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RELATIONSHIP BETWEEN LEAN AND GREEN MANAGEMENT IN CROATIAN MANUFACTURING COMPANIES

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ABSTRACT

The goal of this article is to explore the link between lean and green management, reasons for their implementation, their effect throughout the whole life cycle, as well as the current state of use of lean tools, economic and environmental indicators in the context of Croatian manufacturing companies. A semi-structured interview was used in this research. As a result, the frequency of economic and environmental performance indicators and lean tools in Croatian companies has been defined, as well as the reasons for the implementation of lean management. Additionally, the understanding of the use of Life Cycle Assessment methods, environmental standards has been obtained and the integration of lean and green management in Croatian companies has been explored. Further on, results were compared to the similar study done in the UK. Finally, it can be concluded that the integration of lean and green management is not yet sufficiently present in manufacturing companies, although there are cases in which these two approaches are integrated, primarily in the process and food industry. It is for these reasons that in the integration of these two approaches lies great potential.

KEYWORDS

lean management, green management, product life cycle, manufacturing management, environmental management, ISO 14001

CLASSIFICATION

JEL: L60, R11

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INTRODUCTION

Sustainable development is a very important topic addressed by governments, the scientific community, and increasingly business entities. According to the Brundtland Commission [1], sustainable development is defined as a development that meets the needs of the present without compromising the ability of future generations to meet their needs. Managing the economic aspect of sustainable development is a well-known fact, and so far this aspect of the business has been given the greatest attention. Each company must keep track of their economic indicators, if not for the sake of improvement of their own processes, then because there are laws and reporting obligations to government and administrative bodies, such as financial or tax administration agencies. Economic performance indicators can be divided into three categories [2]: operational indicators, market indicators and financial indicators. Environmental indicators monitor the impact of the activities of a particular company on the environment. There are different standards such as The European Eco-Management and Audit Scheme System (EMAS), ISO 14001 and Global Reporting Initiative (GRI), which have defined the majority of available environmental indicators in different categories (e.g. Electricity usage, Water usage, Industrial waste, etc.).

Businesses and, specifically, manufacturing companies have high potential to reduce their impact on the environment and this fact has been recognized by the United Nations (UN) in its 2030 Agenda for Sustainable Development [3], where they outlined the achievement of sustainable consumption and production as one of the main goals. One of the principles that will guide the direction of the Republic of Croatia toward sustainable development is the promotion of sustainable production and consumption. Sustainable production is, therefore, recognized as one of the foundations of sustainable development [4]. While earlier the compliance with environmental regulations has been considered an additional cost [5], today, the creation of economic sustainability through environmental sustainability is an increasingly successful strategy for many businesses [6].

The opinion of the European Commission is that certain progress has been made in solving the problems of consumption and production, but fundamental changes and significant improvements are still needed in practices of extracting natural resources and the production, distribution, use, and disposal of products [7]. This can be achieved by aligning production models with environmental management [8]. This change can be further stimulated by tools that simultaneously deal with the future and the current state, emphasizing continuous improvement [9].

In manufacturing companies, the problem of energy efficiency and resources use is becoming increasingly important [10]. The efficiency of processes and resource utilization has, for many years, been in the focus of researchers in the field of operations management, and one of their main conclusions was that the modern production systems are expected to be lean and sustainable at the same time.

Companies, today, use different improvement approaches in production management to improve their company-specific production systems and reduce their impact on the environment [11, 12]. Because of a large number of possible approaches, it is difficult for management to decide which of them they will use. Of all the approaches aimed at increasing efficiency, the most famous is the lean management or lean production and as such, it is often used as the basis of the company-specific production system [11], while the common name for the approaches aimed at reducing the impact of the business on the environment is green management or green manufacturing.

The lean manufacturing approach has become an integral part of the manufacturing environment in the United States over the last four decades [13], but also the world's leading

manufacturing strategy [14], through various approaches based on Japanese philosophies (Just-in-time (JIT), Kanban, Kaizen, Toyota Production System (TPS) and other). The concept of lean production has evolved from the TPS [13] into management philosophy, which focuses on increasing customer value by reducing non-value-added activities and waste time from the value chain or through their complete elimination [5, 14-21]. The long history of lean management has resulted in the fact that there are currently many different tools of lean management. Although there is a large number of differently named tools, they often identify the same or similar tools.

The scientific field regarding green manufacturing has not yet been sufficiently investigated, so this same name is often given to other strategies used in companies, such as [16] industrial ecology, industrial symbiosis, eco-efficiency, three pillars of sustainability, eco-effectiveness, natural capitalism, natural step, biosphere law and others. One of the possible indicators of the implementation of green manufacturing in the company is the implementation of environmental standards, such as EMAS [22] or more well-known ISO 14001 [23] standard. The relevance of the implementation and certification of ISO 14001 has been extensively analyzed in academic literature [24, 25] and there are three most common indicators influenced by ISO 14001 [24]: environmental impact, efficiency, and profitability.

These two approaches in companies usually tend to operate as separate systems, often having opposing priorities and, if treated separately, it could happen that these approaches compete for the same organizational resources, resulting in frustration and unexpected results set in company goals [26]. Therefore, the question "Can additional synergic effects be achieved if these two approaches are used together?" arises.

