this is just the starting point; daily and virtually constant problem solving activities are key to Toyota's success (Liker & Hoseus, 2008, pp. 149-156). Spear and Bowen (1999) describe that the activities, connections and production flows at Toyota are rigidly scripted, but at the same time enormously flexible and adaptable. Work is highly specified to content, sequence, timing and outcome, but is at the same time open for change whenever an improvement can be made – using a rigorous problem solving process. As soon as an improvement is made, a permanent solution is instituted. The system stimulates people to engage in experimentation so that learning is promoted. It is also key in the pursuit to achieve the vision of an ideal production system without defects, batch sizes of one, supply on demand according to request, immediate supply, production without waste of materials, labor, energy or other resources, and a safe work environment. Sugimori, Kusunoki, Cho and Uchikawa (1977) argue that an important part of continuous improvement at Toyota is Jidoka, which means that shop floor workers are empowered to stop the production line in case of a failure in order to analyze and resolve it.

Continuous improvement is the most distinctive part of Toyota's respect for the human systems (Sugimori et al., 1977), and the objectives are recognition and appreciation to make the job more interesting as well as to make maximum use of workers' knowledge (Antonakis & de Treville, 2006). However, continuous improvement requires standardization of work, and Adler (1993) establishes that standardizing of work has for long been criticized and blamed for a dehumanizing logic of coercion, leading to workforce discontent and union belligerence, and in turn quality and profit problems. However, standardized work itself is not the problem; rather it is the top-down approach of work-design. "Procedures that are designed by the workers themselves in a continuous, successful effort to improve productivity, quality, skills, and understanding can humanize even the most disciplined forms of bureaucracy" (p. 98). The use of continuous improvement not only serves in the interest of management and organization by improving quality, productivity, innovation and learning; it also increases workers' motivation and job satisfaction. New (2007) confirms this and argue that the monotony standardized work at Lean production factories implies a ruling out of workers autonomy. Rather than the production work itself, the meta-system of improvement is central in motivating workers. The Lean production job characteristics and especially the responsible autonomy substantially increase the intrinsic motivation for workers (Antonakis & de Treville, 2006).

Bessant, Caffyn, and Gallagher (2001) found that continuous improvement is of considerable importance in many companies, but that it is often poorly managed. They argue that managers must see continuous improvement as the evolution and aggregation of a set of key behavioral routines that can contribute in the pursuit of lower costs, improved quality, faster response etc. However, achieving this is difficult and involves articulation and learning of behaviors, practicing and reinforcing them until they become routines.

Lean Production and Corporate IT Systems

In the late 1970s a huge interest in MRP emerged in operations management literature and many believed the computers would completely change the nature of operative manufacturing work, where machines rather than workers would do the bulk of the work (New, 2007). However, Sugimori et al. (1977) stated that the use of computer systems for organizing production logistics would introduce unnecessary costs, overproduction and uncertainty. They favored instead the manual, cheaper, more robust and simple Kanban system which they found more competent in delegating control decisions to foremen and workers, rather than centralizing decision making, which is the approach in IT systems. This section will explore what is outlined in the literature regarding the effects of IT systems on Lean production.

Pull vs. push system for production

Bradford, Mayfield, and Toney (2001) argue that there is a fundamental philosophical difference between Lean production and IT systems; "Lean philosophy emphasizes the continual improvement of production processes, while ERP emphasizes planning" (p. 30). Hicks et al. (2009) explain that the early approaches to IT systems for manufacturing control comes from a time with stable markets, where demand exceeded supply and companies were focused on high volume manufacturing. It was possible to keep high levels of inventory and still be competitive and inventory control software systems supported this. The result was often apart from high levels of inventory, long lead times and poor delivery performance. As stated above, the first approaches to corporate IT systems were computerized systems for ordering material at the right time and quantity depending on inventory levels and scheduled production. However, they were independent on the production loading and capacity constraints (Hicks et al., 2009), both crucial in determining quantities and time for material ordering in a Lean production system. Bradford et al. (2001) confirms this and conclude that ERP systems stem from a push system for production while Lean production is a pull system, implying that users of the former produce according to plans and forecasts of demand while users of the latter produce according to actual demand. Bell (2006) confirms the heritage problem of IT systems and states that since forecasting and planning is such an important part of MRP II software, it has great difficulty to adapting to a Lean shop floor pull execution environment. However, he argues that Lean manufacturing increases the importance of planning since JIT inventory movement gives little margin for errors, and thus IT systems become an important part in pursuing a Lean organization (Bell, 2006, pp. 119, 122). Bradford et al. (2001) argues that IT systems today can support a pull system.

Top-down vs. bottom-up

One of the motives of implementing an IT system is to collect, analyze and disseminate information so that management can make decisions and obtain control over processes, which implies centralization of process management. This contradicts the decentralization approach of Lean production where responsibility and control is pushed as far down in the hierarchy as possible. Piszczalski (2000) argues that computer-based planning and control, and in particular MRP and ERP systems removes control from the plant and over centralizes it. Bartholomew (1999) highlights this stating that Lean production is bottom-up while ERP systems are top-down managed.

IT systems as a source of waste

Vollman, Berry, Clay Whybark, and Jacobs (2005) argue that the process of ordering, execution, confirmation of materials moving, production control, master scheduling, forecasting, identification and communication of specifications are all associated with multiple data entries and data handling and can to a large extent be reduced or eliminated through the use of JIT. The improper use of IT is "an enemy" of Lean production as 99 percent of the data entries can be wasteful (Bell, 2006, p. 52). Vollman et al. (2005) argued that in JIT execution there is no need to track the progress of orders and purchased items because they move so fast through the factory. If they are converted into finished goods within hours of arrival, it is unnecessary to put them into stockrooms and register their details.

Already Sugimori et al. (1977) forecasted the IT systems to bring wasteful activities to manufacturing plants. Bartholomew (1999) argues that Lean production and ERP systems are incompatible as while "the former has the goal of eliminating all wasted time, movement, and materials [the] latter seeks to track every activity and piece of material on the plant floor" (p. 2). Bradford et al. (2001) argue that ERP systems allow for integration and synchronization of transportation system and demand data with the manufacturing floor, helping to ensure the customer-requested delivery dates are met. However, in regard to Lean production, they conclude that tracking every activity is a waste since everything is not made use of. This is confirmed by Piszczalski (2000), who states that IT systems introduce "far too many complications and extraneous tasks" (p. 2). While information should be actionable, ERP systems give planners too much, and fail to identify waste in the supply chain (Ward, 2005). Marczinski (2008) confirms and further elaborates on this adding the lack of customer focus when using IT systems. Customer requirements are subordinated to the productivity in IT systems. If IT systems are to be working in a Lean production environment, the systematic planning and governance must be defined by the value adding and waste elimination at the value stream so that the customer perspective is reflected in the ERP system. IT systems are thus threatening the fundamentals of Lean production. Buckhout et al. (1999) conclude that a well-designed value chain can have many of the controls and other functions built into the business process simply and far less expensively than an IT system possibly could; "much of the communication and control are designed right into the production system – and the computer has a very small role" (Buckhout et al., 1999, p. 117). Production workers pull a Kanban-card and send it to the supplier when more material is needed, manually visualizing the signal and thus no computers are needed.

