AN APPROACH TO ACHIEVE OPERATIONAL EFFECTIVENESS AND SUSTAINABILITY REQUIREMENTS IN MANUFACTURING

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ABSTRACT

Sustainability is now an important part of manufacturing business. Keeping up with regulations is only the first stage of achieving sustainable manufacturing. To gain a competitive advantage, manufacturers need to move beyond this first stage and progress further. The different stages of sustainability are presented with emphasis on the second stage which requires aligning management systems with an environmental strategy. To achieve this, the authors have suggested a novel framework to formulate a robust environmental strategy. The proposed framework utilizes the techniques of Lean Six Sigma and Life Cycle Assessment. Proper alignment of these techniques will result in concurrently improving operational and environmental performance. The authors argue that the framework is needed in industry. To support this argument the authors examined the state of sustainability in 36 UK manufacturing businesses. The results revealed weak alignment of management systems and environmental strategy in most surveyed companies (87%)

Keywords: Sustainability, Manufacturing, Environment, Lean, Six Sigma, Life Cycle Assessment, Strategy.

1 INTRODUCTION

Garetti and Taisch (2012) define Sustainable Manufacturing as *"the set of technical and organisational solutions contributing to the development and implementation of innovative methods, practices and technologies, in the manufacturing field, for addressing the world-wide resources shortages, for mitigating the excess of environmental load and for enabling an environmentally benign lifecycle of products."*. Previous research (IMSS, 2011) show that most companies do not set sustainable practices as their priority because their focus is still on how to improve operational performance. Management techniques such as Lean and Six Sigma have been the main drive for improving operational performance. This research suggests that enhancing these techniques with life-cycle thinking would improve the environmental performance. A framework has, therefore, been designed to incorporate Lean Six Sigma (LSS) and Life-Cycle Assessment (LCA). However, prior to a full study of the framework, it was important to support the argument that it is needed in industry in the first place. Hence, the investigation starts with an assessment of 36 companies to determine their compliance with the second stage of sustainability.

2 LITERATURE REVIEW

A brief review is outlined to address the stages of sustainability and the main techniques used to construct the framework: LSS and LCA. As well as the role of strategy for successful integration.

2.1 The Stages of Sustainability

In the last decade, as the number of companies practicing or considering sustainability grew rapidly, researchers started to look at identifying the stages of sustainability to provide a road map for implementation. These stages also provide a good measure of the level of sustainability in an organization. Zadek (2004) identified these stages as: defensive, compliance, managerial, strategic, and civil. Wirtenberg et al. (2007) presented the stages of sustainability for building the sustainable company, as: (i)"Foundation": participating in strategy formulation and Involving top management. (ii) "Traction": system alignment and managing change. (iii) "Integration": holistic integration and broad stakeholder engagement. Lavery and Pennell (2012) have proposed an approach to progress through the stages of sustainability using a transformation road map. They suggest starting with "Prepare" where targets are set and policies developed. Then moving to "Design" where production efficiency and process design are reconsidered to find opportunities for sustainable practices. And finally, moving to the "Enable" step to develop best practice sharing process and establish measurements and metrics. Kashmanian et al. (2011) drew from these views and from personal experience to describe the stages of sustainability as:

- *Set strategic direction*. To align the company's sustainability and business strategies.
- *Improve operational performance*. To align the company's management systems and environmental performance strategies.
- *Improve value chain performance*. To recognise the breadth of the company's. environmental footprint and therefore the breadth of its sustainability strategy
- *Relate effectively to internal and external stakeholders*. To recognise that the company's sustainability strategy will benefit by not being exclusively internal.