Recent research have been focused on seeking the relationship between initiatives focused on the increase of production efficiency and those aimed at reduction of environmental impacts, under the common name of lean and green manufacturing [27-32]. From a managerial perspective, lean production and environmental management practices are synergistic, considering their focus on reducing waste and inefficiencies [17].

The logic behind the lean thinking with an emphasis on the seven major wastes could be redesigned and integrated into the system concept of sustainability. In the literature, examples that the application of lean management principles [13] increases the competitiveness of the company that is applying them are found, while on the other hand, the influence of lean management on the manufacturing impact on environmental indicators [33] is less known and needs to be further explored. Lean production is associated with removing the waste from the production process [13], and in order for this process of waste reduction to be complete, it is necessary to supplement the list of lean wastes with environmental impact wastes. It is important to note that some literature sources indicate that the implementation of lean and green programs improves business results [5, 34]. Yang et al. [17] conducted a study on a sample of 309 international manufacturing companies, and results of his research suggested that experience in lean production is positively correlated with environmental management practices. The Environmental Protection Agency (EPA) listed six benefits that an organization can enjoy if it coordinates lean and green initiatives [35]:

- cost reduction,
- a shorter length of the process flow and reduction of lead times,
- reduction of risk of non-compliance with laws and regulations,
- meeting customer expectations,
- improving environmental quality,
- improving morale and employee engagement.

The literature review revealed that companies have different motives for initiating improvement activities such as lean and green manufacturing, and the most common motives are related to improving quality, increasing productivity and reducing costs [36], and implemented improvements ultimately lead to increased competitiveness.

Improvements that are implemented through lean and green manufacturing initiatives do not affect only the company in which they are implemented but also the lifecycle of the product. The greater impact of applying lean principles throughout the lifecycle of products has not yet been thoroughly investigated and understood [14]. Consequently, it is necessary to investigate how the application of lean principles affects the green (environmental) indicators, but also the indicators related to the life cycle of the product [37], which could be achieved by using the Life Cycle Assessment (LCA) methodology [38, 39]. Life cycle assessment is a structured, comprehensive and internationally standardized method for quantifying all significant emissions and resources used and associated environmental and health impacts, as well as resource exhaustion problems associated with the entire lifecycle of any product or service. Life cycle perspective facilitates efforts of manufacturing companies to identify opportunities for improvement in their system, but also through all phases of product life cycle [40]. LCA is also a decisive and powerful auxiliary decision support tool that complements other methods needed to make consumption and production more effective and efficient. An integrated approach to lean and green manufacturing that considers impact throughout the lifecycle of the product and the application of the LCA method has the potential to create positive synergistic effects while simultaneously increasing efficiency and reducing environmental impact.

Taking into account the above-mentioned findings, it can be concluded that the area of lean and green manufacturing is the active subject of scientific research, but the relationship between these two approaches is still not fully defined. Although from the perspective of each individual approach there exist numerous studies, there is still the lack of action research carried out in manufacturing companies. Considering literature review and discovered gaps, the goal of this article is to explore the link between lean and green manufacturing, reasons for their implementation, their effect throughout the whole life cycle, as well as the current state of use of lean tools, economic and environmental indicators in the context of Croatian manufacturing companies.

METHODOLOGY

The methodology we used consisted of three steps: (1) literature review, (2) development of the semi-structured interview (SSI) and selection of respondents, and (3) analysis of SSI.

LITERATURE REVIEW

In the first phase of the research, the available literature on the research subject has been analyzed, including scientific and professional papers about lean and green manufacturing, as well as doctoral dissertations published on this topic. The information obtained by reviewing the literature has been used to determine the most frequently used economic performance indicators and performance indicators related to environmental performance, as well as the most commonly used lean management tools for subsequent comparison with results. The literature review was also carried out to gain a perspective of the current research in the area of lean and green manufacturing integration.

Today, numerous studies are being carried out in the area of operations management and production, but there is still a lack of studies in which the researcher goes directly to companies to discover common problems firsthand, but also to establish relationships

between research areas. Based on an extensive analysis of literature in the field of lean and green management and the nature of the problem being investigated, we decided to use the semi-structured interview method.

DEVELOPMENT OF THE SEMI-STRUCTURED INTERVIEW AND SELECTION OF RESPONDENTS

In the second phase, a tool for conducting research with semi-structured interview has been developed. In this study, semi-structured interviews were used to further clarify the information obtained from the literature on the relationship between lean and green manufacturing, but also to better understand the links between lean and green management in manufacturing companies, taking into account the environment in which businesses operate. Qualitative research is appropriate in situations where a researcher wants to understand the meaning given to events and situations by the research participants, and it takes into account the context in which these events and situations occurred, which is very important in the case of implementation of lean and green manufacturing.

The semi-structured interview method has already been used in similar research carried out in the UK, where Biggs [41] investigated the connection between lean and green manufacturing, and Frost [42] studied drivers and barriers in the application of ISO 14001 standards. Kurdve [43] used a semi-structured interview method to explore the use of lean and green manufacturing tools in Sweden. Torres Jr. and Gati [44] in Brazil, Wu et al. [45] in China, and Wiese et al. [46] in South Africa also used a semi-structured interview method for lean and green manufacturing research.