IT systems as instruments for coping with complex requirements of Lean production

Toyota Motor Company's chairman of the board Fujio Cho has stated that "Toyotas biggest challenge is information technology" (Ward, 2005, p. 51). Piszczalski (2000) argues that "even after all the efforts to simplify, auto manufacturing will always be extraordinarily complex. Only by using computer systems can manufacturers possibly get their arms around this Herculean task. This includes recognizing the multitude of constraints and issues that inevitably impact operations and planning" (p. 3). Ward (2005) argues that companies produce multiple products at different paces on the same line, something that can be handled by for example SAP. "What leanware brings is enabling technology – allowing automation, flexibility, robustness and scope to span machines, people and supply chains" (Ward, 2005, p. 51). IT makes it possible to optimize around a constraint or bottleneck and eliminates waste. Hicks et al. (2009) acknowledge this and conclude that IT makes it possible to design tailored planning systems. Specific product types can be treated differently, and special parts with long throughput times and uncertainty can be controlled more easily, thus enabling Lean production to manage more complex manufacturing environments. In line with the arguments of Hicks et al (2009), Marczinski (2008) is presenting an ERP system model that supports Lean production in a complex multistage manufacturing plant. Based on customer requirements, capacity supply, quantity of parts, setup times etc. the ERP system can optimize batch sizes for each product with more accuracy than can be done manually. By using the system, pace of Kanban cycles are easier to adapt. Highly fluctuating ordering behavior from customers, changes in product mix and shortage in primary material can more easily be handled with the use of IT systems. Bell (2006) argues that the necessary continuous recalculations for schedules, takt time, batch sizes etc. require the assistance of software and that several ERP and MRP II systems include this. On the other hand, the parameters controlling the scheduling must be carefully entered in the software systems, and it is often not practical to change thousands of parameters as frequently as actual conditions change. Furthermore accurate information of capacities, cycle times, alternate routings, constraints etc. must be known to make appropriate sequencing decisions, which often can be challenging. Also the software must know the current status of every work station, implying a large amount of burdensome data entries that can introduce waste (Bell, 2006, pp. 136, 172-173).

IT systems and continuous improvement

Using IT systems to standardize processes is an instrument for continuous improvement

Bell (2006) argues that the use of IT can add value by standardizing processes, and that "standardized work on the Lean shop floor enables consistent performance" (p. 67). In line with Spear and Bowen (1999), he argues that this creates a stable environment that encourages continuous improvement. Moreover, using IT for standardization establishes a baseline for reliable performance measurement. Visual tools providing instant feedback on takt time, throughput etc. can help the process flowing smoothly (pp. 67, 300).

Using IT systems to directly support continuous improvement

Bell (2006) argues that data should ideally be captured automatically to improve processes by using for example Andons, but that raw data however "only adds value if it can be transformed into the right information to answer the questions being asked at the time" (p. 302). The required broad range of captured information bears a risk of being wasteful, and the key is to identify which conditions create exceptions and then design the appropriate trigger and signal mechanisms accordingly. By measuring process performance over time, causal relationships can be evaluated, and the process design can be improved accordingly. Although empowered workers controlling the process quickly resolve problems as they arise; more complex problem solving may require an empirical and rigorous approach relying on gathering and analyzing process data (Bell, 2006, pp. 300-306).

IT systems counteract continuous improvement

Vollman et al. (2005) conclude that since JIT calls for continuous improvement, this implies an ongoing migration of manufacturing and control systems to support reengineered manufacturing processes. In order to satisfy ERP system customers with Lean production operations, ERP system vendors are increasingly offering modules or add-on components that support Lean initiatives including the ability to quickly address engineering changes on the line (Bradford et al., 2001), i.e. continuous improvement. However, according to Buckhout et al. (1999) ERP systems lock in the operating principles and processes, and once installed “the odds of being willing to pay for modifications are close to zero” (p. 118) since the costs, complexities and politics “of untangling such expensive investment prohibit most companies from tackling this issue” (p. 118) . This is further noted by Ward et al. (2005) who found that many firms that have invested in IT systems are locked inside those and restrained from implementing Lean production. Markus, Axline, and Petrie (2000) found that ERP system vendors and consulting firms are strongly recommending implementing firms not to adapt the software, and instead adapt their processes to the functions of the software systems. “Almost every analyst of the ERP experience strongly advises companies to avoid modifying the software. Companies are advised to live with existing ERP functionality and to change their procedures to adapt to it” (p. 259). By doing so they run the risk of lower performance levels and upgrading difficulties (Hong & Kim, 2002). This is confirmed by Hitt et al. (2002) who conclude that ERP systems require “simultaneous process redesign of multiple functional areas within the firm” (p. 73), and firms to “adapt processes to the capabilities of the software” (p. 73).

The root of the high failure rate in ERP system implementations is the difference in interests between customer organizations who desire unique business solutions and ERP system vendors who prefer a generic solution applicable to a broad market (Swan, Newell, & Robertson, 1999).

Corporate IT Systems and Lean Production in Practice

Adapting IT systems

ERP system implementing companies have reported basic deficiencies such as a limit of the number of sales representatives, while others found that the system did not fit business rules of commission. It is thus not surprising that ERP system vendors are increasingly looking to adapt the software systems (Hong & Kim, 2002). However many adopters have difficulties in getting the modifications to work well, and another related obstacle is that despite ERP system vendors’ promise of a comprehensive system covering all organizational functions, many companies find themselves forced to retain some legacy systems that perform specialized functions not available in the ERP system package. Trying to integrate the specialized systems with the ERP system is challenging and expensive (Markus et al., 2000).

Adapting processes to IT systems

Sumner (2000) argues that a top-down integration of the ERP system is necessary because if the standardized specifications of the ERP systems are not adhered to there is risk of low performance. Companies that follow the advice of ERP system vendors and consultants to standardize the processes to best practice require a redesign of the processes throughout the whole firm, adapting them to the capabilities of the software (Hitt et al., 2002). The adoption of best practice has shown to be a liability for many firms as the ERP systems with legacies from the 1990s have perpetuated "some of the legendary material requirements planning problems such as complex bills of material, inefficient workflows and unnecessary data collection" (Bradford et al., 2001, p. 28). Soh, Kien and Tay-Yap (2000) found that ERP system misfits come from organizational requirements that do not match the capabilities of the system. Ward (2005) emphasizes the lack of management considerations in ERP system implementation: "Implementing ERP well means you have to change the way the company works; yet none of these products includes change management" (Ward, 2005, p. 49).

Effects of implementations

Far from all implementations are successful; some are disastrous and in several cases companies have quit using the software systems (Hitt et al., 2002). Implementations take too long, cost too much and fail to deliver promised benefits of competitive advantage and cost reductions, and more than 70 percent of all ERP system implementations fail to achieve their corporate goals (Buckhout et al., 1999). Firms that implement ERP systems are often experiencing a performance dip after the implementation, and some even need to permanently increase staffing levels to achieve normal efficiency (Markus et al., 2000). In many cases the processes were efficient and effective before the software implementation because they had been developed and tuned over several years of operation, but "most implementations do not recognize and therefore do not capture this organizational efficiency" (Buckhout et al., 1999, p. 117). Some ERP projects have even been "jeopardizing the core operations of the implementing organization" (Hong & Kim, 2002, p. 25), and in the worst cases the failures have led to bankruptcies (e.g. Buckhout et al., 1999; Markus et al., 2000)

Buckhout et al. (1999) argue that the reason for the high failure rate is that companies are not making the strategic choices needed to configure the systems and processes. Managers seldom decide which information, communication and control the IT system is to provide, and if they do it is difficult to follow since the implementation process takes over and decisions are revised on the basis of the system, not the business. Once the executives have concluded the business case and decided upon implementation, they leave it for the technicians and assume that with the implementation comes the benefits. Technicians are left with too much responsibility and often add "nice-to-have" features that increase the complexity of the system and ruin its benefits. The key is to “translate the company’s vision into concrete priorities, and then decide exactly how the ERP system implementation will help the company deliver some, but not all, of these priorities” (Buckhout et al., 1999, p. 120) and to establish guidelines for involvement in the implementation for different levels in the organization.

