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WASTE IDENTIFICATION AND MEASUREMENT AS A FIRST STEP TOWARDS LEAN MANAGEMENT

Abstract. Lean Management (LM), a modern approach to business, has been gaining importance since the beginning of the 21st century. Lean Manufacturing used by the Japanese automakers continuously seeks to improve business processes by reducing amounts of waste in the long term. Many LM implementations have been spectacular successes, contributing to companies' increased profitability, reduced inventories and manufacturing times, as well as fewer in-house operations.

This article deals with a step-by-step implementation of Lean Management in a Poland-based manufacturer owned by a transnational concern. The waste identification and measurement method presented in the article can be used by practically any traditionally managed firm. Gradual elimination of waste (*muda*) brings a firm's conventional model of management closer to the Lean Management concept, promising measurable benefits even if the firm is not ready to take further steps into Lean Management.

Keywords: Lean Accounting, waste measurement and elimination, value stream costing.

1. INTRODUCTION

When the European and US firms faced fierce Japanese competition in the 1980s, their managers realised that their accounting systems failed to provide them with timely and correct information they needed to plan, control and make decisions. The traditional cost accounting systems supporting the operations of many firms in the USA and Europe fell short of meeting the needs of organizations that had to cope with dynamically and constantly changing economic environments characterised by ever decreasing products' life cycles and hyper-competition calling for competitive strategies focused on customers, quality, time and products' prices (Szychta, 2007). With the fast and timely fulfilment of customers' orders becoming a priority, the need appeared for efficient, faultless and speedy production processes. Enterprises were forced to replace overproduction, high costs of inventories and warehouse losses with smaller lots made "just-in-time."

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At the turn of the 20^{th} century a modern approach to business called Lean Management (LM) have risen in importance. This concept, common among Japanese automakers, stresses continuous improvement of processes by cutting waste in the long term (Bradford et al., 2001). A 2003 report published by the US Environmental Protection Agency estimated that 30-40% of the US companies used Lean Manufacturing practices, while another 5% fully implemented Lean Management. Drickhamer's study found that 55% of US companies had already launched Lean Manufacturing systems (Drickhamer, 2004). Many LM implementations have been spectacular successes, increasing companies' profitability, cutting their inventories, manufacturing times and numbers of the in-house operations. What they also have shown, though, is that LM can produce positive and sustainable results provided that its theoretical requirements are fulfilled systematically for several years and the implementation affects all elements of the management system rather than trying to upgrade the manufacturing component alone.

This article discusses a step-by-step implementation of Lean Management illustrated by a Poland-based manufacturer owned by a transnational concern. The waste identification and management method presented here applies to practically any traditionally managed firm. Gradual elimination of waste brings a conventional management model closer to Lean Management, promising measurable benefits even if the organization is not ready to reach for more advanced LM practices.

2. LEAN MANAGEMENT AND ITS CHARACTERISTICS

When faced with crisis, more firms tend to consider a sequential implementation of Lean Manufacturing and Lean Accounting (LA). Lean Management is a response to the growing complexity of management processes that contributes to considerable waste (Japanese *muda*) of organizations' resources caused by activities that do not add value. The concept of Lean Management that the Japanese companies (Toyota) have implemented so successfully helps remove most no-added-value activities from the making or delivery of, respectively, products and services. Production processes are viewed from the customer's perspective as value streams (Sawyer, Williams, 2007). Value streams are sequentially arranged activities that must be performed for resources (materials, labour and information) to be transformed into products or services that the customers expect (Kroll, 2004).

For a lean enterprise aspiring to understand and deliver exactly what its customers need (Womack, Jones, 1996) inventories are a special type of waste. This attitude to inventory control comes with the Just-in-Time (JiT) method, which allows balancing output against actual demand and customers' preferences (a so called “pull production,” where the force “pulling products” through the production system is customer demand, as opposed to “push production,” where the driving factors are inventory levels or delivery dates – Maskell, Baggley, 2006).

JiT and Lean Manufacturing are so strongly interrelated that some authors use the term “Lean Manufacturing Production” as equivalently describing a JiT-based system of production (Horngren et al., 2008). JiT can be defined as a demand-pull production system, because each half-finished or finished product is only made when the market or the next phase of the production process needs it. JiT aims to provide customers with high-quality products made at possibly low costs on a timely basis.

Lean Management and Lean Manufacturing are inseparably connected with Lean Accounting (LA) that can be essentially described as (Maskell, Baggley, 2006, p. 36):

– timely delivery of vital and clear information needed to take decisions increasing customer value and the organization’s profitability, as well as improving cashflows;

– elimination of all waste inherent in traditional accounting processes;

– compliance with the financial accounting standards, as well as external and in-house regulations defining the financial reporting rules;

– support for human resource investments, distribution of necessary and vital information and promotion of culture focused on continuous improvements (*kaizen*) at each level of the organization.