Interview questions were defined, taking into account the information obtained during the review of the literature, given that some authors [21] recommend using already defined sets of questions to allow for later comparability of the results, but we also added additional questions that allow for a better understanding of the current situation. To define SSI, questions we used the questionnaire developed by Biggs [41] with the interview protocol supplemented by additional questions related to the application of LCA methods in companies and questions about the use of IT support system for lean and green manufacturing approach. There were 14 questions on the subject of lean production (L), 11 questions on the subject of green manufacturing (G) and 3 questions on the integration of these two approaches. Most of the questions were open-ended, with the exception of question L-12, which is concerned with the assessment of a company's leanness and question G-1 about a company's environmental sustainability, which were on the Likert scale. There were no direct questions regarding economic and environmental indicators, as we wanted respondents to mention indicators themselves as part of the response to other questions. We used a direct question about lean tools they have been using, and also questions about the effect of lean production on environmental indicators.

The emphasis of the semi-structured interview was on the discovery of connections between lean and green manufacturing in a specific company from the perspective of people involved in the production improvement or those directly responsible for production management. Companies in which the study was conducted were selected based on their experience in implementing lean management. The main criterion was that the company had more than one year of experience in implementing lean management. One of the authors is actively involved in the organization of the GALP Conference since 2011. That annual conference brings together experts from the area of lean management, so the network of acquaintances from the conference was used in selecting the respondents, but also a "snowball" concept was used when respondents suggested companies for an interview. The respondents were first contacted by phone, where the purpose and methods of the research were explained to them,

followed by an email with details of the interview mentioning that the questions would be from the area of lean and green manufacturing and their relationship. Respondents were informed that the interview will be recorded if they will agree to it and that the data from the interviews will be analyzed as anonymous.

INTERVIEW ANALYSIS

The analysis is the most complex aspect of the semi-structured interview method. The researcher must find useful insights from a large amount of data that will benefit the research purposes without being biased in the analysis of answers. The interview analysis consisted of several steps. All the interviews that have been recorded were transcribed using a piece of software called "*Express Scribe Transcription Software*". All the interviews were then analyzed by initially coding the concepts that are connected to lean and green management to find the frequency of their occurrence in all interviews. In the third step, responses were analyzed by listening to each interview and tracking the records in order to draw the main conclusions regarding the application of lean and green manufacturing in enterprises as well as their possible integration. The results of the interview analysis are presented in the following sections. To avoid bias in the conclusion, they were based on at least 3 or more responses of respondents whenever possible. In case there were findings that only appeared in one interview, this rule was not used since it could have led to the possibility of missing out on important discoveries, which we wanted to avoid. When it comes to research involving people, it is expected that out of 10 respondents not all of them will have the same opinion. To achieve the objectivity of the investigation and to avoid author's bias in topics arising from the analysis of the interview, the author has done his best to also describe negative cases, i.e. examples of respondents' answers that differ from the opinions of the majority.

RESULTS

The sample consisted of 10 respondents all from the manufacturing industry. Most respondents come from medium (6) or large (3) enterprises, and only one respondent came from a small business. This classification was carried out in accordance with the European Commission regulations [47] on enterprise aid categories, where the classification of companies is mentioned. Most of the interviews come from companies that have four or more years of experience in applying lean management, while only one company applied lean management for 1,5 years. All the respondents had managerial positions, such as production directors, executives, continuous improvement managers, sector directors, board members and quality managers, health, safety and environment managers. Majority of the interviews were recorded, two interviews were carried out using only notes; one of the notes was handwritten and the other typewritten using a computer. In one interview, half of the interview was recorded and the other half, the notes were taken. A detailed description of the respondents is given in the Appendix of this article.

The results of the interview analysis are grouped according to the topics that have been crystallized through the research. A total of thirteen different topics were identified.

FREQUENCY OF ECONOMIC PERFORMANCE INDICATORS

Throughout the interviews, the respondents mentioned 35 different economic performance indicators. Figure 1 shows the most common economic performance indicators that an enterprise monitors. It is important to note that not all the indicators companies use are captured, but only those that were directly or indirectly mentioned during the interview. Those indicators should be the ones that are the most important to the companies.

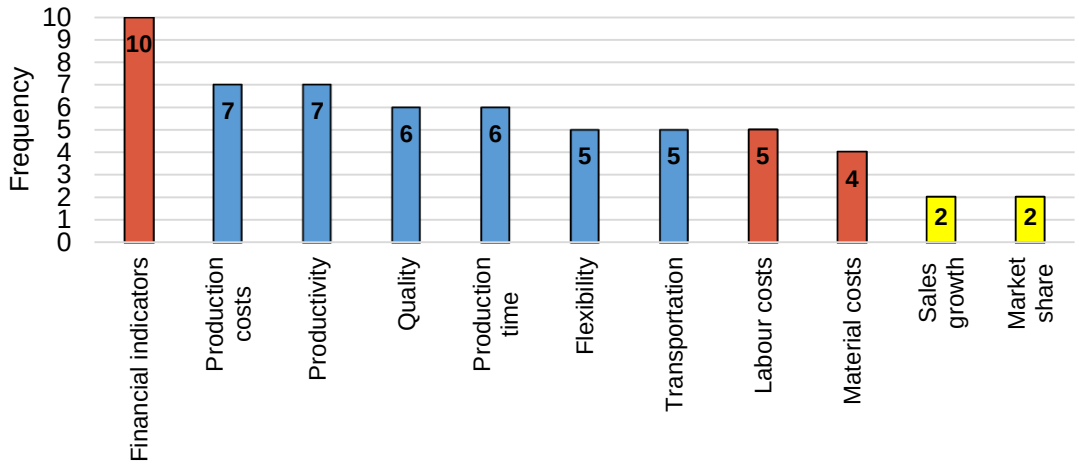

Figure 1. Frequency of economic performance indicators.