The Sequence of Implementing IT Systems and Lean Production

Although there are different opinions whether IT systems and Lean production can work together, there seems to be a consensus on the sequence and state of implementation if both are adopted. Mo (2009) concludes that IT projects should be preceded by Lean manufacturing projects that streamline the operations of the company. The sequence is important; first because the process improvements are visible early and thus people are more confident to make changes in the IT system. Second, the IT changes will then be driven by the needs of the new manufacturing processes. Third, the implementation of the IT system will be straight forward since the staff is already familiar with the new processes. The Lean manufacturing principles need to be established first as an “underlying foundation upon which the ERP system is overlaid” (Nakashima & Berger, 2000, p. 2). Furthermore, “Lean should be the foundation of manufacturing. Onto that should be layered parsimonious computer systems that optimize areas not well handled by Lean. Only then can manufacturing truly serve today's highly dynamic business environments” (Piszczalski, 2000, p. 4).

Summary and conclusion of theoretical background

Corporate IT systems have evolved from a material requirement planning tool to a system that integrates essentially all functions of organizations. Around 60 percent of all multinational companies have implemented the costly IT systems for various reasons, but foremost to automate processes and enable management to take better decisions and actions upon the information. Continuous improvement is key for successful Lean operations. It implies that working procedures are constantly changed to higher standards by all members of the organization, and an important function of continuous improvement is the motivation it gives workers.

Previous literature has explored the fit between Lean production and corporate IT systems in several dimensions. Several scholars argue that there is a fundamental philosophical clash between the two. Essentially IT systems have a push production heritage and centralizing of management while Lean production is the mother of pull production and decentralized control.

The large amount of data entries can be unnecessary and wasteful in Lean operations. However, several authors claim IT systems are necessary for the complex tasks that manufacturing implies.

Several scholars have found that IT systems are difficult to adapt to processes and vendors of the systems are recommending companies to instead adapt their operations to the IT system, a procedure that has become a liability for many firms.

IT systems can support the standardizing of processes and create a supporting environment for continuous improvement. Also they can directly support continuous improvement by improving processes according to measurement of performance. However, several scholars argue that IT systems lock up processes and thus inhibit continuous improvement.

Implementers of ERP systems that try to adapt the software to processes experience problems of IT performance. Implementers that follow the recommendations of ERP system vendors and instead adapt their processes to the system also experience problems as the IT systems are not fit for the organizational requirements. More than 70 percent of all implementations fail to deliver according to their objectives and common problems are that implementations take too long, cost too much and fail to deliver promised benefit.

The literature is consistent in that the sequence of implementing Lean production and IT systems is to first streamline processes and secondly implement IT systems.

There is no clear consensus of how IT systems and Lean production work together. More importantly, literature on the fit between continuous improvement and IT systems is divergent and lacking. No empirical study could be found on that subject. Since continuous improvement is fundamental for Lean production, the discussion of its fit with IT systems is essential.

3. Research Question and Research Method

The theoretical background study reveals that the subject of Lean production and IT systems is of immediate interest. It also reveals an important research gap; there is not much written about the relation between IT systems and continuous improvement. Even more absent are empirical studies in this matter. This thesis aims to fill this gap and will explore how IT systems affect continuous improvement. Essentially the research question is:

"In what ways can corporate IT systems be hindering and/or supporting continuous improvement efforts?"

Research Method

The lack of literature regarding the relation of IT systems and continuous improvement and consequently the nature of the research question, suggest the research method should be inductive, where theory is built from empirical findings (Alvesson & Sköldberg, 2009). However, no matter how inductive the approach, it is important to have a prior view of the general constructs that are to be studied, and their relationships (Voss, Tsikriktsis, & Frohlich, 2002), and literature in adjacent areas has to some extent also been used for discussion of the findings. Thus the study comprises a mix of induction and deduction, a research method called abduction (Alvesson & Sköldberg, 2009).

The lack of previous literature also implies that the study will be explorative and theory building (McCutcheon & Meredith, 1993). For the purpose of explorative studies, the case method is a common starting point (Voss et al., 2002). In such case as the interrelations of IT systems and continuous improvement where the relevant conditions are unknown, the case study approach may even be the only available method (McCutcheon & Meredith, 1993). The case study has the advantage of being unconstrained by limits of questionnaires and models and thus facilitates creative insights and development of new theory, which is the aim of this study. Case research is particularly fit for studying Lean production and IT systems since it copes with the "growing frequency and magnitude of changes in technology and managerial methods" (Voss et al., 2002, p. 195), and since the approach is particularly well-suited when organizational rather than technical issues of IT systems are studied (Benbasat, Goldstein, & Mead, 1987). It enables a phenomenon to be studied in its natural setting, and a relatively full understanding of the nature and complexity of the complete phenomenon can be generated. Furthermore, a case study is especially suited for situations where the variables are still unknown (Voss et al., 2002), which is true for the interplay of IT systems and continuous improvement. Case research was thus chosen for conducting the study.

An important question is how many case studies should be conducted. The fewer the case studies the greater is the opportunity for depth of observation. However, multiple cases can augment external validity and can prevent observer bias (Voss et al., 2002). With a single case study the possibility to generalize the conclusions is limited, and there is a risk of misjudging of a single event (Leonard-Barton, 1990). On the other hand, the case study requires considerable depth to allow for comparison with prevalent literature (McCutcheon & Meredith, 1993), and within the scope of a master thesis it was concluded that a single case study would best allow for the depth that this explorative study requires.

Choice of case

When selecting case the concept of population defines the set of entities from which the research sample is to be drawn (Eisenhardt, 1989), and in defining the population it is important to consider what parameters and factors that are to be held constant (Voss et al., 2002). In order to study how IT systems affect continuous improvement, it is important that the case company employ both. However, it is not easy to tell if and how continuous improvement is practiced in an organization. This is due to the comprehensive nature of the concept. A company that supposedly implements Lean production might actually not be engaging in continuous improvement but instead just focuses on tools and methods of Lean production. By choosing a company that evidently has put substantial effort in continuous improvement, thus holding this parameter constant, the problem can be eliminated. Regarding IT systems, it is sufficient to establish that the case company is employing one for its operation.

On the grounds of being a Lean production pioneer, having developed its production system in collaboration with Toyota and being committed to continuous improvement for decades, a European machinery manufacturer was chosen for the study. At the request of the case company the thesis do not reveal its name, and it will here be called "the Company". In order not to disclose which company it is, details of what is manufactured are not provided and only relevant parts of the production system are described.

Preparations

Although the research question was initially defined in broad terms to enable a creative approach, it facilitated a clear focus (Eisenhardt, 1989). In case research the amount of data that can be collected is enormous and therefore a strong research focus is necessary (Voss et al., 2002), which was achieved by careful preparations. The theoretical background research was carried out by reading numerous books, articles and papers on the subject. A full picture of the research area has been obtained through keyword searching in several journal databases, further exploring in citation databases and through discussions with professors. Also, the study of company documents describing the Company's production system (CPS) has served as preparation.