Lean Management is implemented based on reports that aim at delivering information that constantly drives improvements. The financial and non-financial indicators in the reports should explain the total value of value streams in the organization, customer values (thus strengthening relations with customers) and product design (Michalak, 2009, p. 175). Production processes are controlled using visualised performance indicators, which are measured at both the factory and value stream levels. Tabulated, the indicators are available with weekly or daily frequency. All value-adding personnel can view the data, regardless of the company level it represents. The data are also discussed in more detail by the teams responsible for problem identification that constantly seek process-improving solutions. LA requires in the first place that the reports and information distributed be comprehensible for the recipients. The so-called ‘box scores’ used for presenting the results are one-page reports summarizing several key measures of value streams, such as capacity utilisation, the number of products per capita, sales, or the weekly costs of materials (Maskell, Kennedy, 2007). This approach to controlling and presenting company’s results is a major building block of *kaizen*, a continuous improvement concept underlying Lean Management and Lean Accounting.

Value management in LA is supported by financial and non-financial indicators, as well as cost accounting that shows values flowing through the entire organization rather than concentrating on particular products, processes or jobs (Michalak, 2009, p. 174). According to the LA concept, it is not the manufacturing time that determines product's cost, but the speed at which a unit product moves along a value stream. The primary source of financial information is accounting for the costs and the performance of a value stream. In this process, the direct costs are attributed to the stream generating a given group of products, whilst other costs that are not directly attributable to the value stream are treated as the enterprise-wide operating costs. An important part of LA is "target costing" where a product cost is the difference between the target price and the target profit margin, assuming a *muda*-free production process. The questions that production managers ask themselves are the following: "What will happen if all products we make are defect free; what will happen if we give up quality checks of the materials we purchase? Once the questions are answered, waste can be eliminated from production processes and the product's target cost becomes more achievable. President of Toyota Motor Corporation, Eiji Toyoda, used to say that raising prices by 10% is very difficult, but cutting costs by 10% is not a problem at all. Target costing internalising market and customer-oriented philosophy is a cost accounting method dovetailed with the LA assumptions" (Sobańska, 2010, p. 110).

In Lean Accounting, data are collected, measurements are made and cost are calculated at the cell level to drive the cycle of improvements that the value stream managers and their teams are responsible for in the first place. Performance is measured to pinpoint the areas for improvement, then the roots and costs of the identified problems are analysed and finally solutions are proposed. The last stage is monitoring of how the adjustments made work. If the expectations are met, then the pertinent procedures are changed and the operational costs and other information necessary for value stream management are updated accordingly. To implement Lean Manufacturing a company must adapt its accounting system towards Lean Thinking and ensure that the system itself is not a source of additional waste. For the changes related to Lean Thinking to be effective, they must focus on three areas of activity, i.e. management, production and accounting.

Implementation of Lean Management is a long-lasting process that needs to be gradually introduced to all components of the company's business. The question that is frequently asked concerns the best place for starting improvements and waste reduction. James P. Womack, the founder of the Lean Institute, advises against introducing Lean Management across the company at the same time. Most organizations choosing Lean Management follow his recommendation. They start with the production area and move along until they reach the financial and accounting departments. Other experts in the lean concept, Brian

Maskell and Robert Jenson, suggest that special caution be exercised when introducing Lean principles into the two departments. They also advise that the transition from traditional accounting systems towards an advanced LA model be gradual. To make the change smooth, B. Maskell and R. Jenson have developed a 4-Step Lean Accounting Maturity Model (Maskell, Jenson, 2000).

In the real world, many firms organised on Lean principles use traditional cost accounting methods and classical performance indicators. These hybrid organizations exist, because they are concerned about whether Lean Accounting will be able to perform the traditional financial reporting functions of accounting systems. Besides, many firms prefer to phase in this new management concept using a "small-steps method;" they start with waste identification and measurement, then they separate their value streams and finally introduce the principles of Lean Accounting.