As is shown in Figure 1, the respondents most often speak about financial indicators, although it was common that they did not specify specific financial indicators but stated them generally as essential for tracking during the implementation of lean management. Some of the financial indicators mentioned by the respondents were an increase in the income over the years, as well as realized financial savings through the implementation of lean initiatives.

What is Lean Management for Companies

When conducting a semi-structured interview, respondents were asked to explain in one sentence what the principles that make up lean management are. From the interviews, several key terms the respondents used to describe lean management were drawn: continuous change, lean is Kaizen, change to better, continuous improvement in all segments, set of tools, reduction of all wastes, optimization of processes, flow, elimination of all non-value adding operations, recognise system areas for improvement in short time, well-organized company with clear goals, constant and continuous learning and improvement, recognition of waste, continuous process improvement.

Reasons For the Implementation of Lean Management

By analyzing the interviews, information was obtained on the reasons why companies usually decide to implement lean management. In total, 23 reasons were recognized by the respondents as drivers of their lean management implementation. Only the reasons mentioned 2 or more times are shown in Figure 2.

Cost reduction was recognized as the most common reason for implementing lean management in Croatian companies.

Lean Management Tools Used in Companies

Through interviews, each respondent was asked which lean management tools the company is currently using or had used. Figure 3 shows summarized responses about the frequency of lean management tools used in Croatian and UK companies.

5S is recognized as the most commonly used lean management tool in Croatian companies, while the same category in UK's companies includes 5S, VSM and Kaizen.

Importance of a Custom Approach to Implementation of Lean Management

Respondents P2, P3 and P5 talked about the importance of a customized approach to implementation of lean management. Respondent P5 mentioned that the meaning of Just in

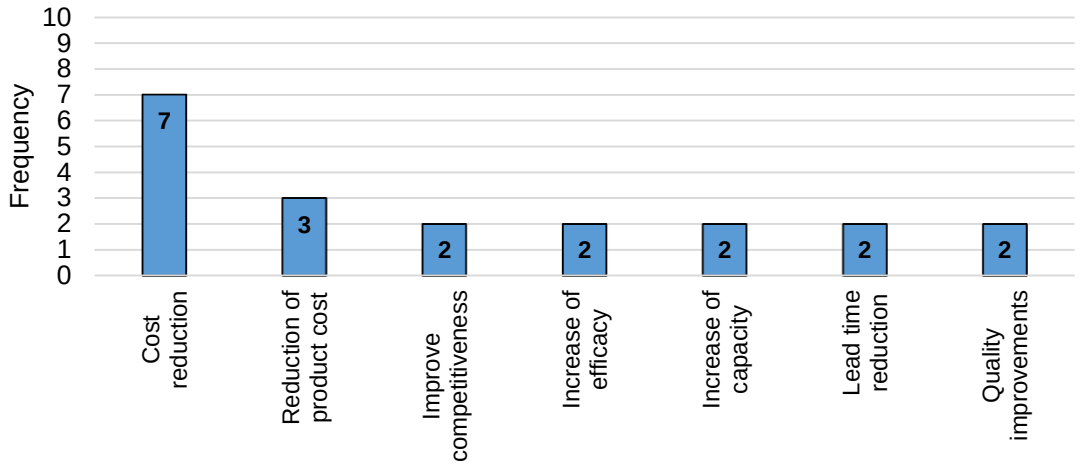

Figure 2. Reasons to implement lean management.

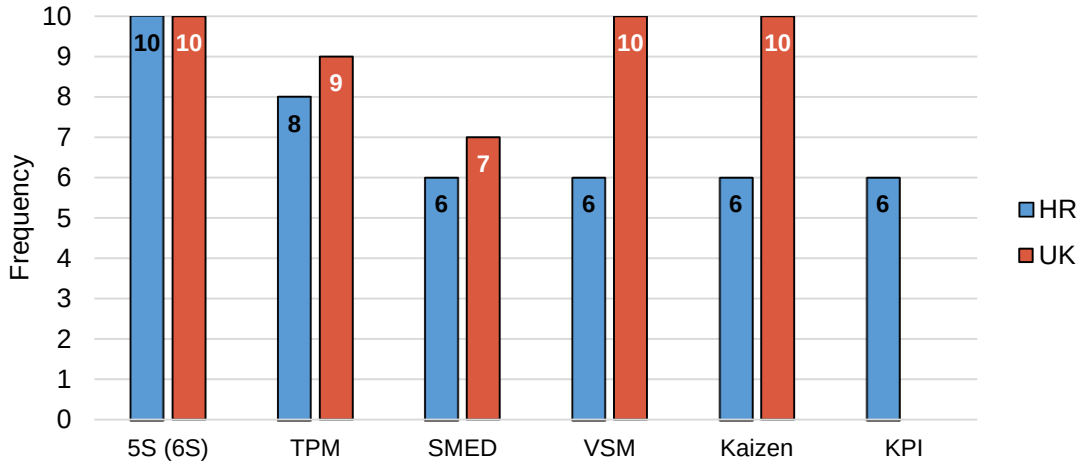

Figure 3. Frequency of lean management tools in the interviews.