It is of importance that the prime contact is someone senior enough to be able to open doors and to locate key interviewees (Voss et al., 2002), and the CFO proved to be highly helpful in this matter.

Conducting the case study

Triangulation, using several sources of data to study the same phenomenon, allows for "converging lines of inquiry", making the conclusions from the case study more convincing and accurate (Yin, 2003, p. 98). By using interviews, observations, informal conversations, internal documents and attending management meetings this case study essentially covers the full spectrum of data collection techniques proposed by Voss et al. (2002).

Having a formal script of questions was important to make sure no important angles of approaches were missed, but since the area of knowledge is rather unexplored, a high degree of flexibility was important. The interviews were semi-structured, which allows for development of idea according to sudden comprehensions of the matter (Myers & Newman, 2007). As basis for constructing the interviews the funnel model was used. Its advantage is that it starts with broad and open-ended questions first and as the interview progresses the questions become more specific (Voss et al., 2002), a model that proved necessary as some interviewees had quite strong opinions in the matter.

Choosing interviewees

When choosing interviewees it is important to make sure that "various voices" are represented (Myers & Newman, 2007). In order to facilitate this, representatives from all relevant hierarchical levels and functions were interviewed. The IT systems and Lean production operations cover and affect the all of the Company, but instead of studying the whole organization, the research focuses on situations where interesting linkages between the IT systems and continuous improvement are present, so that an analytical depth could be provided (Voss et al., 2002). Fourteen employees were interviewed with an average duration of one hour, and were conducted the 15th and 16th of March 2012. Several interviews were followed-up with emails and phone calls to obtain clarifications and confirmation of findings. A list of the interviewees is given in appendix A.

Questioning

The interview is a social encounter and minimizing social dissonance is important. By managing first impressions, adapting clothes and jargon to the position and personality of the interviewee (Myers & Newman, 2007), the quality of disclosure was improved. By also using phrases and terms from the CPS documents rather than the literature's recognized terms, a common understanding is created, enabling qualitative discussions.

Another important consideration in designing the research is the trade-off between efficiency and richness of data (Voss et al., 2002). The management of the IT system and the management of operations are separated into different functions at the Company, and questions regarding their respective field of work were essential, but also asking questions cross-wise, that is process questions to the IS & IT coordinator and IT questions to the production system development manager was very fruitful. However, as Voss et al. (2002) comment it can also be very time consuming and careful balancing had to be carried out.

The recording of data was first conducted using a recorder, but early on it was discovered that it made the interviewees less comfortable and free-spoken, and the recorder was thus replaced with note pad.

Observations

In order to obtain an overview of the Company, the study started off with a guided tour in which most of the manufacturing processes were observed. Later on as the interviews generated questions and interesting suggestions, more focused and detailed observations were conducted at two production lines. Since unauthorized visitors are not allowed to walk around the manufacturing facilities alone there was always someone around, responsible for the safety of the case study conductor. This responsibility was continually transferred between managers and workers depending on where the observations were conducted, and simply on who had time. This turned out to be positive as there was always someone around to ask what actually was observed, and the continuous transferring of responsibility facilitated for different points of view to be represented. The observations were recorded using a notepad and by taking photos.

Documenting and analyzing data

In order to maximize recall and facilitate follow-ups a detailed write-up from interviews and all impressions was conducted shortly after each day of data collection (Voss et al., 2002). As a single case study was conducted, conclusions are based on within-case analysis (Barratt, Choi, & Li, 2011) and comparison with literature in adjacent areas of research. By overlapping analysis and data collection, adaption of data collection to relevant issues was enabled, and a better understanding of the reality was captured. As patterns evolved the write-up was re-written several times until a full understanding was reached (McCutcheon & Meredith, 1993). The write-up was structured using what McCutcheon and Meredith (1993) call a logical tool, where logical connections among observed events are sought and interpreted. The thorough and structured write-up served as basis for the presentation of the case and laid foundation for analysis and conclusions. Through the process, hypotheses and concepts emerged and by continuously comparing those with the data a close fit was secured (Eisenhardt, 1989).

The literature review revealed a gap in research, but still there is literature in adjacent areas. As the study involves two different areas of research, a broad range of literature has been reviewed. As a single case study has been conducted, it is particularly important that the theory building research is linked to literature, and thus the emergent concepts, theories and hypothesis have been compared with the existing literature (Eisenhardt, 1989). The analysis of what is similar, what is different and why, has forced the research into deeper insights (Voss et al., 2002).

Quality and limitations

The quality of the research contribution is largely determined by the construct and content validity (McCutcheon & Meredith, 1993). By continuously coming back to and develop the literature background study in connection to the data collection and while analyzing the data, a good basis for construct and content validity was created.

Case studies brings problems with internal validity of proposed relationship, but is reduced by using triangulation of data. Although to some extent also mitigated by the triangulation of data, external validity is a bigger problem as a single case study is conducted in an unexplored field of study, and no previous cases are available for replication (McCutcheon & Meredith, 1993). The problem magnifies with the fact that this case study has been conducted by a single investigator (Eisenhardt, 1989). Although to some extent mitigated by the comparison with adjacent literature, it limits the possibility to generalize findings and conclusions.

Relatively early it became obvious that the number of IT systems at the Company is numerous and that they are differing not only between workshops, but even between production lines. Although mapping all IT systems and their interrelations would have given a good overview, it would have been extremely time demanding and would add little value to the study.

4. Context of the case

The Company is a leading European machinery manufacturer with operations all over the world. The Company delivers finished products to the market, while the studied manufacturing site is one of many throughout the world that produce components for these. As it cannot be revealed which company is studied, details on what is manufactured are not provided and only the parts of the production system that are relevant for this case study are described.

The Company's Production System

For decades the Company has developed its production system in collaboration with Toyota. There are academic publications that indicate the similarity between the CPS and the TPS. For example, a recently published peer-reviewed article empirically shows that the influences from the TPS have become increasingly distinct and today the CPS is similar to the TPS. Although the different manufacturing sites are producing different components of the products at different geographical locations, they are all managed and deeply characterized by the CPS. Below follows a brief description of parts of the CPS, all drawn from company documents.

The CPS builds on a number of principles. One is to achieve a "normal state", implying a striving towards a state where work is always performed the same way according to standards in a defined takt. This facilitates the detection of deviations, problems and failures so that the Company can continue to challenge and streamline processes through continuous improvements. Different visualization techniques enable easy access to progress information. When deviations are discovered, a reaction is activated immediately so that important information about the problem is secured, and if necessary the working standard is changed. This is called real time management at the Company. The takt is determined by the demand from customers so that overproduction is avoided and deviations can be discovered more easily.

A second principle is "consumption driven production" and is a mechanism to avoid wasteful overproduction. Small batch sizes, minimized buffer stocks and short cycle times enable time and quantity of production to be regulated according to demand signals from customers. An information flow is following the physical flow in order to create a simple and secure connection between processes.

A third principle is "continuous improvement" and implies continuously challenging and improving the normal state; eliminating waste from overproduction, unnecessary operations and transports, stocks, failures, waiting times and unused knowledge. The process improvements and standard refinements are built upon facts rather than intuition. By lowering the takt time, shortening the lead times or removing a working position, the processes are continuously challenged and improvement prospects are made visible.

