Competitiveness by integrating the green perspective in production – A review presenting challenges for research and industry

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ABSTRACT

Environmental concern has risen as an important topic in management research as well as within the manufacturing industry. The realization that environmental sustainability should be viewed from a value-adding perspective and not only from a regulatory or cost perspective has implied a dramatic change of focus when creating competitive strategies. In production system research, some argue that green is the next great leap after lean, and many publications on the synergies and contradictions of lean and green have been published. This paper aims at high-lighting relevant topics related to environmental sustainability within a production system from the view of academia as well as industry. A review of related research has been performed together with an orienting empirical study of three companies in Sweden. The result reveals that the holistic view is often lost due to trade-offs and uncertainty, implying that incorporating environmental sustainability in an organization becomes difficult. This indicates that there is a growing need for methodology and decision support tools for integrating the green perspective at all levels of the production system. The concepts of continuous improvements and "lean and green" are identified as favorable options to succeed with this integration, implying important areas for future research.

1. INTRODUCTION

The current global business environment implies a great challenge for producing companies to continuously adapt and improve their production systems. In this process, environmental sustainability has surfaced as the new competitive criteria. Historically, environmental management was primarily concerned with reacting to environmental legislation [1] and the development of the sustainability perspective has partly been in response to a desire to reduce potential liabilities. Lately, environmental sustainability has been fueled by opportunities in new markets as well as a demand from other stakeholders [2]. Within the manufacturing industry, there is no doubt that the importance of environmental performance has increased. The need for sustainability and a globally increasing product demand drive a gigantic need for technology and strategies that will reduce environmental impact [3, 4]. In Europe, one example of the numerous initiatives within this area is the Manufuture Platform [5] which has sustainable manufacturing as one of its four high-level objectives. Manufacturing companies now need to operate a business that is competitive as well as sustainable from a societal, environmental as well as economical perspective [6].

Research regarding environmental sustainability is being carried out at many institutions around the world, indicating the importance of the field. Many academic and industrial R&D activities focus on the product, but there is a clear need for further developing the knowledge about environment sustainability from a production system point of view. Hence, a research gap regarding *how* to best implement and integrate a "green" strategy to improve

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the environmental performance at all levels of a production system (all processes, resources, principles and methods included) has been identified. An extension of the lean concept to include further environmental perspectives is commonly considered to result in numerous positive synergies, but there are still obstacles to overcome. Therefore, this paper aims at reviewing important topics related to the environmental sustainability of a production system (illustrated in Figure 1).

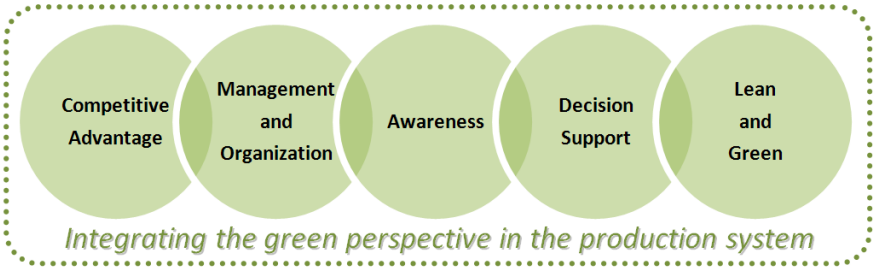

Figure 1: Reviewed topics related to environmental sustainability within a production system.

2. METHODOLOGY

This paper is based on a review of the research within the area of environmentally sustainable production. The studied material primarily includes journal articles from each relevant field (illustrated in Figure 1). The empiric data has been obtained during a company study of three manufacturing companies in Sweden; two automotive companies and one automotive parts supplier. Qualitative methods such as observations, individual interviews and group interviews have been used. To improve the general understanding of the area of environmental sustainability, open interviews were conducted. In addition, semi-structured interviews were carried out with representatives from different business units. In order to get a holistic view of the present situation in the companies, a total of 15 people in different positions within the companies were interviewed, ranging from production managers through LCA experts to assembly personnel. The questions were focused on five key areas, as illustrated in Figure 1. In addition, the lean and green concept was included as a separate area. To complement the qualitative information with quantitative facts about the environmental work at the companies as well as the progress and the results of this, material (including e.g. presentations, statistics, project reports, audits and meeting minutes) was collected and analyzed. All empiric data has served as a means to identify and analyze industrial challenges and possibilities.