3. WASTE IDENTIFICATION AND MEASUREMENT IN THE SELECTED FIRM – A CASE STUDY

The organization analysed in this article is a large transnational manufacturing concern with subsidiaries in many countries, including Poland. Until recently it has operated a traditional management system, typically applied to mass production conducted in an environment characterised by less dynamic competition. For a very long time, the concern's managers did not feel that the management model needed any modifications. Dynamically growing sales, particularly in Eastern European countries, gave them a sense of security and confirmed that their approach was the right one. Only the lessons that the Board learnt during the economic crisis in 2009 made it launch profound changes to the way of doing business. The *concern* is departing from its management model based on a mass-production philosophy to one appreciating a customer-oriented philosophy and the top management has decided to implement a lean production system. The Board believes that the changes will help improve product and process quality and will reduce the costs of innovation, operations and after-sale services, thus leading to the better satisfaction of customers' needs. As planned, the concern will need several years to become a fully lean organization. The project is supported by an external consulting firm, a leader in lean implementations in Europe.

The first stage of Lean implementation started in the mid-2010 and involved four factories that the concern runs in different countries. Because the implementation costs are high, the other subsidiaries will be reorganised based on the experience gained during the first project, without the support from the external consultants. The pilot group consisted of the concern's strategic factories, including one facility located in Poland. To coordinate the project activities, a team consisting of a Lean Manager acting as the project's top supervisor, production director, factory controller, and process engineers from particular production departments was assembled in addition to the external consultants. On an “as needed basis,” the team was additionally supported by the logistics director, quality director, machine operators, shift managers, production line managers, and maintenance staff. At this stage, project activities had the form of three-week workshops that the team had been preparing for several months before they started. The preparatory phase was necessary in order to create a possibly detailed data baseline (a database) with information on the in-house processes. The data selected for this database covered the previous 12 months. In particular, they were extracted to show the following: the production cost budgets; cost structure by cost type as well as broken down into fixed and variable costs; average wage rates paid to the production workers; utility rates paid for one kWh of energy, cubic meters of gas and water; average repair cost per unit of finished product; maintenance costs; component transportation costs. The technical information (the factory layout, the chart showing particular production departments and the location of individual machines and pieces of equipment on the shop floor, machinery and equipment idle times arising from the scheduled maintenance breaks and failures, manufacturing times by product, machine and department, duration of quality checks, absenteeism, use of energy and other utilities by a product, a machine and a department, rates of defects by a product, a machine and a component, workload rates of the in-house materials handling equipment, numbers of workers by department, numbers of machine operators, numbers of workers manning the production lines) was deemed as important as the financial data. During the database production period a gap between the factory data layout and the project’s needs was a frequent problem that was solved by rearranging the data. Because in several instances the necessary information was not available at all, it was generated by making estimations of other indicators. The problems encountered at this stage spurred the reorganization of the concern’s management accounting system.

The first stage of Lean implementation aimed to perform a cost deployment analysis, which was treated as a stepping stone towards the identification, elimination or limitation of the sources of waste. The concept of waste (*muda*) is essential to being able to understand the concept of Lean Management. Waste may be interpreted in many ways, but for the sake of the project it was defined as a wasteful use of resources, i.e. one that does not generate added value for the concern.

The project team identified five categories of waste by the type of resources used in the concern: waste of machines and equipment; waste of materials; waste of energy; waste of human resources and waste of processes.

The first category of *muda* concerns manufacturing times in the factory. The following main types of losses were identified:

– operation of machines and equipment interrupted by failures, changeovers, maintenance work, inspections;
– machines and equipment running more slowly than they could because of poor quality of the intermediate goods and raw materials, restarts, etc.;
– machines' productive time wasted when defective products are made or repaired;
– machines shut down for the scheduled breaks (workers being on vacation and holidays, etc.).

The second source of waste as identified during the project was the use of human resources. The following categories of losses were found:
– losses caused by inefficient management – excessive absenteeism, strikes, workers waiting for materials, instructions or decisions, unutilised and ignored creativity of the workers causing wastage of ideas and learning abilities;
– wasteful movements – activities not creating customer value, such as looking for parts, walking around the work station, bending down, reaching for things;
– inefficient workflow – production process planned and organized in a manner that prevents full capacity utilization of a production line, bottlenecks, unautomated processes;
– defective products – necessary repairs of defects and the fixing of errors, manufacture of defective products, designation of workers to repair the defective products, quality inspections of finished or half-finished products.

To facilitate the identification of the losses connected with human resources, production activities were subdivided into three categories: value-added operations, e.g. cutting, hole-making, welding, bending, painting, bonding, screwing in; semi-value added operations – holding, positioning, joining and non-added value operations – waiting, walking, turning, carrying, looking for, pushing, looking, lifting.

The third category of *muda* concerned the use of the direct and indirect production materials. Three types of losses were distinguished in this area: use of the direct production materials – defective products, losses caused by a restarted machine, excessive use of materials, obsolete materials; excessive use of the indirect materials; excessive use of spare parts and maintenance materials.