Time manufacturing is not the same in Japan and Europe or, more precisely, in Croatia. Respondent P2 stated that lean management is not something that can be implemented by copy-paste principle. In order to achieve a customized approach, companies (P2) use services of external consultants. In some cases, a set of tools to be used in companies are imposed by the parent company (P7, P9). The parent company normally leads the implementation of lean management across all businesses. Sometimes companies start the implementation by following a well-known methodology, but over time the methodology is adapted and only the tools that bring the most benefits to a particular company are used (P10). Finally, respondent P3 further stated that for the success of the implementation of lean management, trust should exist in the company, which can be achieved through open communication, transparency and fair wage.

The Integration of Lean Management in Existing Standards

In several cases, respondents mentioned that there is integration of standards in their company. Therefore, respondent P1 noted that they are currently working on the integration of the 3 standards they use and each contains a risk analysis in order to have only one risk analysis at the end. Respondent P3 mentioned the integration of standard procedures developed within the lean management to ISO 9001 standard procedures, and the reason is that in the case of revision of the ISO standard, they will have to carry out the revision of the standard procedures developed within the lean management. Respondent P8 also noted the integration of standard procedures derived from the lean management in the ISO 9001 system, and as a main reason, mentioned the need to reduce the need for duplicate reports.

Frequency of Environmental Performance Indicators

Companies have a legal obligation to take care of the environment, and there are mandatory indicators that must be monitored and reported. Summarized environmental performance indicators and their frequency are shown in Figure 4.

As the most common environmental indicators in Croatian companies, the use of electricity and industrial waste are recognized.

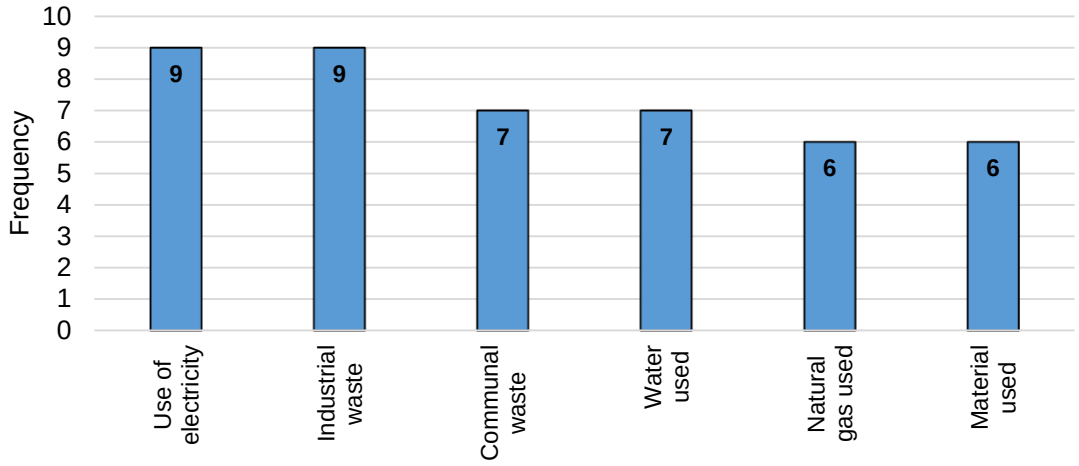

Figure 4. Frequency of environmental performance indicators.

Relationship Between Environment and business

Most companies rated their business as friendly to the environment (median 8, average value 7,75). Throughout the interview, all the respondents stated that they have an organized way of collecting, sorting and disposing off waste in the company, and waste disposal is left to companies specialized in that business.

Use of LCA methods and Ecological Certificates

In order to find out whether companies are thinking about the impact of their products over the product lifecycle, respondents have been asked a question about the impact of lean management activities on the product lifecycle as well as whether they use LCA in their business. Only one respondent (P2) said that they used the LCA method, although he noted that it was still related to individual initiatives and not the method the enterprise used systematically. Furthermore, P4 stated that this was under the jurisdiction of marketing, and P9 stated that the products were monitored through their lifecycle only financially, although, for example, the impact of all business activities through the carbon footprint was monitored in the same company. Other respondents responded negatively to this question.

ENVIRONMENTAL STANDARDS

According to the data obtained through the interviews, 6 out of 10 respondents stated that their company had ISO 14001, and of the remaining four, two mentioned that they are planning to implement ISO 14001 in the next two years, while 2 respondents said that they would implement ISO 14001 only when asked by the customers. None of the respondents mentioned EMAS.

Environmental Improvements – an Opportunity for Companies

All respondents to the question, whether they consider environmental improvement as a cost or an opportunity for their company, responded that they see it primarily as an opportunity.

The interview analysis has crystallized several reasons why respondents consider reducing the impact on the environment as an opportunity. The first reason is that their customers are seeking information on certificates related to environmental impact, such as ISO 14001 and information on work safety. The second reason is that it enables businesses to reduce energy consumption and reduce waste, and if waste is sorted, it can be sold. The third reason is that companies want to create a healthy environment in which they work through environmental activities. The fourth reason is that reducing the impact on the environment by reducing scrap in processing materials creates savings for the company. Respondent P9 mentioned the concept of "zero waste", which should enable companies to eliminate all waste arising from their processes, although, as stated by responded P4, initially, these initiatives require certain investments. Certain companies use IT systems and the environmental balance sheet to monitor changes in environmental impact indicators. Respondents P2 and P10 stated that they make an environmental balance sheet and respondent P7 stated that they use the IT system at the group level to report on the impact of the business on the environment. Respondent P9 stated that they have a local environmental impact monitoring system that reports at the group level, and sometimes the environmental group regulations are much stricter than the regulations by the environmental laws in the Republic of Croatia.