The Company also has a set of values where the "respect for the individual" is important.

The Company's IT systems

Since the introduction of IT systems, the Company had them decentralized and adapted to local conditions. Around year 2000 the case site and the headquarter site started to phase out local applications, homogenizing and standardizing the software systems and the way they are used, to integrate their respective systems. IT systems are bought in modules and further developed and integrated with the other systems by a fully owned subsidiary which will here be called ITdev. The standardizing of systems is a pursuit towards a common system across production sites, and the motive is to simplify the work for IT system module vendors and for ITdev. The financial and administrative system at the case site is to a large extent shared with the headquarter site, and is connected with a system that manages the ordering of components and products. This system is in turn connected to the material handling systems, including logistics systems, assembly systems and controlling systems. A superior material and planning system at the headquarter site receives orders from sales offices around the world and allocate work orders to the production sites. The work orders generate lists for automatic and manual distribution of goods to the assembly and manufacturing shops within the factory, sent via the material handling systems. The work orders are detailed and include specifications of how the component is to be configured and constitute the basis for assembly configurations. They are transferred to local workshop systems that control the work for operators and assemblers.

The IT system is not capable to follow the components for the assembly processes but as soon as the main body of a component is welded, it is tagged with a traceable id. From work order to goods ordering to internal distributions, the IT process is automated and in the normal state no manual data entry is needed after the order is put at the sales office. All of the organizational functions are connected via the IT systems and although it is constructed by separate modules, it generally works like one big entity where the different modules are connected via links and administered via the superior system.

IT development policy

Some IT systems are developed in-house while others are purchased. The decision to buy modules instead of a pre-integrated system seems to be a deliberate strategy. The CFO emphasizes its importance by contrasting its benefits with the negative outcome from an outsourcing strategy:

"Companies using for example SAP have to adapt their processes according to the IT system, while [the Company] can purchase systems that are adapted to the processes" (CFO, March 15, 2012)

The Company can thus select among several software module providers and choose the ones that are best fit for the operations and the CPS. By also further developing IT systems and carrying out maintenance in-house, they become more fit to the CPS than they would if these processes were outsourced. This way the systems are not controlling the operations, rather the needs of the operations are controlling the development of the IT system. The logistics development manager points out the strong positive effects of this setup:

"This prevents the IT system from hindering the [CPS]" (logistics development manager, March 15, 2012)

5. Findings

Intended Functions

The IT systems at the Company can be divided into two different groups. Systems in the first group are designed to support the movement of components and support the normal state. The systems in the second group are designed to directly support continuous improvements.

IT systems supporting the normal state

Safeguarding the normal state at the production lines is an important component in the CPS, and especially for continuous improvement. By preserving a normal state where tasks are performed the same way every time without interruptions and failures, the Company can focus on improving the processes instead of engaging in fire fighting. Problems are easily detected and the gap between the current state and the optimal conditions is made visible. Furthermore, when a production line is able to achieve normal state long enough, the pace of production can be increased and more defects detected. Importantly, for these systems the management has minimized the manual data registration and has instead focused on automatic data registration of product movement.

Below follows a number of situations in which IT is used for safeguarding the normal state.

Sequence and takt time controlling

An important role of the IT systems is to control the sequence and takt time. The superior system receives work orders and optimizes the sequence to which they are to be produced. Also the speed of production is controlled with the system by deciding takt time at the lines. These tasks are complex and facilitated by the use of the IT system.

Automatic safeguard of stock units

When goods are received, they are automatically scanned and transported to the warehouse. As goods are needed in the assembly and manufacturing lines, they are automatically transferred to the internal distribution hub where forklifts and transportation trains pick them up. In the warehouse, goods are placed and picked up by automatic lifts. In order to safeguard access even though a lift would stop working, goods are automatically spread out on different shelves.

Safeguarding forklift and train transport accuracy

The forklifts and transportation trains are equipped with information terminals that inform the drivers where to go, what to pick up, and where to deliver. A scheduling system accounts for the required time for collecting goods at the warehouse and deliver at the production line, a process that can take 90 minutes to complete. The system reduces the number of incorrect deliveries, facilitates a punctual supply, creates predictability and safeguards the normal state.

The system also has direct effects on productivity as it minimizes the driving distances and utilizes the capacity more optimally. It reduced the required stock quantities and the required space for goods in the production area.

Safeguarding product pick up at the line

At some assembly lines the mounting of wrong articles can imply costly scrapping of components. Scrapping is not only costly because of the material waste, it also interrupts the flow. Preventing such mistakes has thus become an important matter for safeguarding the normal state, and the Company has developed several systems for secure pick-up of components before the mounting is performed.

At some lines operators use a bar code reader to scan a code on the component body, and a display indicates what articles should be mounted on the specific component. Next they scan a box at the line inventory and receive confirmation from the bar code reader that the box contains the right products for pick up.

At other lines, the scanning of the bar code on the component body triggers the barcode reader to send a signal to the line inventory shelf and the boxes containing the products to be picked up are lit up by spotlights. The light is switched off as soon as the operator has picked up the products, and if the hand is inserted into the wrong box the light there is turned red.

At yet other lines operators use a headset in which a voice specifies what products to pick up. Next, the worker confirms the pick-up in the microphone and the voice specifies the next item to pick up. Apart from safeguarding correct pick up, the system is also productivity enhancing as the order products are picked up in is configured so that the worker's movement is minimized, and without a product list hands are free and the work is faster.

Display systems

Many lines manufacture the specific attributes of all different component models and the work order flow alter between models continuously. The work that operators are to perform is changing accordingly, and it is thus important that the information process is well-functioning in order to secure the normal state. At some production lines, prior to the stage where the identification tag is attached, monitors connected to the sequence display the corresponding component model identification number of the present work. By seeing that number the operators know by heart or can look up in documents what work to perform. At other lines the sequence number generates a blueprint displayed on monitors and workers see in real time exactly what work to perform.

Also, at many lines a monitor display how well synchronized the line is to the takt; if it's working according to the required production pace, too fast or too slow.

By visualizing the present situation, operators are informed of their performance and actions to deviations can be taken in real time.

Vision systems

At robots lines where there is no identification tag, vision systems take photos of the component, identify the model type and accordingly determine what work to perform. Although the work orders carry this information too, the vision system safeguards for a sequence failure.

Vision systems are also used for quality assurance. At some lines robots are equipped with instruments to measure the position of the component, and precision work can be performed. At other manual lines, a photo is automatically taken after the processing and the computer system compares the photo with an ideal component according to the sequence, detecting potential failures.

Tracking failures via IT system to ensure quality standard

As the normal state implies that work is performed the same way every time, a defect implies that the process has either not been performed according to the standard operating procedure, or it is not ideally designed. Determining what has caused the defect is thus of great importance for continuously improving the processes. If the same defect is discovered on two components, the risk that other components have received the same defects is considerable. The paths through the production lines of the two defect components can be tracked using the IT system (at lines after the identification tag is attached). If an intersection is identified, the other components that have passed that station are tracked and subsequently quality checked. Importantly, the source of the failure is identified and the problem can be addressed. Furthermore, when operators discover a machine failure they can track down which components that passed the specific machine and who was operating it. This is especially useful in a painting workshop where components are not coming out in the order they enter.