The fourth type of waste led to energy losses (all types of energy, i.e. electrical, heat, etc.). The following groups of losses were distinguished:
– energy wasted by a restarted machine;
– energy wasted because of poorly insulated buildings;
– technological heat loss;
– energy lost due to leaky installations;
– excessively automated production processes;
– losses caused by inappropriate working conditions – a lack of windows or few windows make energy consumption rise, because the working areas need artificial lighting then and the A/C systems are switched on more often.

The fifth and last category of *muda* grouped all resources that matched none of the four categories above. This category was very broadly termed ‘process waste’ and its components were:

– overproduction – the making of products that are not in demand generates the following types of *muda*: excessive storage and transportation costs, products’ growing obsolete, inappropriate processing of components, wasteful movements and, last but not least, defective products;
– wasteful transportation – the handling of the work-in-process materials, half-finished and finished products (e.g. on forklifts) lengthens manufacturing processes and increases costs beyond what is necessary (e.g. because of leasing payments for the forklifts or the wages paid to their operators);
– overstocking – excessive amounts of raw materials, work-in-progress materials or finished goods lengthen the lead times, products become obsolete and exposed to physical damage, production costs grow unreasonably and the capital embodied in inventories represent is frozen;
– mismanagement in the production area – inefficiently organized and setup production lines, machines and equipment and vast production floors generate losses connected with lighting, heating, depreciation, property tax and other levies.

The next stage of Lean implementation was a cost deployment analysis. To perform this analysis, its level of detail must be determined first. The options considered in this particular case were the following: factory costs; costs by cost centre and process costs.

In choosing the appropriate level of cost analysis factors such as the cost nature, the complexity of production processes and product characteristics must to be taken into account. After consultations with the factory’s staff, two centres generating costs directly attributable to production were selected: the mechanical department and the assembly department. In the course of work the project team assumed that, if need be, the level of cost analysis could be brought down to a production line or a process section, etc., or raised to investigate the factory-wide costs.

At the next stage, the cost deployment analysis concentrated on locating the loss-generating places (i.e. waste). To this end, the project team identified loss types (using the already available classification of waste sources) and attributed them to particular areas (the assembly department or the mechanical department; otherwise, if this was not possible, a loss was attributed to the whole factory). Then weights were assigned to each of the identified losses. To perform the procedure, the known areas of waste were subjected to a qualitative and quantitative analysis, which was one of the most difficult operations during the project. The analysis was largely based on the already established database, as well as using the knowledge and experience of production directors, process engineers, and department managers. Many line managers and machine operators were also interviewed to gather the necessary data. This activity led to the creation of a matrix of weights of the identified losses, which was provisionally called an A matrix.

The matrix A columns contain the cost centres (the mechanical and assembly departments and the entire factory), while its rows indicate loss types classified according to the five categories of waste. The weight of each loss is colour-coded: the red represents a very high level of waste, exceeding 100 000 euros a year; the yellow is significant waste, with losses estimated between 50 000 euros and 100 000 euros; the green denotes moderate waste, generating losses below 50 000 euros. The white colour means that a loss of the given type was not found. The main sources of waste in the factory were machines and equipment, human resources and processes. In total, 5 very significant (red) and 24 significant (yellow) categories of losses were identified. An organization going through transition to become a lean organization should analyse the weights of particular losses at least twice a year.

The third stage of the cost deployment analysis aimed to identify the original losses and to separate them from the secondary losses. Only the red and yellow losses in matrix A were examined. The green losses (moderate) were omitted from further analysis. They still need monitoring, though, because their weights may grow heavier in the future, moving the losses to higher categories (significant or very significant). The losses underlying other losses were placed in the rows of matrix B that shows the causal relationships between the earlier identified types of waste.

The losses originating from other losses are grouped in the matrix columns. The black cross in the matrix cells means that a quantifiable correlation between the particular types of losses was found. The red cross indicates that although the losses are correlated, a reliable estimation of their correlations is not possible for the lack of data. The red cross predominating in the matrix shows that the organization’s accounting management system is not efficient, because the system fails to support decisions that could either eliminate or at least limit waste. The correct identification of losses leading to other losses is crucial for the next stages of the cost deployment analysis, because the secondary losses are not likely to be eliminated, if their root causes remain unknown. Any errors made during this stage may lead to false conclusions about the real situation of the organization, thus prompting wrong decisions at all levels of management. The project team working in the factory being analysed managed to isolate a number of original losses, most of which were caused by machines and equipment. The low productivity of the hardware called for excessive stocks of materials and half-finished products to be maintained, as well as contributing to high rates of defects and affecting the labour costs. Most correlations between machine failures and the resulting defective products were found in the mechanical department.