Integration of Lean and Green Management

Through the analysis of the interview, it was obtained that only 3 out of 10 respondents (P4, P6 and P9) mentioned savings related to green business when they talked about lean management. When asked directly about the impact of lean management on the environmental performance indicators, all respondents agreed that the implementation of lean management results in a reduction of the environmental impact.

Specifically, P1 stated that there was a decrease in the consumption of materials and the use of tools in production. Respondent P2 stated that these indicators were not tracked within the lean management, but since there is an environmental balance sheet, it is possible to find out from it. P3 believed that it results in stock decrease and waste reduction, though he was not sure how, and indirectly results in reduction in all of the mentioned impact indicators. Although they do not monitor the consumption of water and electricity, he also considers that there is a reduction in those segments. Respondents P4, P6 and P9 believe that there is a reduction in environmental indicators mentioned in the question. Respondents P5 and P9 emphasized that emissions to the air are reduced. Respondent P7 stated that there was a decrease in the consumption of resources, materials and electricity, and also stated that there was an increase in water consumption, which respondent P1 agreed to, but only in absolute terms and the reason was the increase in volume of production, while the consumption of water per unit of product produced decreased. Respondent P10 believes that, among other things, waste, resources and materials are reduced. People satisfaction was mentioned by P8 as one of the most important indicators along with all the above-mentioned.

The aim of this research is to investigate the connection between lean and green management in manufacturing and, accordingly, respondent P1 believes that by systemic approach and integration of parts of the system, a company can achieve greater competitiveness and increase productivity. He particularly emphasized the importance of care for energy independence of the company, which is evidenced by the fact that the introduction of new technologies will increase the dependence of companies on energy and hence the company's imperative to work on energy sustainability. Introduction of solar electrical systems can certainly help. Dependence on external factors can also be reduced through the use of waste heat from the machines for the preheating of water. Respondent P2 considered integration of lean and green as a good idea, especially since some lean management tools have a direct

impact on the environment. Respondent P3 agreed with P2 and argued that whether we emphasize it or not, lean management has a positive impact on the environment. Respondent P4, however, argued that lean tools could be used to reduce the impact on the environment, although he claimed that we are generally delayed with the introduction of lean tools in general because while digitization is being carried out in the world, we have not yet established our processes and it is not worth digitizing bad processes. Respondent P5 believes that besides reducing the impact of the business on the environment, cash benefits should also be expected when introducing lean tools and taking into account their impact on the environment, primarily through the return of the product back to the manufacturer. Respondent P6 pointed out that there is still a lot of space for implementing lean management, not only in manufacturing but also in service industry, while P7 said that using lean tools affects the sustainability of production and the environment. Respondent P8 supported the idea of integration and stated that businesses can only succeed if they monitor key business and environmental impact indicators. Respondent P9 believes that there is a causal link and that he does not agree with the statement that lean management only affects economic indicators, but it has, as well, an obvious impact on environmental indicators, while P10 considered that the main point is in the increase of the competitiveness by making a quality product, for which there is a market, with as little resources as possible.

The Impact of Improvement in Production in Other Phases of the Lifecycle

By analysing the interview, it was found that most respondents believe that improvements in production could have an impact on other life cycle phases, but they were often not sure in what way exactly, although they have recognized several possible ways. Thus, respondent P1 believes that it certainly has an impact but has not been looking at it from that perspective. Achieved improvements can help in the use phase by reducing complexity of the product, which can result in reduced weight and easier assembly. Respondent P2 also thinks that it has an impact by increasing the quality, which then extends product life expectancy, and waste reduction decreases the impact of business on the environment. Respondent P3 argued that improvements reduce waste and at the same time affect cost reduction and indirectly reduce environmental impacts. Respondent P4 also believes that improvements in production have an impact on the environment because by implementing improvements, they reduce energy consumption and scratch, but he did not mention the impact of these activities on the product lifecycle. Similarly, just like respondent P4, respondent P5 mentioned that there is an impact on production but does not mention the impact on the other phases. P6 mentioned that there is no impact on the use stage of a product lifecycle but only in the production phase. Respondent P7 thinks that the production cycle, from order to delivery, is decreased, while technological preparation and design may affect the use phase. Respondent P8 agreed with respondent P7 and believes that the use phase can be affected by the creation of functional products. Respondents P9 and P10 believe that the use stage is affected through an increase in quality, and the impact of improvements in production is possible through waste reduction, which is considered by respondent P10.

Negative Cases

Some respondents, including P4, P6, P5, pointed out that the introduction of lean management resulted in a reduction in the amount of transport, mostly due to delivery optimization, better machine layout and transport intensity. On the other hand, respondent P1 noted the indirect linkage of lean management with increasing transport costs. Namely, the company recently opened a new plant as a result of the expansion of production, and which the respondent attributed to the results of the activities of lean management. As the new plant is not close to

the existing one and certain products are manufactured at both locations, there is an increase in transport costs and, therefore, associated emissions in the air.