3. RELATED RESEARCH

Porter & van der Linde [7] state that "An underlying logic links the environment, resource productivity, innovation, and competitiveness". However, the connection between the strategic view of corporate management and actual environmental activities in other parts of the organization is sometimes lacking. In this chapter, important areas related to the environmental performance of a production system are presented in an attempt to create an initial frame of reference and decrease the ambiguity. Most of these topics are included in O'Brien´s [8] suggestions for generic characteristics of a sustainable production system.

3.1 COMPETITIVENESS THROUGH ENVIRONMENTAL SUSTAINABILITY

Competitiveness can be described as creating high value by low costs, implying that value improvement and cost reduction are two important goals [3]. As stated by Porter & van der Linde [7], "How an industry responds to environmental problems may, in fact, be a leading indicator of its overall competitiveness". In the mid 90's, Hart [9] introduced his natural-resource based view of the firm, a theory of competitive advantage based on the firm's relationship to the natural environment. Even though the initial incentives with environmental improvements were often connected to regulatory pressures, companies have now realized the strategic competitive advantages from appropriate environmental strategies [10].

Porter & van der Linde [7] argue that pollution is a form of economical waste since it is a sign of inefficient processes which add cost but no value and they stress the importance of being an early mover recognizing the competitive benefits of environmental improvements. This has also been acknowledged by other researchers. Shrivastava [11] argues that environmental technologies should be seen as a competitive force and a tool for competitive advantage. Competitive advantages can according to Sarkis [10] occur from proactive measures by

including the environmental perspective in all functions connected to manufacturing. His view is that this will lead to win/win situations where improved environmental and financial performance improvements correlate. Competitiveness is ultimately closely connected to financial performance and one question many researcher now pose is "does it pay to be green?" [12], but since different strategies for environmental improvement may influence the result; a more specific question is "*when* does it pay to be green?" [13, 14].

In order to create a competitive production system, the formulation of a manufacturing strategy is important. Manufacturing strategy as the missing link in corporate strategy was first identified in the renowned publication by Skinner [15] and has since then been further recognized. The framework described by Hill [16], where the order-winning and qualifying criteria form the link between the marketing strategy and the manufacturing strategy, also serves as a means to integrating manufacturing strategy into the overall business strategy with the aim of increasing a firms competitiveness. However, now there seems to be a missing link in the competitive criteria. In traditional manufacturing strategy literature, quality, delivery, flexibility and cost are the most commonly mentioned competitive priorities. According to e.g. Shahbazpour & Seidel [17], the literature in the area of manufacturing strategy and performance often does not include sustainability as one of the competitive objectives. However, today's market requires manufacturing to reduce the consumption of natural resources and demands more environmentally conscious societies and due to such external forces, sustainability has been emerging as the latest manufacturing objective, making environmental performance increasingly relevant for producing companies. To support this, de Burgos Jiménes & Céspades Lorente [18] argue that the set of competitive criteria should cover all areas in which the operations function can support the company to gain competitiveness, including environmental sustainability. Through this, the objectives connected to sustainability as a competitive criterion should therefore be met in the same way as economic objectives.

3.2 Management and Organization for Environmental Sustainability

Management and organization are both important aspects in order to successfully transfer the manufacturing strategy into action and hence, create processes which support the chosen competitive criteria. Clearly stated, environmental policies from top management together with defined areas of responsibilities are crucial in order to succeed with improvement activities [2, 19]. However, according to Griffiths & Petrick [20] there is a research gap concerning which corporate architectures and organizational change processes that enable environmentally sustainable strategies. They state that the established way of working in many organizations seeks to avoid change as well as exclude the stakeholders who strive to improve the environmental performance in favor of other objectives.

A commonly used and widely spread practice to improve the environmental performance is the use of Environmental Management Systems (EMS). Garrod & Chadwick [21] acknowledge that many companies have adopted a range of tools for environmental management, but few have truly transformed their operations. One of the most commonly used EMS is the international standard ISO 14 001 [22]. Still, ISO 14 000 certification alone does not guarantee that an environmentally sustainable system is created [10]. A commonly stated problem is the fact that environmental performance and operational performance are the responsibilities of separate departments [23]. This indicates that environmental experts are separated from the daily operations, which in turn eliminates many environmental improvement opportunities. To deal with this, Shrivastava [11, 24] suggest Total Quality Environmental Management (TQEM - a set of techniques to solve organizational problems from a whole system perspective) for integrating the environmental perspective in an organization. He also mentions that, for an optimal effect, it is required that employees take greater responsibilities in solving problems. According to Sarkis [10], the organization is dependent on the employees to acknowledge the idea of evaluating products and processes based on environmental characteristics. He views integrating the knowledge about environmental management into everyday workforce practice (in a similar way that quality management responsibility has been integrated though the lean perspective) as an opportunity to involve other than technical staff in the environmental activities.