The project team was also responsible for estimating (in financial terms) the portion of a secondary loss attributable to the root cause. The calculation data were obtained from the accounting system and during interviews with specialists and experts representing various fields (logistics, maintenance, or quality). The data were entered into matrix B, replacing the earlier crosses indicating causal relationships.

The fourth stage of the cost deployment analysis was used to produce matrix C. This matrix was to show the type of a cost (direct and indirect materials, labour, use of energy, depreciation, external services) and its value attributable to the distinguished categories of waste.

The rows are the identified categories of waste and the columns are the cost types. Accordingly, the totals in the columns indicate the overall cost of the given type generated by all *muda* categories distinguished, while the totals in the rows show the total value of losses (across all types of costs) caused by one category of waste. The analysis of the data presented in the cross section allowed estimating the total loss arising from wasted resources at 7.3 million zlotys a year, its main reasons being defects and waste (3.4 million zlotys a year), inadequately manned production lines (2.1 million zlotys) and activities failing to create customer value (1.3 million zlotys). Most losses were attributed to the mechanical department and their main cause was the direct materials. The primary cause of waste in the department was underperforming machines and equipment (frequently running below 60% of their capacity) and high rates of defects. As regards the assembly department, most losses were tracked to unproductive workers' time and their causes were non-value added operations (long quality checks and extended waiting periods, etc.) and relatively high absenteeism.

During the fifth stage the project team developed methods and tools for eliminating or reducing the losses. To each solution proposed its implementation costs and estimated savings were attached. If implemented, the selected solutions could bring the net savings of 1.7 million zlotys a year over a 12-month horizon (net of implementation costs), with additional future savings amounting to 3.5 million zlotys a year. The proposed tools were also capable of reducing the amount of the idle current assets (mainly represented by the stocks of raw materials and half-finished products) by 2.7 million zlotys.

To go ahead with the plan, the Board's approval is necessary. The twelve projects selected for the Polish factory are estimated at 3.7 million zlotys in savings a year, achievable within 3-5 years after their implementation. Most of the activities planned are 10-12 week-long workshops to be delivered by external consultants. Their main subjects concentrate on improving the performance of machines and equipment in the mechanical department, adjusting job instructions in the assembly department (with a view to eliminating the non-value added operations and increasing production line throughput), reorganizing the quality assurance system (by cutting quality check times without compromising product quality) and improving efficiency of the maintenance department.

The Board's approval of the organizational performance improvement plan, being the last act in the cost deployment analysis, is only a first step towards a truly lean organization. Never-ending improvements and unceasing efforts to create customer value require that the analysis be repeated with some regularity (twice a year at best), as this approach allows timely identification and elimination of the major sources of waste. The awareness of this requirement caused that the team of experts and specialists has not been disbanded. They continue to implement Lean practices on their own, without the assistance of the external consulting firm.

4. CONCLUSION

Working on the Lean project the team members have come to understand the role and importance that the management accounting system has for the concern. Most project participants have realised very clearly that the information the system holds is very helpful or even indispensable for making the correct decisions. However, an equally obvious finding has been that the present management accounting model is incapable of providing all vital information that a lean organization needs to manage its business. The most prominent problems highlighted are the following:

– the concern's management accounting system uses budgets negotiated between the particular departments and the top management. The negotiations usually refer to performance results achieved in the previous years (a zero base budgeting approach is not used). As a result, waste generated in the previous periods is built each time into successive budgets. This makes loss identification more difficult; losses are not discovered until negative differences between the actual and budgeted values appear;
– the standards established when budgets are being drawn up go on unchanged throughout the year. Considering that the economic environment and business conditions are subject to continuous changes, this increases the risk that the real values will considerably diverge from those planned, regardless of how well the concern performs;
– as well as being unable to effectively support strategic decision-making in the concern, the management accounting system stays in conflict with lean manufacturing practices, because it cannot generate reliable reports on the sources and amounts of waste;
– the present accounting system does not allow satisfactory measurements of what has been achieved through the remedial actions. In particular, it undervalues the costs of underperforming machines and equipment.

The above means that without appropriate modifications to the accounting system a full transformation into a lean organization is not possible. Lean Manufacturing practices must be accompanied by Lean Accounting solutions.

Therefore, implementation of the LA rules should be one of the next steps the concern needs to take on its way to becoming a lean organization. Having LA in place will enable the concern to make reliable effectiveness measurements of the implemented solutions, as well as aiding the value-adding processes it has already initiated.

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