POLISH JOURNAL OF MANAGEMENT STUDIES
Ulewicz R., Czerwińska K., Siwiec D., Pacana A.

2022
Vol.25 No.2

# ANALYSIS OF THE SYSTEMIC APPROACH TO THE CONCEPT OF LEAN MANUFACTURING – RESULTS OF EMPIRICAL RESEARCH

**Ulewicz R., Czerwińska K., Siwiec D., Pacana A.***

**Abstract**: Lean Manufacturing is a profound system designed to enhance every manufacturing industry's efficiency by reducing waste through internationally recognized tools and techniques. Enterprises of all sizes and industries strive to adopt Lean Manufacturing (LM) concepts to maximize their resources, such as personnel, facilities, materials, and operating schedules, to be economically effective. There are several models for implementing Lean philosophy in enterprises. The conducted research is aimed at reviewing and conceptualizing the LM system implementation framework in the enterprises in Central and Eastern Europe. The analysis was based on the results of surveys conducted in micro, small, medium and large enterprises, mainly in production, trade and service organizations. As a result, among others, the main premises, methods and benefits of implementing the LM system, thus identifying the specificity of the concept in the context of the size of enterprises and the industry from which they come, were indicated. The originality is the analysis of the effectiveness, efficiency and productivity of Lean activities, distinguishing the size of the organization from the group of micro, small, medium and large organizations (MSME). The research results show that the LM implementation model in enterprises from Central and Eastern Europe is based on the Shingo model.

**Key words:** Lean manufacturing, Lean production, Lean tools, operational performance, value, operations management

DOI: 10.17512/pjms.2022.25.2.24

*Article history:*
*Received* February 22, 2022; *Revised* April 10, 2022*; Accepted* April 23, 2022

## Introduction

Progressing globalisation processes, dynamically changing market, increasing intensity of competition, and threats related to crisis phenomena require the management to undertake improvement actions and implement efficient management systems. For companies, ensuring a stable position and competitive advantage means selecting and applying an appropriate management strategy related to efficiency gains (Brzóska et al., 2011; Fredriksson & Larsson, 2012; Grabowska, 2017; Mednikov et al., 2018; Andriani et al., 2019; Yu et al., 2020; Heckova et al., 2021) and often innovation. (Penalver et al., 2018; Ko & Mom, 2019; Shin & Alam, 2020; Roque et al, 2020; Zhou et al., 2021). One of the management concepts that create significant opportunities in terms of flexibility of production processes, cost

* **Ulewicz Robert**, Częstochowa University of Technology, **Czerwińska Karolina, Siwiec Dominika, Pacana Andrzej,** Rzeszów University of Technology
✉ corresponding author: robert.ulewicz@pcz.pl
✉ k.czerwinska@prz.edu.pl ; d.siwiec@prz.edu.pl, app@prz.edu.pl,

efficiency and waste reduction is the concept of Lean Manufacturing (Shah & Ward, 2003; Wolniak, 2013; Deshmukh et al., 2017). The methods, tools, and techniques of this management concept influence the reduction or complete elimination of waste and the creation of value in products and processes. Lean in this context, should be understood as the reduced consumption of a company's resources concerning the "ordinary" conditions under which the company operates (Gupta & Jain, 2013; Fullerton et al., 2014; Pacana & Ulewicz, 2020, Sudhakara et al., 2020; Danko et al, 2022). Reducing the use of resources is possible by reducing or eliminating unnecessary activities and carrying out only those that are necessary and performed in the proper order, correctly the first time and in a manner that increases company profit while maintaining an appropriate level of customer satisfaction (Bortolotti et al., 2015; Pacana et al., 2019; Wolniak et al., 2018, Gazda et al. 2013, Ostasz et al., 2020, Ingaldi, 2021). This approach includes the modernization of production processes, the organisational structure's improvement, and the links that occur between the company and its suppliers and customers. Therefore, it can be concluded that it is an integrated and comprehensive way of business management (Baird et al., 2011). According to the LM concept, Managing an enterprise creates favourable conditions for implementing Industry 4.0 technologies (Hasseb et al., 2019; Slusarczyk, 2018). Whereby, through networking and the free exchange of data, organizations can produce more economically and respond more quickly to individual customer needs (Wolniak, 2013, Sanders et al., 2016; Lai et al., 2019; Ding et al., 2021; Ghouat et al., 2021, Krynke 2021).

In recent years, there has been a growing interest in the concept of Lean Manufacturing (LM), which is being implemented worldwide (Gavriluta, 2019; Matharu & Sinha, 2019; Ojha & Venkatesh, 2021). However, in Polish economic conditions, enterprises may face numerous difficulties in implementing and applying this concept (Achanga et al., 2006; Ulewicz et al., 2020). In the literature, one can often find opinions that the Lean concept can be applied in its complete form in a company where the specificity of its functioning is closer to the specificity of functioning of the automotive industry (Koch et al., 2006; Valentinovich, 2013). Large companies are more motivated to implement the Lean concept. They also have more resources that can be used to implement the concept. (van der Steen and Tillema, 2018; El-Khalil, 2020). Small and medium-sized businesses have a more challenging time with implementation. This is due to, among other things, insufficient resources, lack of knowledge, as well as lack of support in the implementation process by external companies, for which many times small and medium-sized enterprises are not attractive enough from the point of view of potential implementation benefits (Maszke et al., 2018; