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Ranking dominant losses in small and medium-sized enterprises (SMEs) in the context of the lean concept application

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A B S T R A C T

The Lean concept was devised in large business systems and is tailored to this way of conducting business. It is a set of principles, techniques and procedures used to identify and eliminate losses within processes. The results of applying this concept are impressive. Western businesses are delighted with the success of large enterprises that have implemented or have begun to implement the Lean concept. Considering the structures of business systems in transitional and EU countries, a question has arisen as to whether it is possible to apply the Lean concept to small and medium-sized enterprises, as these account for more than 99 % of all business systems. The research which was conducted with the goal of designing a suitable model for the implementation of the Lean concept in small to medium-sized enterprises was based on an analysis of the essential elements of this concept. This article presents part of the conducted research that refers to analysis of losses and identification of the dominant losses according to the opinions of real sector experts and scientists from the academic community. The results of this research were used to define procedures for the elimination of major losses and design a final model for the implementation of the Lean concept in small and medium-sized enterprises.

A R T I C L E   I N F O

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1. Introduction

Worldwide experience has shown that the Lean concept can be successfully applied to improve the processes and overall functioning of large corporate systems, and the results of this application have been impressive. The methodology was first developed in a large Japanese company (TPS-Toyota). It was then disseminated to large companies in the United States and Europe. It was developed and adapted for large companies. As with other successful large system solutions, the Lean concept was gradually adopted by small and medium-sized companies. This has been particularly pronounced more recently, when this methodology has been more intensively researched and applied in Europe and other regions where corporate systems are, on average, much smaller than in the United States [1, 2].

The lean concept envisions products that adapt to the actual needs and expectations of customers, i.e., meet requirements at the required quality and within the agreed delivery times with minimal use of resources [3, 4]. To achieve these goals, it is necessary to eliminate those activities that do not add value or cause waste due to over-production, delays, unnecessary transportation or movement, warehousing, or the like [5, 6]. The authors of [7] state that companies, for example, have successfully reduced their losses and production of waste by applying the lean concept to identify and eliminate or reduce losses. It is important to emphasise that the Lean concept is the industry standard in the automotive industry and its basis for eliminating losses is increasingly being applied in other manufacturing [8] and service sectors. Authors who have studied the lean concept and its application emphasise its importance and role in identifying losses in processes [9, 10]. Errors in the basic approach to the lean concept, e.g. a partial approach, are often cited as reasons for lower success rates in the application of the lean concept [11-13]. Research by authors [14-18] emphasises that the lean concept is expected to improve the capability of companies and increase value for customers through lower prices and improved quality.

The key elements for the success of the lean concept in small and medium enterprises are the efficient identification of processes in relation to their business results, the determination of the top management, the application of the general principles of the lean concept, the reduction of losses, the use of modern lean techniques, continuous improvement, and a good conceptual structure tailored to the particular company [19, 23]. It is important to note that the entire process must begin with questions that identify where resources (time, materials, and the like) are being used and how waste can be reduced or eliminated. This results in the need to identify and rank the dominant losses to finally have an approach for designing an ultimate model for implementing the lean concept in small and medium enterprises [1].

The following chapters briefly describe the most important losses in SMEs, the research and analysis conducted, and the ranking of the losses. Finally, the most important guidelines and actions to eliminate the main losses are recommended to the managers in the production processes. Overview of post-implementation activities.

2. Losses in small and medium-sized enterprises

2.1 Defining losses

Losses or wastes are essentially anything that customers are not willing to pay for. The authors of the article define losses (waste) as all actions in a process that are not necessary for the successful completion of the process. Furthermore, these authors state that after such losses are eliminated, only those operations and activities (called 'value added') remain in the process that are necessary for the successful delivery of such a product or service to customers.

The Japanese word *muda* is translated as 'waste' or 'losses' in most other languages, but the core of the word has a much deeper meaning. The work that takes place in a process is realised through discrete stages or operations. In each of these process stages, input elements are transformed into output elements, either adding or not adding value to the product or service.