3.3 Integration through Increased Awareness

It is generally accepted that what is not measured is seldom considered and hence, not improved. This indicates the importance of environmental performance measurement in order to identify environmental improvement areas. Porter & van der Linde [7] argue that measuring environmental impacts alone leads to vast opportunities for improvement, and indicate that better information and evaluation methods are needed. Key Performance Indicators (KPI) represents a set of measures, focusing on the aspects of organizational performance which are most critical to

a company's success [25]. In industry today, the use of KPI´s is already widely spread, usually measuring indicators connected to the most common competitive criteria (quality, delivery, flexibility and cost).

A weakness stated by Lober [2] is that "evaluating a corporation's environmental performance […] is difficult due to the lack of an agreed-on definition as to what exactly constitutes 'greenness' as well as there being no consensus as to what measures to use." Hence, to integrate environmental sustainability though increased awareness, "green" performance measurement practices need to be developed. This is also stressed by Thoresen [19] who concludes that no environmental improvements will occur unless the company has a functioning and well adapted set of what he refers to as Environmental Performance Indicators (EPIs). He states that EPIs may be used in a variety of decision situations at different levels, both externally and internally, in order to ensure that the environmental impacts of a company are constantly reduced. For this, each company needs their own set of performance measurement indicators, but it is also important to acknowledge that the information required at different levels in the organization differs. Thoresen proposes three categories (plus a number of sub-categories) to guide the construction of performance indicators.

- *Product life cycle performance*, concentrating on the environmental implications of a product in order to support the development of products and enhance environmentally benign design decisions.
- *Environmental performance of selected process technology*, with relevant performance indicators for production system design (e.g. investment decisions) in order to aid the selection of environmentally benign process technology.
- *Environmental performance of operations*, where the performance indicators should capture the environmental impacts from manufacturing and management processes during operation of the production system in order to support continuous environmental improvements.

The results of performance measurement and other important indicators will also have to be visualized in order to yield results. The importance of visualization is stressed by Grief [26] who´s Visual Factory concept enables team members to see, understand and achieve continuous improvements. Further, he argues that visualization is not only a means to display information, but also an important tool in order to create an efficient work organization.

3.4 Creating a Transparent Basis for Environmental Decision-Making

Production system development is one significant opportunity to improve its environmental performance. The aspects that are considered will evidently affect the environmental performance of the company in a long-term perspective. Hence, the basis for decision-making is extremely important in order to successfully integrate environmental sustainability in all parts of the production system. Cost is a central but complex driver, since many costs are hidden or difficult to estimate. EPA [27] argues that when environmental costs are hidden in overhead accounts, business decisions might be made without sufficient consideration of the potentially costly environmental impacts downstream of the decision. The lack of information can imply that managers simply expect environmental improvement activities to be costly, leading to that potential investment opportunities are disregarded [28]. However, Klassen [29] stressed the importance of integrating environmental technologies within the context of other manufacturing investments in process technologies and organizational systems. One method for this is Life Cycle Costing (LCC), an approach that has an expanded life cycle perspective, and thus considers not only investment costs, but also other costs that may arise during the product's estimated lifetime [30]. Further, keeping a holistic perspective, including responsibilities outside the own manufacturing activities (where management decisions and actions are supposed to have a significant impact on the environment) will be important [19].

It is often perceived that reducing one factor of production may increase another [28, 31]. However, through implementing new and more efficient production systems and management practices these trade-offs can many times be avoided [31]. Still, limited time and information often prevents managers from realizing the improvement potential [7], and uncertainty complicates decision-making. Hence, a shift of responsibility is needed. TQM and lean practice are examples where it has been proven possible to eliminate trade-offs (in this case between quality and cost) through e.g. employee involvement [7, 31].

3.5 Lean and green integration

Lean production has its origin in the Toyota Production System (TPS) [32-34] and the concept is widely spread in the industry. Lean production is a management philosophy focusing on value creation and waste reduction in the manufacturing, which is often illustrated by a house (as in Figure 2).