2.2 Lean Six Sigma And Life-Cycle Assessment

Lean Manufacturing provides the cost-effective approach for managing operations while reducing wastes in processes. Six Sigma provides support for Lean to solve specific problems. Integrating the two was found to be beneficial (Assarlind, 2013). While the elimination of the seven process wastes, as identified by Womack et al. (1991), is a step towards sustainability, Lean Six Sigma's (LSS) approach needs to be improved to include the green wastes identified by Hines (2012): Greenhouse Gases, Eutrophication, Excessive Resource Usage, Excessive Water Usage, Excessive Power Usage, Pollution, Rubbish and poor health & safety. Moreover, LSS accounts only for what is perceived to be waste within the company's boundaries. The authors argue that to use resources and time to merely tackle wastes within a company's boundaries is perhaps not the best way to improve the environmental performance over the span of the life cycle. For example, if money is allocated to mitigate the waste of water, it is important to define the stage of the life-cycle at which water is wasted the most. A good case in point is the case study of a pair of Levi's jeans (Camp et al., 2010). It was found that in the whole life of the product 45% of water is consumed during the use stage by customers. As a result, the company shifted its focus to the use stage where large, and potentially inexpensive improvements could be made.

As stated, to have a greater impact on the life-cycle as a whole, the role of a life-cycle technique is essential. Life-Cycle Assessment (LCA) is a method to assess environmental impacts through all stages of a product's life-cycle, i.e. cradle to grave (Rebitzer et al., 2004). To avoid complexity in LCA studies in situations where resources and time are limited, a screening LCA could be conducted. Screening LCA is a simplified LCA method that requires less resources and time than a full LCA (Jensen and EEA, 1998).

2.3 The Role Of Strategy

Integrating multiple techniques requires a control strategy to ensure that they work in harmony. In this research, integrating LSS and LCA. Hill and Hill (2009) emphasised on the need for a well-defined strategy by showing the problem of having multiple functions within a company working without

proper integration. They argue: "*Lacking essential integration, the result is a compilation of distinct, functional strategies which sit side by side, layer on layer in the same corporate binder. Integration is not provided if, in fact, it was ever intended*". In that respect, an Environmental Strategy (ES) to integrate LSS and LCA is necessary.

3 CONCEPTUAL FRAMEWORK FOR INTEGRATING LSS AND LCA

3.1 Framework Description

The framework shown in Figure 1 consists of the ISO 14040 framework which is the standard approach to conducting LCA studies. Lean and Six Sigma methodologies are grouped together in a non-standard setting as there is no common model for LSS (Bendell, 2006). ES coordinates LSS and LCA to deliver the requirements of the Environmental Market (EM).

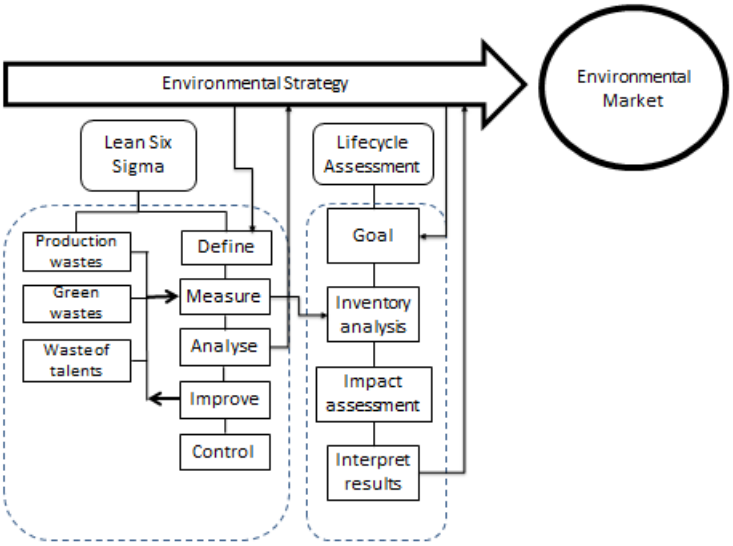

Figure 1. Aligning LSS, LCA and ES

3.2 Framework Use

A company needs first to define the requirements that would enable it to build successful relationships with stakeholders in the environmental market. ES goals are defined and the flow of information from LSS and LCA starts. ES delivers a course of decisions accordingly. For LCA, the goal defined will be the first phase of a LCA study, after which information about inventory and process will be analysed. Impact assessment and result interpretation will then be carried out to feed information to ES. ES in turn provides the outlook for a DMAIC improvement cycle starting with the Define stage.

The Measure, Analyse and Improve stages of the DMAIC cycle utilise a range of Lean and Six Sigma tools and techniques to eliminate the seven production wastes and the Green wastes. Another important type of waste to be considered is the loss of people's talent and complete involvement (Hines, 2012, Drew et al., 2004). The Measure stage provides data to LCA about local processes.

3.3 Framework Development

The initial proposal of this research has developed over time. The authors' previous work describes its foundations (Fargani et al., 2014). Additional developments were made based on literature reviews. However, specific information about linking LSS and LCA was not available and, therefore, collecting primary data was required. This will enable further developments to the framework and provide detailed understanding of its application. The data will be first used to justify the need for conducting this research by investigating whether manufacturing businesses are still struggling with the second stage of sustainability. The question we aim to answer is:

Are manufacturing companies aligning their management systems and environmental strategy according to academia's recommendations?

4 RESEARCH METHODOLOGY

Data from a survey questionnaire of 36 UK manufacturing companies was collected. As with most field research in operations management, the survey was faced with data sampling constraints and time limitation (DeHoratius and Rabinovich, 2011), which limited its scope. 240 manufacturing SMEs and large companies from 8 industrial sectors were contacted. At first, an email invitation using survey monkey was sent to 150 companies. However, the response rate was extremely low (1%) which required a change of distribution method. A phone call invitation before sending the questionnaire was used to contact a further 23 companies, which yielded an improved response rate of (15%). Simultaneously, fellow academics were asked to invite their contacts in industry to participate. 100 companies were emailed, all of whom responded within days. A total of (26%) responded making this approach very little time consuming and most successful. In total, a sample size of (36) was collected.

The depth of information was considered in the questionnaire design and was reduced to a level that promotes participation without compromising data quality. Four main areas were covered:

- Market conditions and requirements
- Operations management and performance
- Investments in development programs
- Environmental management

Most of the constructs used to measure this areas were adapted from the IMSS multi-item scales (IMSS, 2011). A pilot was sent to selected academics with research focused on manufacturing and environment to obtain appropriate feedback.

5 ANALYSIS AND RESULTS

5.1 Descriptive Statistics

The analysis start with general observations on the collected data. The first remark is the lack of participation by small companies (17%). Large companies responded the most (45.7%), but only 43% of them fully completed the questionnaire. The most skipped questions by large companies were about the size of annual Investments in development programs, 75% did not answer these questions. In comparison, medium companies answered most questions (77% completion) and small companies answered all the questions (100% completion).

In general, Lean is a widely practiced methodology in the sample population (63%) with a mean of 3.05 (based on 5 points Likert scale). Implementing Six Sigma has a mean of 2.35 and reported by (65%). LCA on the other hand was the least used with only 25% of participants using the technique.

5.2 Reliability

Before using the data collected for running the analysis, the reliability of the constructs had to be tested because the questionnaire was newly designed. The tests have been carried out using Cronbach's Alpha test. Field (2009) describes the acceptable level of alpha to be above 0.7. The reliability test was applied on all constructs. To provide an example of the process, two tests for the constructs (Environment) and (Operations) are given in this paper. (Operations) consists of the following items:

- What is the level of implementation of Lean?
- What is the level of implementation of Six Sigma?
- What is the level of product quality improvement?
- How much is the annual investment in processes and equipment?
- What is the level of delivery speed and reliability improvement?
- Workers' motivation improvement?
- Labour productivity improvement?