Losses are manifested in errors that need to be corrected, in the production of products for which there is no demand, in excessive inventory, and in residual products that are produced unnecessarily. It can also include activities that are not required in the processes, unnecessary movement of employees, unplanned movement of products from one workstation to another, waiting for work, documentation, inspection, handover, or any other form of delay, including complaints from or refunds to customers or product end users.

Taiichi Ohno [24] classified losses in production processes into seven categories: Over-production, unnecessary inventory, defects, unnecessary/superfluous movement, improper processing, waiting, and transportation. Subsequent scientific literature has defined another category of losses, namely losses due to inadequate utilisation of human potential. So, when we analyse losses, we refer to these 7+1 types of losses.

Today, environmental protection as part of the required business efficiency is gaining more importance than in the past. This is because customers and end users are looking for environmentally friendly products and services due to the increasing scarcity of renewable resources and the imposition of (mandatory) regulations. Therefore, this article includes losses attributable to environmental, energy, and safety management systems (green losses) [25].

2.2 The place and role of small and medium-sized enterprises in the economy

For more than two decades, small and medium-sized enterprises have been the engine of economic development. They hire new employees, adapt to changes more easily than large companies, require fewer corporate resources, have shorter and faster communication channels, etc. But their significant role in generating income and investing in fixed assets should not be overlooked either.

In most countries, the size of a company is determined by legislation. Three criteria are considered, total assets, total income, and the number of employees, two of which must reach certain values for a company to be classified in a certain size category. According to the legislation and recommendations of the Commission of the European Union, the main criteria for defining small and medium-sized enterprises are the following [1]:

- Medium-sized enterprises are enterprises with fewer than 250 employees and an annual turnover of less than 50 million euros and/or an annual balance sheet total not exceeding 43 million EUR;
- Small enterprises are enterprises that employ fewer than 50 people and/or whose annual balance sheet total does not exceed 10 million euros; and
- Micro enterprises are enterprises that employ fewer than 10 employees and/or have an annual turnover or annual balance sheet total of less than 2 million euros.

Thus, small and medium enterprises account for 99.7 % of the total number of enterprises in Croatia (92.2 % are micro enterprises, 6.3 % are small and 1.2 % are medium enterprises). They account for 68.3 % of total employment (1.03 million), which is higher than the EU average, and generate added value of 20.5 billion euros (59 %), which is equal to the EU average, and 51 % of GDP [1]. Small and medium-sized enterprises create the most jobs. The fundamental characteristic of small and medium-sized enterprises is their ability to adapt quickly to changing economic conditions.

3. Research implementation

3.1 Research sample selection

Since the research was partially conducted in small and medium enterprises of the real sector, it was necessary to define a meaningful sample eligible for this research. This was ensured by an appropriate selection of companies, taking into account their activities and their international classification (European Accreditation Classification – EAC). It is important to point out that the studied sample of small and medium enterprises is from the industrial sector, i.e. manufacturing.

The researcher's assessment and the opinion of experts on the lean concept led to an approximate number of SMEs in the Republic of Croatia that apply the lean concept. The sample size was 36 SMEs, which corresponds to 34 % of the studied companies. According to the form and characteristics of the sample, it was a quota sample, i.e. an intentional sample, which means that the researchers of this article selected the companies to be studied. One to two respondents from each of the 26 selected small and medium enterprises participated in the survey, making the total number of respondents 30. The sample included companies that were 'reachable' at the time this research was conducted, were willing to provide the required responses, and were at various stages of implementing the lean concept. The criteria used to select the study participants from the selected small and medium enterprises were their knowledge of the Lean concept and their position in the company [1].

In this research, an appropriate opinion of scientists from the academic community was obtained. Care was taken to select scientists from the Republic of Croatia and from other countries.

The aim was to compare the opinions of experts from practice and academia on the problem of losses in SMEs. A total of 85 surveys were sent out, 30 of which were answered within a reasonable period of time. The opinions of scientists from academic communities outside the Republic of Croatia were also included in this research. Several times, about 220 surveys were sent out, of which 30 were returned within the time limit. The criterion of knowledge of the Lean concept and experience in theoretical and practical work with its implementation was used in the selection of scientists [1].