Tracking scrapped products

Scrapping components is wasteful, and if the scrapping is a result of a malfunctioning process there is an improvement opportunity of that process. The scrapping is registered in an IT system, and once a month a report is sent to each workshop for analysis. Accordingly each workshop can determine if and where improvements are needed.

IT systems supporting continuous improvement

IT registration of deviations

One frequently used mechanism for registering deviations, especially at the assembly lines, is Andon cords. The assembly lines are moving at a speed according to the preset production pace and operators are to finish their work before their station reaches a certain marking where the next operation starts. If operators have problems assembling some part(s) they pull a cord attached to the roof called the Andon cord, and a display above the line indicates which assembly station have problems. The pull of the Andon cord indicates something is wrong; an operator is not working according to the standards and might need education, the standard way of working is not adequate, the standards documents are not explaining correctly how work is to be done, an assembly part is broken, the work is not sufficiently easy to execute, defects from previous lines or suppliers are discovered etc. The team leader pays careful attention to the display and come to help the operator. If the problem is solved before the station reaches the marking, the Andon cord is pulled again indicating problem solved. If the problem is not solved the cord is not pulled and the line stops by the marking: a stop period is started. Real time management is initiated immediately to see what went wrong and what can be improved so that the problem will not recur. If the source of the failure is a prior production line, the manager of that line is immediately contacted. This is of major importance since too long stops in production at one line generate imbalances in production of the whole plant.

An IT system is automatically registering the pull of the Andon cord, indicating which working station had problems at what time and the duration of the stop or problem period. The operator manually records what went wrong on a desktop station by the line. This generates statistics of problems and is analyzed by managers and presented on group level so that everyone can learn and improve. Stop times are discussed in the line groups at morning meetings the day after to generate improvement ideas. Meetings are subsequently held at each hierarchical level to go through the important failures, stop times and improvements from the day before, using the statistics as basis for discussions. The Andon cord pull tracking system is also used for locating where the production speed can be accelerated or rationalizations can be made. If there is less than four minutes of stop time per day for a long period of time, the production speed will be increased or a production position will be removed from that line, increasing the workload and new defects of the standard way of working will be discovered. By accumulating data the managers are able to analyze what is wrong in the process and address it at the line. Every week a report of all major production disturbances and recurring problems is structured, compiled and discussed at the lines. The report helps the operators and managers to see where improvements are needed.

Dysfunctions of IT Systems and the IT Strategy

Some of the intended effects of the IT systems are not achieved, and also the effects of the IT strategy deviate from what is intended. The reason for retaining the IT development in-house is to make sure it stays fit to the CPS, but several signals indicate IT changes is a time consuming process that can hinder continuous improvement efforts. Although IT systems are designed to either secure the normal state or directly support continuous improvement, there are signals indicating that they are instead hindering the operations and add waste. There is open criticism against the dysfunctions and the production system development manager questions the Company's dependence on the systems:

"I wonder sometimes why we have an IT system at all; we must always question its existence" (production system development manager, March 16, 2012).

This section outlines the dysfunctions and the actual effects of the IT systems and the IT strategy will be contrasted with the outcomes they were designed to have.

The IT strategy has an inverse effect

Although retaining the IT development in-house is strategically aimed to make the IT system better fit for the CPS, there are signals of an opposite effect.The IT strategy has two aspects that counteract its purpose. First, when continuous improvements require IT systems to be changed, the process of doing that is time consuming since the Company uses a highly structured process for IT changes. The desired IT change is specified in a change request and the required time for writing it depends on the magnitude of the change, the experience of the worker etc. The change request is sent to the IT development committee, which comprises managers from the production sites sharing the IT systems. The description of the problem and proposed solution needs to be of high quality; otherwise it is rejected and sent back. The IT committee examines the description quality, determine the worth of the change, and pass it on to ITdev for an assessment of required time and investment. The IT committee and ITdev use almost a month to analyze and decide on the change and its priority. The required time for changing a system depends on the nature of the change and which IT system that is to be changed. The committee prioritizes among change requests where productivity improving and quality improving projects receive high priority. Changes are implemented in one out of three to four releases per year while urgent changes can also be patched.

The multistage process is time consuming and especially the implementation phase is criticized for taking too long. Essentially a statement by the logistics development manager emphasizes just how time consuming an IT system change can be:

“A good idea should not take more than one year to implement” (logistics development manager, March 15, 2012)

When improvements of IT systems are made as part of process improvements, the time consuming change process contains the Company’s operations in a less productive state than is available. Furthermore it can have a negative effect on the incentive for improvement suggestions if a good idea for change ends up in the queue, and thus in the long run there is a risk that fewer improvements are suggested.

Second, the common system pursuit and phasing out of local applications implies that the number of shared IT systems is increasing. Thus the number of people that have to agree on IT changes are increasing, creating a risk of a number of problems. The required time to analyze and decide on changes can be extended. A proposed change might be beneficial at one site but not at another, and thus productivity-enhancing changes might not be implemented. There is also the risk of the opposite; non-productivity-enhancing changes are forced on one site, wasting valuable time. However, there is also a positive side effect; as representatives from the different production sites discuss the matters of IT systems and their relations to operations, sometimes process improvement opportunities are discovered.

IT systems designed to secure normal state can be hindering and add waste

There were a few signals indicating that the IT systems securing the normal state were not working properly. Although uncommon, failing IT systems sometimes cause production stops and even elementary dysfunctions were reported; off-schedule virus protection updates at the desktop stations by the line have caused production stops. In this way the IT systems that are to secure the normal state hinder operations and even add waste. However, these dysfunctions seem to have been exceptions and the overall impression of IT systems designed to support the normal state is that it is mostly well functioning.

IT systems designed to support continuous improvement have an inverse effect

Although the IT registration of deviations is designed to be instrumental for continuous improvement, there are signals indicating they are adding wasteful tasks. The two main components of the system are collecting and analyzing information, and both add waste to operations.

In the process of collecting information, four wasteful tasks were found. First, the pull of an Andon cord is not visible at the managers' desktop and in case of a large failure, operators are required to call the manager, thus adding an unnecessary process. Second, it is not possible to register the reason for the Andon pull in the system that automatically registers the pull and stop time. Instead this is registered in a separate system, which decrease the overview and more time is required for analysis. Third, the operators are also required to register the failures manually on a notice board. This is done to keep statistics on the source of the failures; the present production line, a prior production line, a supplier of parts etc. Fourth, every morning all line managers present the failure statistics from the day before on a meeting with the work shop manager. Before the meeting, the failure statistics are manually entered in yet another IT system to produce the information material for the meeting. Workers and managers are critical as to why all these systems are not integrated.

In analyzing information, operators and managers on the shop floor are dissatisfied with the large amount of information handling. The production system development manager emphasizes this and argues that continuous improvement is hindered by this time consuming process:

"We are logging quality deviations, we are logging stop times, we manually add comments, and get a long list of what happened. It is more information than we can handle, it takes a lot of time to sort out what is important, and it is hard to analyze. We need to be critical to what we are logging. It constrains us from improving, it takes too much time" (production system development manager, March 16, 2012)

Compared to real time management, the improvement of processes via the IT system is unambiguously more time consuming. The fact that continuously improving processes is part of everyday work at the Company became obvious early on in the case study. While observing the interaction between IT and the CPS on one of the assembly lines, there was an accident at one of the working stations. As a worker bent down to attach a product on the underside of a component, she almost stuck her eye on the end of a cable tie. Immediately the worker stopped the line, and the whole team gathered by the station where the accident occurred. They went through what happened and decided what needed to be changed in the specific working procedure to eliminate the risk of sticking the eye on the cable tie. One worker was given the responsibility to change the working procedure descriptions. After a few minutes the line was running again and the change of the process was implemented and standardized. The production system development manager argues real time management should replace the IT logging:

"By replacing logging of problems with real time management we get keener on solving problems" (production system development manager, March 16, 2012)

Furthermore, by using IT systems unknown complications are hidden and it can be hard to know who has fed the system with information. Thus, solving the problems takes a lot of time.