As part of the interview, respondents were asked whether environmental improvement is an opportunity or a cost for them, and most respondents have confirmed that it is an opportunity, although there is an opposite opinion. Some respondents consider the reduction of environmental impact also as a cost and as an opportunity for their company. Respondent P3 stated that it is easy to define the cost, but the opportunity is not so obvious. Respondent P4 stated that while it is initially costly, the return on investment starts coming in after a very short time.

DISCUSSION AND CONCLUSION

The respondents are from companies in various industries, both of Croatian and foreign ownership, and from companies of different sizes. The greater representation of medium and large companies in this research arises from the fact that small businesses usually have their production organized as workshops and, thus, do not apply lean management, although the P6 example shows otherwise, but it must be taken into account that this company is 50 % owned by a foreign group, which could be one of the reasons for the implementation of lean management.

Enterprises monitor different economic and environmental performance indicators – some of them follow the force of the laws and the obligation to report regularly either to the economic or environmental indicators, and some indicators are monitored to better manage their processes to ensure their sustainability in economic and environmental terms. When discussing economic performance indicators, respondents talked frequently about financial indicators, including among others, increase in the amount of income through the years, as well as the financial savings achieved through the implementation of lean initiatives.

Lean management for respondents represents a continuous (never-ending) process of learning and constant improvement through the involvement of all employees, by recognizing and then removing all activities in the process that do not add value from the customer's point of view. All this is done using lean tools. The goal of lean management is to meet customer requirements in an efficient way, which creates a well-organized company.

When looking at the reasons the respondents stated as motivation for their businesses to embark on the lean management implementation journey, the most common reason was cost reduction. Among the more frequent reasons, there is also an increase in quality, and respondents also mentioned increasing the ability to meet customer requirements and better organization of the enterprise, which is in line with the research that was carried out by Terziovski i Sohal [36] in Australian companies. Some of the mentioned reasons are directly related to each other, such as reduction in production costs, which directly affects the reduction of the product's manufacturing price. One characteristic of all the reasons is that they can increase the company's competitiveness on the market. If the results are compared to those of Biggs [41], which she obtained by doing a similar semi-structured interview in UK companies, it can be seen that in Croatian companies the reason for cost reduction is mentioned in 7 out of 10 interviews, while Biggs has reported that it was mentioned in 6 out of 10, which does not represent a significant difference, and it can be concluded that for both Croatian and UK companies, the biggest emphasis during the implementation of lean management is on cost. Interestingly, only one respondent from Croatia stated explicitly that the reason for the implementation of lean management was pressure from the owners, the international company, which was also the case in the research conducted by Biggs. From this, it can be concluded that companies have a desire for continuous improvement in order to reduce costs and achieve better market position, and the biggest influence on the implementation of lean management comes from the market and customers. To achieve this,

companies have to involve all the employees in the process of continuous learning and improvement so they can recognize and remove from the process all the activities that do not add value from the customer's point of view.

Respondents mentioned the use of lean tools, and by analysing the interview, it was found that 39 lean tools were used by companies. When research is carried out in different manufacturing companies, there is a problem of standardization of terms, which was also the case with the definition of tools used, since different names can be used in companies for the same tool. As has been written earlier, it is possible that not all the tools used by companies are registered in the interview. But for those tools that were mentioned by the interviewees, it can be concluded that they are important to them. Of all the tools of lean management, the most common is 5S and it is mentioned in all the interviews. The presence of the 5S tool in all companies that apply lean management is expected, since 5S is one of the basic tools of lean management and one of the first tools that is used at the start of the lean management implementation. One of the reasons why companies start with the 5S implementation is because of its simplicity and visual impact, which means that the 5S results are immediately visible on the shop floor. On the other hand, 5S is one of the simplest lean tools and is often used by companies to test if they are ready to devote themselves to continuous improvement activities. TPM is another tool companies implement most frequently. The reason for such frequency can be found in the company's focus on the utilization of machines. Let's say companies can very easily calculate Return on investment (ROI) of each machine and how much it should be utilized to pay off for the investment. The third most commonly used tool group is SMED, VSM, KPI and Kaizen. In this tool group, attention is more on Kaizen. Sometimes companies use it interchangeably with lean management, but more often, it is mentioned in the context of specific application, such as Kaizen Workshop [48].

If a comparison of the tools obtained through this research and the tools obtained in the UK survey (Figure 4) is made, it can be concluded that the 5S tool is, in both cases, the most represented. Additionally, all the companies in the UK survey used Value stream mapping, compared to only 6 in Croatia. As stated by Biggs [41], Poka-Yoke tool was applied in all companies interviewed in the UK, while in the Croatian companies it was not mentioned at all. Also interesting is the data regarding the application of the One-piece Flow and Cell Production tools, where these two tools are present in most UK companies, while in Croatia they are not mentioned at all. In only one company, a production line was observed, which could be identified as a one-piece flow of the material.