It is assumed that the sample size is significant for the field in which the research was conducted. Since the opinion of experts from all over the world was also obtained, it is assumed that the results can be generalized to countries that have a similar economic structure as the Republic of Croatia, but taking into account their specifics.

3.2 Research methodology and ranging losses

Ranging losses in the real sector

Research has been conducted in both the real sector and the academic community to classify the prevailing losses. A method based on Spearman's Rank correlation coefficient was developed to rank the losses in the private sector [26]. The real sector ranking was done using a semi-structured interview. Participants assigned an appropriate rank to each factor based on their opinion: rank 1 (the most important) to rank 9 (the least important). Factors with equal influence were also ranked in the same way. Respondents could assign the same ranks to different factors.

Respondents could assign the same ranks to different factors. For these reasons, the ranks had to be redesigned. Therefore, factors with the same rank received a new rank that corresponded to the mean value of the rank that the factors shared among themselves. Multiple factors with the same rank value were assigned a related rank. The average rank was determined as the arithmetic mean of the ranks that the factors would have received if they had not been related ranks. With the rank table redesigned, the null and alternative hypotheses for the Spearman's Rank correlation coefficient were as follows:

$$H_0: \rho = 0$$
$$H_1: \rho \neq 0$$

The probability of a type I error was set an extremely high significance limit, i.e. α = 0.01. The significance limit α denotes an area of rejection of the $H0$ hypothesis. Calculation of Spearman's Rank correlation coefficient ρ is suitable if the number of pairs in the sequence is less than or equal to 30, and is calculated using Eq. 1.

$$\rho = 1 - \frac{6 \cdot \sum_{i=1}^{9} (R^{(1)} - R^{(2)})^2}{N \cdot (N^2 - 1)} \tag{1}$$

where R is the squared ranks' difference of the corresponding variable value pair, and N is the number of influencing factors (N = 9).

The verification of the statistical value of ρ was performed using the hypothesis test for the significance of the correlation coefficient tr. The statistical value for ρ was verified using the t-distribution, whose value was calculated with Eq. 2.

$$t_r = \frac{\rho}{\sqrt{\frac{1 - \rho^2}{N - 2}}} \tag{2}$$

where ρ is Spearman's Rank correlation coefficient (ρ = 0.984).

Since the calculated value t_r (15.04) was higher than the tabular value t_t (2.99), it was assumed that the correlation coefficient was significant. With this statement, a one-sided and positive correlation was confirmed. Since the value of Spearman's Rank correlation coefficient reached 1, it could be confirmed with high reliability that the newly designed ranking tables were suitable for initial ranking and could be used for further analysis.

Since there were several equal ranks in the range of losses defined by the experts, the expression for the Spearman's Rank correlation coefficient had to be corrected. The corrected rank correlation coefficient is called Kendall's concordance coefficient and is usually referred to as Kendall's W in the literature. By its logic, the concordance coefficient W tests the relationship between the reviewer's actual concordance and the maximum possible concordance. Eq. 3 was used for the calculation

$$W = \frac{12 \sum S^2}{m^2(N^3 - N) - m \sum_{i=1}^{m} T_i} \tag{3}$$

where m is the number of interlocutors conducting significance ranking factors (m = 30), T_i is the sum of correction factors for related ranks, and S^2 is the sum of squared sum of the rank deviations of all respondents' and the sum of the averages.

The significance of Kendall's coefficient of concordance (W) was performed by applying the χ^2-test, as defined by Eq. 4. This required that the calculated value of this value is greater than that in the table.

$$\chi_r^2 = m \cdot (N - 1) \cdot \mathrm{W} \tag{4}$$

Since the ratio between the calculated and tabulated values was 46.56 > 20.1, the hypothesis test regarding the agreement of the opinions of the respondents showed that the ranks were interdependent, which means that the hypothesis of the agreement of the ranks of the respondents could be accepted. The calculation, i.e. the determination of the strength of the influence of all factors, was performed with the help of the dominance coefficient ϕ, which was calculated with the Eq. 5.

$$\phi = \frac{\sum_{i=1}^{m} s_{ij} \cdot \tau_i}{\sum_{i=1}^{m} \sum_{j=1}^{k} \tau_i \, s_{ij}} \tag{5}$$

where τ represents the coefficient of participating experts' competences. The values of the dominance coefficient are shown in Fig. 1.