Summary of Findings

The IT development strategy is designed to support the CPS but works inversely

The decision to develop IT systems in-house is strategically aimed to make them better fit for the CPS. However, when process improvements are dependent on changes in the IT systems the process of doing that is lengthy, which contains the Company in a less productive state than available and lowers incentives for proposing changes. Furthermore, the pursuit of a common system and phasing out of local applications can be counteractive for the CPS as IT adjustments might hinder productive process change and/or force unproductive process changes on sites.

IT systems safeguarding the normal state add waste but are mostly well functioning

IT systems support processes to work without interruptions and failures, safeguarding the normal state on production lines so that continuous improvements are enabled. Although the IT systems are sometimes failing and add waste, they are mostly well functioning.

IT systems designed to support continuous improvement have an inverse effect

The Company uses an IT system to automatically register Andon cord pulls to track problems so that problem patterns can be analyzed. However, the system adds several time consuming non-value adding tasks in the processes of collecting data and analysis of the generated information, and the Company is thus restrained from improving processes.

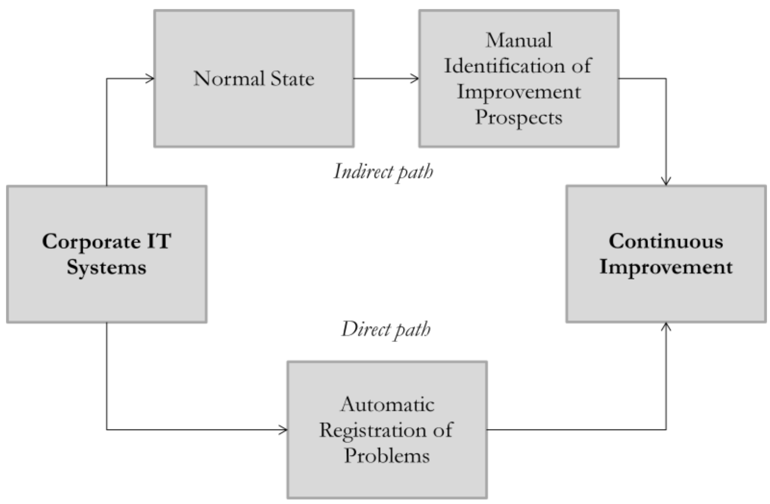
6. Discussion and Conclusion

This thesis aims to answer the question "in what ways can corporate IT systems be hindering and/or supporting continuous improvement efforts?". The findings suggest that the influence is both stemming from the systems per se and from the development of the systems. Effects from IT systems per se involves the effects from IT systems designed to support continuous improvement, both directly through the Andon cord pull registration system and indirectly via IT systems supporting the normal state. The IT system development effects on continuous improvement derive from situations where continuous improvement efforts require changes of the IT systems.

The findings establish a foundation for discussion, which generate three propositions. This section first discusses the two different types of IT systems and their effects on continuous improvement and the development process and its fit to continuous improvement; each followed by propositions. Secondly, managerial implications of the propositions are given followed by suggestions for future research.

The Effects of IT Systems on Continuous Improvement

The impact of IT systems on continuous improvement can be divided into direct and indirect factors. These are shown in model 1 below. The indirect path implies that the use of IT systems supporting the normal state of production facilitates manual identification of improvement prospects and thus continuous improvement. The direct path involves systems designed to directly support continuous improvement, essentially the automatic IT system of Andon pull registration.



Model 1

The indirect effect of IT systems on continuous improvement

The indirect impact of IT systems on continuous improvement involves a process in two steps. First, the condition of the normal state is influenced by several different IT system functions. Second, the condition of the normal state influences how easily workers can identify improvement prospects and thus continuous improvement is either facilitated or inhibited.

Bell (2006) suggests that IT systems are used for stabilizing production, and the Company use numerous systems for this purpose (i.e. supporting the normal state). Several authors argue that the large amount of data entries required by IT systems is a source of waste (e.g. Vollman et al., 2005; Bell, 2006), and the case study indicates that IT systems are sometimes failing, hinder operations and thus have a negative effect on the normal state and add waste. However, these problems are few and by for instance using automatic registration of product movement, the systems require few manual data entries. In line with arguments by Bell (2006), the importance of planning is high as there is not much room for failures in the consumption driven production environment at the Company, and the IT systems play an important part in this. A rather restrained attitude towards manual tracking of processes and movements circumvent wasteful IT activities, which in turn stabilizes production.

In line with suggestions by Spear and Bowen (1999) and Bell (2006) production stability facilitates a standardized way of working, which in turn encourages continuous improvement. Improvement prospects are more easily discovered and production pace can be increased, facilitating the discovery of yet more improvement prospects. Furthermore, with few interruptions in the processes, time is saved which can be used either to increase the pace of the production or to discover more improvement prospects. Although some negative indirect impacts on continuous improvement can be identified, it is mostly positive and working properly. Thus, the systems designed to support the normal state are effective, the indirect influences on continuous improvement are positive and the indirect path is working properly.

Proposition I

"IT systems designed to support the normal state positively enhance manual identification of improvement prospects and continuous improvement"

The direct impact of IT systems on continuous improvement

The direct impact comes from IT systems designed to directly support continuous improvement; the automatic Andon pull registration system. In line with suggestions by Bell (2006) the automatic capture of data is applied in order for causal relationships to be evaluated, so that processes can be improved accordingly. As the automatic Andon pull registration system illuminate problems, deviations and their patterns, the direct system do exert positive influence on continuous improvement. However, three negative influencing factors stemming from the system can be identified.

First, the four wasteful tasks of handling the data wastes time that otherwise could have been used for continuous improvement efforts. In line with the general opinion this IT system adds wasteful activities (e.g. Piszczalski, 2000; Sugimori et al., 1977; Vollman et al., 2005), and specifically in line with Bell (2006) the improper application of this IT system adds almost exclusively wasteful tasks.

Second, the resulting data from the system is extensive and time consuming to analyze. Bell (2006) argued that the collected data only adds value if it is transformed into the right information to answer the questions being asked, and the Andon pull registration system is not sufficiently competent to do this. The result is unstructured data that is excessive and sometimes unmanageable (Piszczalski, 2000; Ward, 2005), and thus difficult to act on. The dysfunctional system not only obstructs improvement efforts based on the collected information, it also wastes time.