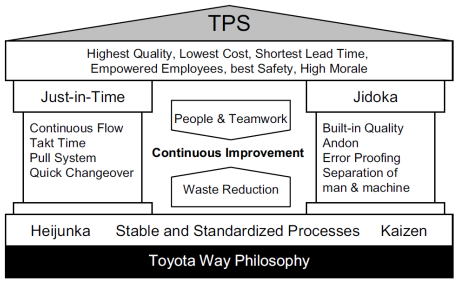

Figure 2: The core principles of the Toyota Production System [37].

Many researchers acknowledge that the basic principles of quality programs, such as TQM can be effective tools for eliminating environmental impacts [7, 11, 24]. In addition, several studies investigating the relationship between lean production and environmental sustainability have been performed, e.g. [28, 31, 35-38]. As stated by Florida [31]: "Advanced manufacturing facilities, such as those organized under the principles of lean production, draw on the same underlying principles – a dedication to productivity improvement, quality, cost reduction, and continuous improvement, and technology innovation – that underlie environmental innovation." Bergmiller & McCright [38] too indicate a strong correlation between the lean and green concepts. Through a comparison between models suggested by leading researchers, they have created a comprehensive lean and green systems model in order to show that lean and green are parallel by nature. After performing a number of investigations and case studies concerning the synergies of lean and green, EPA indicates that lean provides an excellent platform for incorporating environmental management tools and hence, integrate environmental activities into day-to-day operations. The Lean and Environment Toolkit [39] developed by EPA offers practical strategies and techniques for this.

According to Soltero & Waldrip [40], the lean concept Kaizen is an beneficial tool for developing the workforce's continual improvement skills. Hence, they argue that industry has much to gain by integrating Kaizen into its efforts to reduce waste. This is supported by Shrivastava [24] who states that, since the majority of environmental impacts are relatively small, they are consequently perfect to deal with through the use of continuous improvement techniques. King & Lenox [28] refer to that lean develops awareness among workers that is valuable in all continuous improvement activities and can thereby facilitate discovering opportunities for environmental improvement. In addition, they state that practicing lean production may reduce the marginal cost of environmental improvement activities, and hence add value through encouraging managers to invest in these.

Even though the positive synergies are numerous, Rothenberg et al. [36] still argue that lean production is not able to address all environmental issues. There are blind spots with respect to environmental risk and life-cycle impacts which need to be addressed [35]. Just-In-Time (JIT) is one of the lean concepts that is often questioned regarding environmental sustainability since smaller lot sizes may imply additional transports [10].

4. ORIENTING EMPIRICAL STUDY

In this chapter, the result of an orienting empirical study carried out at three companies within the automotive industry in Sweden is presented. Thereby, the topics presented in the previous chapter are considered from an industrial perspective. All companies included in the empirical study have well developed environmental practices, are ISO 14000 certified and have a generally strong organizational support concerning environmental improvements. Many of the "low-hanging-fruits" of environmental improvements (legislative environment, health and safety activities such as energy reduction, mapping of environmental aspects, improved waste management, and elimination of hazardous substances) have been covered. In some parts of the companies, more sophisticated methods and tools are also being evaluated. Projects with different degrees of environmental focus are regularly being administered in order to analyze various improvement potentials. Many of these are performed in corporation with partners from both industry and research. The following parts give the industry´s view on the topics of this paper:

Green as a competitive means: The orienting empirical study shows that there is a substantial interest amongst the companies to take action to decrease their environmental impact. The goal of adding value to the business and reducing costs in all parts of the production system is identified as key drivers in order to increase competitiveness. The companies agree that the common manufacturing objectives such as cost, quality, delivery and flexibility will not be enough in order to stay competitive when external stakeholders require an increased focus on sustainability.

Hence, a need for investigating how environmental sustainability can be integrated to create a competitive production system has been identified.

Management implications: One important challenge identified by the companies is the fact that environmental improvements are administered by specialized functions (separated from the line management) which makes it hard to integrate environmental continuous improvements in day-to-day operations. Another improvement area identified is using ISO 14 000 to enhance improvements according to the company requirements instead of viewing it from a regulatory perspective.

Measure and visualize – an incentive for continuous improvement: Today, there is a state of information push in many organizations. To deal with this, the interviewees identified the importance of concretizing the corporate strategies for environmental sustainability and to break them down into sub-objectives, adapted to the different parts of the organization. Since employee involvement is an efficient way of identifying improvement areas, an argument was that everyone needs to be aware of how their actions influence the overall environmental performance. Hence, developing relevant indicators for all levels and functions of the business will be essential. What to be measured, how to relate the result, how to set goals and how to reach the goals were identified as key challenges by the companies. Also, visualization will be crucial in order to succeed in using continuous improvements practices and make everyone relate and become aware of how they can improve the environmental performance of their workplace.