Ranging losses by scientists

A suitable questionnaire was developed for the purpose of this research. It was designed according to the previous selection of variables and allowed the assessment of the respondents involved. The form contained 9 statements with 5 response options that corresponded to the Likert scale, allowing the expression of positive or negative attitudes towards each statement. In their responses, respondents expressed the degree of their agreement or disagreement with the position expressed in the statement (disagree at all, agree, do not know/neutral, agree, and strongly agree). After the initial evaluation, a weighted average calculation was performed for each participant, from which an individual ranking was determined for all 9 variables. These ranks were then used in the subsequent analysis. The weighted average, also referred to as the weighted arithmetic mean, is the average in which a weight (the weighting factor) is assigned to each quality item. The difference with the arithmetic mean is that the data that are averaged are not considered important. In this way, these calculated weights determine the relative average importance of each quantity [1].

Table 1 and Fig. 2 show the ranking of losses of scientists within the Republic of Croatia according to the weighted average. An identical procedure was performed with scientists outside the Republic of Croatia. Table 2 and Fig. 3 show their ranking of losses.

The statements offered to the participants were related to the impact of losses on business results, and for each of the following 9 statements, the participants' opinion was sought on which aspect is the main cause of losses in the production process:

Statement 1 – 'Over-production' is the dominant cause of losses.
Statement 2 – 'Inventory' is the dominant cause of losses.
Statement 3 – 'Transportation' is the dominant cause of losses.
Statement 4 – 'Waiting' is the dominant cause of losses.
Statement 5 – 'Excess motion' is the dominant cause of losses.

Statement 6 – 'Defects' are the dominant cause of losses.
Statement 7 – 'Over-processing' is the dominant cause of losses.
Statement 8 – 'Utilisation of human potential' is the dominant cause of losses.
Statement 9 – 'Green losses' are the dominant cause of losses.

3.3 Brief description of losses

Losses related to over-production

Over-production means producing more, earlier, or faster than is required for the next stage of the production process. It is neglected by companies that view over-production and larger inventories as a safety rather than a loss. Over-production is often the result of production planning based on sales forecasts rather than specific orders. In addition, over-production can be the result of poor communication and business relationships with suppliers, the use of high performance hardware, extensive labour, long lead times, poor business decisions, and a host of other reasons. In both the technical literature and academia, this is considered a major cause of losses. The cost of initialising machinery and production processes beyond what is required is often a hidden loss and must be accounted for. Combined with the additional cost of inventory or the inability to sell additional inventory after a certain time, this can lead to further losses [27].

The lean concept is based on the pull principle of production, which involves manufacturing products according to customer orders. This means that production must be adjusted to demand, i.e., the goal should be to produce only what is needed when a customer demands it, according to the 'just in time' principle, while many companies use the 'just in case' principle. The statement for the survey participants was: 'Over-production' as a loss represents a dominant impact on the efficiency of the production process.

Losses related to inventory

Accumulating unnecessary inventories of materials, work in process, tooling, or finished goods creates unnecessary costs. It is important to note that unnecessary inventory adds no value to the final product and represents a net cost to the manufacturer until it is sold to a customer. This cost is a significant problem for SMEs because unnecessary inventory creates additional space problems, additional moves and transportation, and the possibility of damage or reduction in the quality or value of the products. The statement for survey respondents was that 'inventories' as a loss represent a dominant impact on the efficiency of the production process.

Losses related to transportation

Transportation is the movement of materials and products from one place to another. This is a loss because it does not add value to the product and does not impose a cost that customers are willing to pay for. For manufacturers, it is an unnecessary cost because they must pay employees who are directly or indirectly involved in internal or external transportation, and they must also provide adequate transportation and appropriate equipment and supplies. Regardless of whether transportation is optimally set up or integrated into the technological process, it always represents a loss [28]. In this sense, the lean concept requires an analysis of all technological processes and the elimination or shortening of unnecessary transportation. The statement for the survey participants was: 'Transport' as a loss has a dominant influence on the efficiency of the production process.