Third, the vast time required for collecting and acting on information from the Andon pull registration system and the fact that managers are responsible for analyzing the data suggest that workers are deprived of time and empowerment in regard to continuous improvement. Considering that the meta-system of improvement is essential for motivation (New, 2007) and that especially the responsible autonomy increases motivation (Antonakis & de Treville, 2006), workers' reduced engagement in improvement efforts have negative effects on their motivation. While the TPS is deeply concerned about the human aspects, most literature on Lean production has been neglecting it. Sugimori et al. (1977) argued that letting shop floor workers stop the line in case of failure to immediately initiate an improvement effort is an essential part of Toyota's respect for human systems. Respect for people is fundamental for the TPS (Liker, 2004), and is also one of the core values at the Company. Jidoka is called real time management at the Company and the findings suggest it is effective. Since the positive motivational effect requires procedure designs to be developed by workers themselves, making them more engaged in following top-down designed work procedures bares the risk of discontent and lower performance (Adler, 1993). In the end the lower motivation could also have the effect of restraining valuable improvement suggestions.

Thus, the direct impacts on continuous improvement are mostly negative and the direct path is not working properly. The IT systems designed to directly support continuous improvement seem uncomplicated to improve, but the problem with lower motivation and performance would remain.

Proposition II

IT systems designed to directly support continuous improvement might imply a negative effect on worker motivation and performance, potentially restraining improvement suggestions.

IT System Development Effects on Continuous Improvement

The IT system development effects on continuous improvement materialize when continuous improvement efforts require IT system changes. The case study suggests that the Company's customizing of IT systems with individually purchased modules and retained IT development in-house, instead of buying an off-the-shelf ERP system, is a strategy to prevent IT from counteracting the CPS and thus continuous improvement. With the current IT strategy, the Company avoids a number of counteractive effects that an off-the-shelf ERP system would bring on continuous improvement. The difficulty in changing processes when off-the-shelf ERP systems are implemented (e.g. Bartholomew, 1999; Buckhout et al., 1999; Ward, 2005), general performance problems inherent with off-the-shelf ERP systems like organizational misfits (Soh et al., 2000) and basic deficiencies of the systems are avoided. Furthermore, performance deteriorations from having to change processes and thus departure from Lean production operations, and performance deteriorations caused by difficult adjustments of ERP systems (Hong & Kim, 2002) are also avoided. By not following the general trend of implementing an off-the-shelf ERP system, the Company is thus avoiding a range of problems that would counteract continuous improvement. However, the case study suggests that in-house development of IT systems has embedded other aspects of inflexibility instead, and brought effects that counteract continuous improvement. When process improvements require an IT change, the lengthy and bureaucratic change process detains the Company in less productive processes and can even restrain suggestions of process improvements. The intentions of the IT strategy are not met and it even has a reverse effect, counteracting continuous improvement. The fact that the flawed automatic Andon pull registration system has not been changed can be seen as a manifestation of this. The system's two first negative influencing factors are wasteful and seem to be "low hanging fruit" in terms of continuous improvement, but have not been taken care of. The reason is likely to be that the process of changing it is too lengthy and complicated to encourage workers to carry it out. An important insight of this research, contributing to the management literature is that a customized IT system is not a guarantee for a fit to continuous improvement.

Proposition III

Even in-house development of IT systems can counteract continuous improvement.

Conclusion

This thesis aims to answer the question "in what ways can corporate IT systems be hindering and/or supporting continuous improvement efforts?". As the methodology section outlined, especially the fact that a single case study was carried out and a single researcher was conducting it limit the opportunity for generalization. Nevertheless, the findings establish a foundation for discussion, which generate propositions.

The IT systems effects on continuous improvement are both stemming from the systems per se and from the development of the systems. Effects from IT systems per se involves the effects from IT systems designed to support continuous improvement, both indirectly via IT systems supporting the normal state and directly through an Andon cord pull registration system. It is proposed that IT systems designed to support the normal state positively enhance manual identification of improvement prospects and thus indirectly continuous improvement. Furthermore, it is proposed that IT systems designed to directly support continuous improvement might be instrumental if well-designed, but the mere use of the system implies a negative effect on worker motivation which potentially restrains improvement suggestions. The IT system development effects on continuous improvement derive from situations where continuous improvement efforts require changes of the IT systems. It is proposed that even in-house development of IT systems can counteract continuous improvement.

Implications for Managers

The three managerial implications drawn from this discussion are applicable for organizations that engage or plan to engage in continuous improvement.

Managerial implication I

Organizations should utilize IT systems to support a normal state of production. They facilitate identification of failures, abnormalities and problems. Furthermore, they also manage the complexity inherent in optimizing the sequence of manufacturing. The result is an environment in which real time management for continuous improvement is facilitated.

Managerial implication II

At the Company, the criticism of workers and managers against the IT systems designed to automatically generate suggestions for continuous improvement efforts (the automatic registration of Andon pulls), culminates in suggestions of abandoning it and exclusively engage in manual identification and implementation of improvement prospects (real time management). Considering the positive indirect impact from IT systems securing the normal state, the effectiveness of real time management and the three negative direct impacts from IT systems designed to support continuous improvement, an exclusive focus on the indirect path in model 1 should be more effective. However, Bell (2006) argues that some problems require an empirical and rigorous approach relying on gathering and analyzing of process data, and the system do to some extent assist problem illumination at the Company. It seems unproblematic to change the Andon pull registration system and make it less wasteful. It could thus be an effective system for automatic generation of continuous improvement suggestions. However, independent of its efficiency, using such system can imply that workers engage less in continuous improvement efforts and thus become less motivated. The effects can be lower performance and fewer improvement suggestions, leading to worse performance development over time. The IT strategy decision of using IT systems for direct support to continuous improvement must not only be based on the potential positive effects on continuous improvement suggestions, it also has to be based on an evaluation of the magnitude of the negative effects from lower worker motivation.

Managerial implication III

It requires more similar studies and comparative studies on the effects on continuous improvement in companies using off-the-shelf systems to determine which strategy gives the best opportunities for non-counteractive IT systems. The issue becomes important when continuous improvement efforts require IT systems to be changed, and it is reasonable to argue that in-house development of IT systems should facilitate a better fit for continuous improvement. This however requires an effective IT system development process and collaboration between the manufacturing workers, engineers and the IT department. The problem of a lengthy and bureaucratic change process, detaining the Company in less productive processes and restraining process improvements suggests that the process has to be shortened and simplified. By extending the IT committee with representatives from ITdev and initiators of IT changes in respective cases, several transfers between stages in the process could be omitted and the process time shortened. The arrangement would also facilitate accurate understanding of improvement prospects. Workers would not have to write detailed change request documents and IT engineers would receive first hand information. In the end IT systems would become better adapted to processes, and more supporting for continuous improvement. Furthermore, it would improve collaboration between workers and engineers in manufacturing and IT engineers, which also would facilitate a better fit of IT systems to continuous improvement.

Future Research

The lack of empirical studies in the field of continuous improvement and IT systems calls for more. It would be particularly interesting to compare the results of this study regarding the fit of the IT strategy and continuous improvement, with results from one that researches the same in a company using an off-the-shelf ERP system. This would shed light on and give nuance to the discussion of an ideal IT strategy. Furthermore, testing the second proposition with quantitative studies, examining the motivation of workers that are exposed to IT systems designed to directly support continuous improvement would be interesting. Also comparative studies of similar cases in different organizations and industries would enable o validate and test the propositions and the managerial implications of this thesis.

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Appendix A

The presented order of the interviewees is the chronological order in which the interviews were conducted.

15 march 2012:

Workshop manager top coat paint shop

Visitor guide

Controller

IS & IT coordinator

CFO

Logistics development manager

16 march 2012:

Production system development manager

Production manager

Team leader assembly line

Production engineer

Production engineer

It engineer ITdev

Production manager

Production manager