Developing a "green" production system: Many of the prerequisites for the future possibilities to improve the environmental performance are set when developing the production system. However, the empirical study shows that when developing the production system, the environmental function is often only consulted at a late stage in the processes, implying that the prerequisites have already been set and the room for change is limited. At many levels of the production system, environmental aspects are not prioritized over e.g. cost, much due to uncertainty and possible trade-offs. The difficulty to estimate both environmental opportunity costs as well as the future impact of the activity, together with a planning horizon that requires short pay-offs, often makes it difficult for managers to prioritize pure environmental investments. A life cycle perspective on investments would improve the situation, implying that clear directives from top management together with a more proactive environmental policy (including guidelines and decision support) are required. The interviewees stated that the complex nature of environmental aspects, ranging from toxicity to resource consumption, imply trade-offs that are often hard to foresee. Limited knowledge about environmental impacts affects the environmental awareness, implying a general hesitation regarding which environmental areas to focus on.

Integration through "lean and green": All companies in this study have started the journey to implement lean production but now, environmental improvement measures needs to be efficiently integrated at all levels of the organizations. Since continuous improvement techniques could be used to address both productivity and environmental improvement issues, this is viewed as an efficient way of avoiding duplicated work, reducing the complexity of environmental management as well as increasing the number of identified improvement opportunities. However, *how* to succeed with the integration of lean and green is viewed as a challenge but will most likely be a prerequisite for success. A famous industrial example of lean and green is found in the "Toyota goes Green" initiative. The goal is to achieve harmony between manufacturing activities and the natural world based on the concept of "a plant that fully utilizes natural resources, while operating in harmony with the natural environment" [41]. With Toyota as the most bench-marked company in the world, many manufacturing companies will most likely move in the same direction.

5. DISCUSSION AND CONCLUSION

This paper includes a review of relevant topics regarding integration of environmental sustainability practices in a production system and identifies challenges and possibilities for research as well as industry. The authors would like to acknowledge some limitations of the methodology and content of this paper. The empirical study has an orienting approach to give industrial input and is *not* intended to reflect the view of the entire manufacturing industry. In addition, the literature within the areas is extensive, implying that important topics and views might have been overlooked when performing the review. To deal with this, the paper is mainly based on highly cited authors and the references of their work have been closely studied. Further, all the reviewed literature could not be covered within the scope of this paper.

Today, "green" as a competitive means is a widely recognized phenomenon. It is generally accepted that a company's contribution to environmentally sustainable development is dependent on an integration of environmental requirements into industrial products and processes [7]. However, the result of the review and

orienting empirical study indicates that even though much research has been conducted within the area, questions are still remaining. Many companies include sustainability in their business strategy, but the link between strategy and daily operations is often weak. One important challenge identified is the fact that environmental responsibility is often separated from production and operations management leading to constraints regarding environmental awareness within the organization. Hence, we argue that keeping environmental work separated from operations may lead to sub-optimization and overlooked opportunities for continuous improvements.

Florida [31] states that creating a productivity-enhancing environmental strategy is one way of optimizing the manufacturing processes to simultaneously improve environmental and industrial performance. With that in mind, this paper identifies a need for further research regarding *how* environmental sustainability can be integrated in existing organizational strategies and decision-making in order to strengthen the competitiveness within the manufacturing industry. Integration through the concept of employee involvement is commonly mentioned as a solution, and to achieve this TQEM or lean methods are suggested. In unison with other researchers we suggest a development of an integrated model for simultaneous implementation of lean and green. Creating a "green production system" to be a competitive means to the manufacturing industry requires a development of knowledge within the area as well as supporting tools to facilitate the needed visualization, control and management of environmental parameters within the production system. Further, how to visualize and evaluate environmental and economic effects of environmental improvements is identified as a challenge.

To conclude, the prerequisites for achieving competitiveness through environmental improvements continuously change. Therefore, it is important to remember that "Operations management strategies, objectives and decisions must be reviewed continuously in the light of environmental opportunities so that the acquired manufacturing capabilities can be used to gain a competitive advantage and new manufacturing capabilities be identified for long-range corporate planning" [42].

5.1 FUTURE RESEARCH

The review and the orienting empirical study both indicate that there are still challenges to be overcome regarding integration of the green perspective in production. Based on the result presented in this paper, developing *methodology and decision support tools for sustainability evaluation and improvements* as well as *a framework for lean and green integration* are identified as candidates for future research.

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