Losses related to waiting

Waiting times are very often the result of machine breakdowns, supply problems, poor material and capacity planning, poor design of technological procedures used in the production process, poor structuring of documented information and poor control structures, and so on. Waiting time is the time lost due to slow or stopped production in a single part of the production process while the previous step is being completed. A classic example of waiting time is any production line with multiple orders or operations. If there is a different technological time between two operations, i.e. if the processing time of the second operation is longer than that of the first or vice versa, waiting times or losses occur. Operations that require more time must be made more efficient or production must be balanced by measuring and calculating with production rates. Losses due to waiting lead to a disruption in the flow of work, which is one of the main principles of lean production [29]. The statement for the survey participants was: 'Waiting' as a loss has a dominant influence on the efficiency of the production process.

Losses related to excess motion at workplaces

Any movement of workers in the workplace that is not directly related to value creation is unproductive and represents a loss. For example, by observing a worker in a processing system, it is possible to determine when value is actually being added. In theory, this is a very short period of time, sometimes only a few seconds. The other movements are actions that do not add value, such as lifting or lowering in the position where processing is taking place. The few seconds lost in such an operation due to unnecessary employee movements become minutes and eventually hours due to repetitive activities. Excessive movements in the workplace are often the result of poor ergonomic solutions in the machines, tools or equipment themselves. The statement for the survey participants was: 'Excessive movement' has a dominant influence on the efficiency of the production process as a loss.

Losses related to defects

Defects (scrap) in production can occur in items, assemblies, or finished products. It results from quality control measures that identify a specific nonconformance of a product to requirements, specifications, or contracts. For non-conforming products, repairs (rework) of deterioration must be made. If for any reason it is not possible to make such repairs, or if a customer is unwilling to purchase the product at a reduced price, the manufacturer must scrap the product as defective. All actions taken to fix a nonconforming product represent additional costs because time and materials are lost in the manufacturing process. However, the greatest cost to manufacturers comes from nonconforming products reaching the customer. Sometimes these costs can be much higher than expected [30]. This can lead to high reclamation or modification costs or simply the loss of customers. Non-conforming products result from frequent design changes, machine setup errors, decreasing operator concentration, errors in production documentation, and the like. The statement for survey participants was that 'defects' represent a dominant impact on the efficiency of the production process as a loss [31, 32].

Losses related to over-processing

Over-processing adds value to a product that customers have neither asked for nor want to pay for. Such activities represent an unnecessary cost to manufacturers. This loss comes in the form of lost time for employers and use of resources. Over time, these are costs that can significantly reduce the efficiency and effectiveness of a given process. Over-production can result from unclear standards and specifications or poor technical documentation. Many manufacturers strive to produce the highest quality product possible, but do not know what truly adds value to a product or what is essential to the end user. Examples of over-processing include painting surfaces that will never be seen or exposed to corrosive processes, or polishing and nickel plating surfaces that are not required by the customer. The statement for survey respondents was, 'Over-machining' as a loss represents a dominant impact on the efficiency of the production process.

Losses related to the utilisation of human potential

When existing knowledge and entrepreneurial know-how are not fully utilised, this harms companies in various ways: Loss of efficiency, unnecessary new hires, demotivated employees who lack recognition, etc. Employees remain underutilised, and companies fail to realise the full potential of their workforce. Employees are a company's most valuable resource, and without their commitment and loyalty, companies cannot be as competitive as they can be in the marketplace. It is very important that the contribution of all employees is recognised [1]. Most companies do not allow their employees to participate in the production process beyond what is required because they fear that they will become overqualified, demand higher wages, or leave for another company that can offer them better conditions as compensation for their newly acquired knowledge and experience. The statement for the survey participants was that 'the non-utilisation of human potential' represents as a loss a dominant impact on the efficiency of the production process.

It must be emphasised that this loss is the most difficult to identify and quantify and, in this context, the most difficult to eliminate.