The reliability test for this construct produced a very low level of alpha (.287) which indicates that the measures were inconsistent. To find out what the problem was, each item was checked in terms of correlation to the total score. Correlation is a measure of the strength of association between variables.

The correlation analysis of (Operations) revealed a negative total-item correlation for the item 'Investments in improving processes and equipment' which was causing the low level of alpha. By deleting this item, a high level of alpha was obtained (.821). Therefore, this item is excluded from the analysis.

The second construct (Environment) includes the following items:

- What is the level of improvement in material, water and energy consumption ?
- What is the level of improvement in waste and pollution emissions?
- What certificates does the company acquire?
- Do you have an Environmental Management system?
- How much is the annual investment in environmental programs?

The alpha obtained for this construct was very low (.149). The item that was causing the low alpha was 'Investments in environmental sustainability programs'. Deleting this item increased the level of alpha to (.423). The item 'Having an EMS' was also affecting alpha and deleting it increased the level to (.611). However, the conflict of this item could be due to some companies working on reducing consumption and emissions without formally implementing an EMS. Therefore, the Alpha level of (.423) will be considered as acceptable since the number of items in the construct is relatively low and the average correlation between items is respectable (.407) (Field, 2009).

The reliability tests revealed some issues in the survey design. For example, data about the investments in improvement programs were inconsistent with other data. This could be caused by a limited access to financial information as the respondents were mostly production/quality managers (Boyer and Verma, 2000). Another limitation revealed is that the (Environment) construct is newly developed by the authors and not rigorously tested.

5.3 Aligning Management Systems

A positive answer to the research question would justify the need for the proposed framework. To determine whether a company is complying with the second stage of sustainability, the recommendations of Kashmanian et al. (2011) were evaluated:

- *Enhance awareness and engage employees.*

This was addressed in the questionnaire using three items that measure the level of 'Knowledge and involvement of employees', 'Employees' satisfaction' and 'environmental activities such as Green-day and cycle to work'. These variables are grouped as (Employees' engagement)

- *Develop metrics for sustainability by conducting LCA studies.*

This was addressed by a single item: a question whether the company conducted LCA.

- *Facilitate information exchange between corporate management and facilities.*

A general observation of missing answers and comments from participants were used to evaluate this point.

- *Establish facility sustainability standards.*

A single item was considered sufficient to measure this point and that is 'do you have an EMS in place?'

A company that is considered to have a good alignment of its management systems should have a total score of more than 23. This threshold was calculated based on scores achieved in : (i) employees' engagement, (ii) communication between departments, (iii) conducted LCA, and (iv) has an EMS. The results show that only 5 companies fulfilled the requirements of the second stage of sustainability (2 large, 2 Meduim and 1 small company). The mean score obtained by participating companies was low (Mean= 17.32, σ= 6.32). This positively answers the research question and strongly justifies the need for applying the proposed framework in manufacturing in order to fully comply with the requirements of the second stage.

6 CONCLUSION AND FUTURE WORK

This research's general aim is to assist manufacturing companies in reducing their environmental footprint. When a company allocates funding for environmental programs, it is important that this funding is used effectively. Using the proposed framework enables the company to view its internal and external opportunities and have a clear strategy on how to achieve greater impact with less money. Conducting the survey to empirically justify the need for the framework has been carried out. It was found that only 13% of the participating companies were complying with the second stage of sustainability as defined in prior research, i. e., to have good integration of management systems and environmental strategy.

The research project will now carry out an investigation into the characteristics that would make a company suitable for using the framework. For example, will it work better for SMEs or large companies? While the results gave a clear answer to the research question, issues such as inaccurate information arose during the reliability analysis . Bias remains an issue because the research methodology used a single source of information (the individual responding to the survey), "notably the possibility of subjective bias due to an individual's unique prospective and limited access to information" (Boyer and Verma, 2000). Therefore, In-depth semi-structured interviews will be carried out to ratify the current findings, and collect more data to Improve the framework further.

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