From the data on the implementation of lean tools in Croatian companies, as well as on the basis of the data obtained from the literature, it can be concluded that companies use different tools, and the selection of tools most often depends on the results that a particular company wishes to achieve. The choice of tools can, therefore, be influenced by the methodology that companies follow in the implementation, the advice provided by the consultants engaged in the implementation, and, in some cases, the choice of tools is defined by the group and the local enterprise does not have much flexibility in the selection. Not only tools, but also the entire program of lean management implementation cannot be simply copied from one company to another, but it is necessary to adopt it to the culture and specific environment in which it is implemented. And for the success of the implementation, it is important that there is trust in the company, which can be achieved by open communication, transparency and fair wage. When considering a set of tools that exist in lean management, it can be seen that the choice of tools to be used, in most cases, is left to the company to decide, which can be a challenge, especially for those companies that are just getting introduced to lean management improvement programs. This leads to the conclusion that companies would benefit from a model that would assist them in selecting lean management tools according to predefined

criteria. Criteria for such a model can be defined based on the literature analysis and on the results of the frequency and importance of the individual economic and environmental indicators obtained from the conducted interview.

The use of electricity was recognized as the most common environmental indicator in Croatian companies. This indicator is not always directly related to the environment, but appears also in discussions about the influence of lean management, as was the case in interviews with respondents P4, P6 and P9. The second most common indicator is mainly related to industrial waste disposal, where companies, in most cases, by waste management, consider a disposal of scrap material from the manufacturing. Although it is worth noting that all the companies have a defined waste disposal system, most often defined by the law on environmental protection, but increasingly, the company's strategy to reduce costs by reducing waste by sorting and selling it.

The results obtained show that companies in Croatia do not use the LCA methodology for environmental impact assessment throughout the product lifecycle. On the other hand, in companies that use lean management, 6 out of 10 have introduced the ISO 14001 system and two plan to introduce it over the next two years. It should be noted that although companies use and follow all the rules defined by the ISO 14001 system, if it was not required by the customer, the companies do not carry out official certification. Respondents mentioned that there are certain activities in the companies that integrate different standards, and there is an example of integration of lean management in the existing corporate standards. In this way, the companies reduce paperwork and increase the sustainability of the improvements.

Although reducing the impact on the environment requires certain financial expenses, which are sometimes not so small, most companies consider reducing the impact of business on the environment as an opportunity, primarily in long-term cost reductions, reduction of energy, water, gas and other resources use, reduction of waste, and scrap, taking care of employees, general reduction in the impact of business on the environment and increasing the competitive advantage by obtaining environmental certificates. The best examples of good environmental management practices and environmental impacts come from foreign-owned companies, and the parent company is from Western Europe, where environmental awareness is more developed.

Integration of lean and green management is not yet sufficiently present in manufacturing companies, although there are cases in which these two approaches are related. This connection is present in companies from the process and food industry where electricity, gas, water and other resources account for a large share of production costs. Therefore, it is logical the focus of these companies to monitor and reduce their consumption. This is also why lean management initiatives are connected to the green part of the business. Accordingly, in the integration of these two approaches lies great potential. From the responses above, it is possible to draw another conclusion: companies still do not recognize the impact that improvements in production have on other stages of the product's life cycle, and most of them relate this impact to quality, cost benefit and increase in the product life span. With this in mind, companies need tools that will help them see the impact of their activities throughout the lifecycle of the product, and one of these tools is surely the LCA.

The results and conclusions of this article are based on the data obtained from companies in the manufacturing industry. For this reason, this article can serve as a guideline to other researchers who want to explore the link between economic and environmental sustainability in service companies, as well as government and public administrations. Further, the direction of future research can go toward studying the possibilities of integrating social approaches to lean and green manufacturing.

The area of sustainability of production, both economically and environmentally, will be an increasingly important topic of scientific research, but also of initiatives implemented within the enterprise. This article confirms that there is a link between approaches of lean and green manufacturing, but also that companies still do not sufficiently use the benefits of their connection. In addition, the most frequent lean tools, economic and environmental performance indicators used by Croatian companies were defined, and the results were compared with companies from the UK. During the interview, there were 27 preliminary conclusions, most important of which were mentioned in this article.

Finally, it can be concluded that the integration of lean and green management is not yet sufficiently present in manufacturing companies, although there are cases in which these two approaches are integrated, primarily in the process and food industry. It is for these reasons that the integration of these two approaches has great potential.

APPENDIX

Table 1. detailed description of the respondents. SVP is medium sized enterprise, VP-VM – large enterprise in full international ownership, VP – large enterprise, MP-DM – small enterprise in partial international ownership, SVP-M – medium enterprise in international ownership, and VP-M – large enterprise in international ownership.

#	Size	Main business activity	Experience in Lean, years	Interview participant	Interview conditions
P1	SVP	Manufacture of refrigeration and ventilation equipment	10,5	Quality manager	Recorded
P2	VP-M	Manufacture of electrical machinery and devices	6	Continuous improvement manager	Notes only
P3	SVP	Construction, manufacture and sale of machinery	4	Production director	Recorded
P4	VP	Manufacture of food products	4	Production sector director	Part notes / part recorded
P5	SVP	Manufacture of refrigeration units	4,5	Production manager	Recorded
P6	MP-DM	Manufacture of motor vehicles	1,5	Production director	Recorded
P7	SVP-M	Manufacture of metal structures and fabricated metal products	5,5	Production director	Recorded
P8	SVP-M	Manufacture of paper and cardboard products	6	Production director	Recorded
P9	VP-M	Manufacture of drinks	7	health and environment manager	Notes on PC
P10	SVP	Manufacture of metal structures and fabricated metal products	13	Board members	Recorded

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