Losses related to environmental protection

As stated in the introductory part of this article, losses in the production process and in other processes of any system are also associated with losses related to the energy management system, environmental protection, and workplace safety. Seven types of losses have been identified, grouped under the title 'Green Losses'. They are related to green production, minimising process waste and pollution from processes, and from the design and execution of products and services. The statement for survey participants was that 'Green losses' represent a dominant impact on the efficiency of the production process as a loss.

3.4 Results of loss ranging

The results of loss ranging by competent experts from the field are shown in Fig. 1, and the results of loss ranging by scientists within the Republic of Croatia (ZRH) are shown in Table 1 and Fig. 2. The results of loss ranging by scientists outside the Republic of Croatia (ZIRH) are presented in Table 2 and Fig. 3.

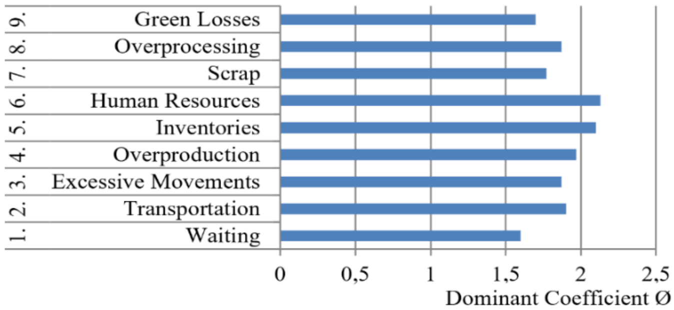

Fig. 1 A presentation of loss ranging as defined by real sector professionals

Table 1 Loss ranging on the basis of weighted sverages (Croatia)

Ordinal Number	Loss Type -Statement-	Degree of Agreement*					Weighted Average	Range
		SD	D	N	A	SA		
1.	Over-production	1	12	6	10	1	1.97	7
2.	Inventories	0	8	8	11	3	2.10	8
3.	Transportation	0	9	6	13	2	1.90	6
4.	Waiting	0	1	4	18	7	1.60	1
5.	Excessive Movements	1	4	11	13	1	1.87	4
6.	Scrap	0	4	2	15	9	1.77	3
7.	Over-processing	0	5	7	15	3	1.87	5
8.	Utilisation of Human Resources	1	4	6	13	6	2.13	9
9.	Green Losses	0	5	18	5	2	1.70	2

* SD-Strongly Disagree; D-Disagree; UN-Unknown/Neutral; A-Agree; SA-Strongly Agree

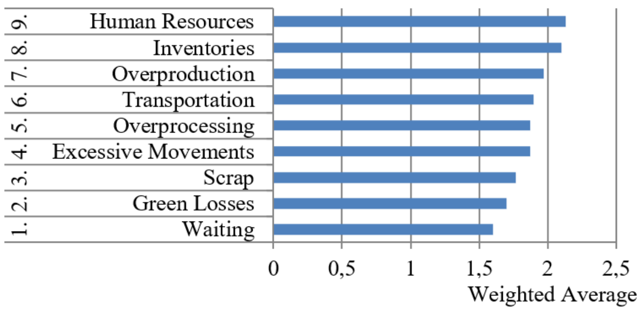

Fig. 2 A presentation of loss ranging as defined by experts from within Croatia

Table 2 Loss ranging on the basis of weighted averages (outside Croatia)

Ordinal Number	Loss Type -Statement-	Degree of Agreement*					Weighted Average	Range
		SD	D	UN	A	SA		
1.	Over-production	0	4	8	14	4	1.93	6
2.	Inventory	2	6	6	10	6	2.47	9
3.	Transportation	0	8	4	17	1	1.63	3
4.	Waiting	0	0	3	16	11	1.56	2
5.	Excessive Movements	2	4	5	15	4	1.97	5
6.	Scrap	1	5	6	12	6	2.23	7
7.	Over-processing	1	6	0	18	5	1.63	4
8.	Utilisation of Human Resources	3	6	5	11	5	2.43	8
9.	Green Losses	6	2	21	1	0	1.43	1

* SD-Strongly Disagree; D-Disagree; Unknown/N-Neutral; A-Agree; SA-Strongly Agree

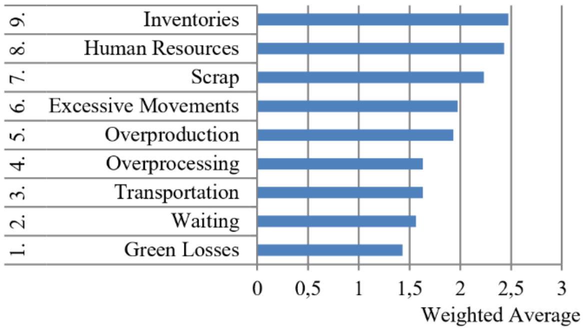

Fig. 3 A Presentation of loss ranging as defined by experts from outside Croatia

Statistical data verification

Because the data describing the losses are ordinal in nature, the analysis involves ranking the data rather than the data themselves. In nonparametric statistics, the Kruskal-Wallis test is most commonly used to compare the ranks of losses from three or more samples. In this study, three samples were used. The first sample refers to the private sector (RS), the second to academic scientists from the Republic of Croatia, and the third to academic experts from outside the Republic of Croatia. The Kruskal-Wallis test essentially tests the hypotheses that have been established. It is a test of an analysis of variance, except that instead of numerical measurement data (continuous variables), rankings (discrete variables) are used [1]. A test of statistic H is created by the Eq. 6.

$$H = \frac{12}{N(N+1)} \sum \frac{T_i}{N_i} - 3(\mathrm{N}+1) \tag{6}$$

where N is the total number of observations, and T_i is the sum of the ranks in a single sample. If the samples are large enough (in this case the samples are considered large enough because each sample contains 5 results), H has the same distribution as the *HI*-squared, so its significance can be read in the χ^2 Table with $k-1$ denoting the degree of freedom and the level of significance α. The results of the Kruskal-Wallis test for the individual samples are given in Tables 3, 4 and 5 for a significance of 5 % (α = 0.05).

Table 3 Analysis of losses within the RS sample

RS			
Test Statistic *H*	Value of *p*	Test Statistic *H* Custom Value	Value of *p*
43.40	0.000	43.43	0.000

Table 4 Analysis of losses within the 'Croatia' sample

Croatia			
Test Statistic *H*	Value of *p*	Test Statistic *H* Custom Value	Value of *p*
32.08	0.000	35.63	0.000

Table 5 Analysis of losses within the ZIRH sample

Outside Croatia			
Test Statistic *H*	Value of *p*	Test Statistic *H* Custom Value	Value of *p*
39.38	0.000	43.40	0.000

Before determining the final ranking of losses, it is necessary to determine whether there is a statistically significant difference between the three samples in terms of perceptions of the intensity of the impact of these losses on the overall efficiency of small and medium-sized enterprises. To test this, the hypotheses $H0$ and $H1$ were established.

$H0$ – there is no significant statistical difference between RS, 'Croatia' and 'Outside Croatia' in terms of perception of the impact of losses on the overall efficiency of small and medium enterprises.

$H1$ – there is a significant statistical difference between RS, 'Croatia' and 'Outside Croatia' in terms of perception of the impact of losses on the overall efficiency of small and medium enterprises.

The results of the Kruskal-Wallis test in relation to the perception of the impact of losses on the overall efficiency of small and medium-sized enterprises on the part of RS, 'Croatia' and 'Outside Croatia' are presented in Table 6. These results indicate whether the null hypothesis can be rejected, i.e. an alternative is accepted at the selected significance level. Specifically, these test results show that the ranks defined by the real sector, scientists from the Republic of Croatia and scientists from outside the Republic of Croatia are not statistically significantly different in terms of the perception of the impact of losses on the overall efficiency of SMEs (p-value is 0.084, i.e. $p > 0.05$). From this it could be concluded that it is statistically correct to accept the $H0$ hypothesis.

Table 6 Results of the Kruskal-Wallis test for the Three Samples (RS, Croatia and Outside Croatia)

RS, Croatia and Outside Croatia			
Test Statistic H	Value of p	Test Statistic H Custom Value	Value of p
13.90	0.084	14.06	0.080

From the analysis and comparison of the individual ranks (see Tables 1 and 2), the following can be deduced. When analysing the ranking determined by scientists from the Republic of Croatia (Croatia), a high ranking (ranking number 2) for 'Green Losses' can be observed. In this particular case, 18 participants or 60 % declared themselves neutral/undecided about this type of loss. This means that they did not have a specific opinion about this type of loss. Similarly, 5 or 16.7 % stated that they disagreed, while 16.7 % expressed agreement.

The analysis of the ranking determined by researchers outside the Republic of Croatia (Outside Croatia) showed, as mentioned above, a high ranking (rank 1) for 'Green losses'. In this particular case, 21 participants, or 70 %, stated that they were neutral/undecided about this type of loss, while 5, or 20 %, disagreed with the statement that this is the predominant loss that significantly affects the business efficiency of SMEs. For these reasons, the responses of the participants from 'Croatia' and 'Outside Croatia' regarding 'Green Losses' are excluded from the analysis.

Taking into account the results of the Kruskal-Wallis test and the above statement, the rankings were combined and the final results of the loss ranking (Table 7) were presented. There are three 'significant losses' for SMEs, namely: waiting time, transportation, and excessive movement. There are other losses, but these three are prevalent and require more attention in improving the processes.

Table 7 An analysis of individual ranks and a presentation of the final loss rankings

Code	LOSSES	RANGE 1 'RS'	RANGE 2 'ZRH'	RANGE 3 'ZIRH'	SUM OF RANGES	FINAL RANGE
G_1	Over-production	4	7	6	17	4
G_2	Inventory	5	8	9	22	5
G_3	Transportation	2	6	3	11	2
G_4	Waiting	1	1	2	4	1
G_5	Excessive Movement	3	4	5	12	3
G_6	Scrap	7	3	7	17	4
G_7	Over-processing	8	5	4	17	4
G_8	Utilisation of Human Resources	6	9	8	23	6
G_9	Green Losses	9	2	1	12	-

4. Conclusion

Eliminating and reducing losses is one of the main goals of any improvement system, and this includes the Lean concept. This paper is mainly about identifying the most important loss types from the defined 9 loss types that occur in the production environment. The calculation of the ranks is based on the opinions of the surveyed participants using Spearman's rank correlation coefficient and weighted average method. The results indicate that the top three loss types were identified from the total nine losses. Most respondents indicated that losses related to waiting time, transportation, and excessive movements were the main causes of losses for small and medium enterprises. Statistical analysis of the results confirmed this conclusion. Based on the results of this research, it can be concluded that production managers and professionals responsible for the production process must systematically monitor these three main types of losses so that they can be eliminated or continuously reduced. Elimination of the prevailing losses significantly increases productivity and other indicators of production processes [33, 34].

The activities of those responsible for loss elimination should focus on the following:

- Identification of losses;
- Implementation of the proposed loss elimination systems;
- Training employees in the application of the lean concept to eliminate or reduce losses;
- Measuring losses;
- Establishing liability for losses,
- Analysing risks and opportunities for loss management.

Specific procedures for eliminating losses are based on the nature of the losses, their magnitude, and their priorities. Procedures include continuous training of staff and planning of activities of responsible staff with continuous measurement, monitoring and improvement.

Various lean techniques can be applied to reduce losses in production systems, such as: 5S, Kanban, Andon, production bottleneck analysis, Kaizen, Jidoka, JIT, TPM, VSM, Gemba, SMED, OEE, PDCA, TQM, SMART goals, Continuous production flow, Tact time, Visual Factory, Poka-Yoke, etc. [35, 36]. The application of various lean techniques is essential in all occasions for the identification, analysis and elimination of losses, with emphasis on numerical indicators (Six Sigma).

Well-organised loss management and the lean concept in general help SMEs to withstand unforeseen situations such as a pandemic, political and economic unrest, etc. unforeseen events.

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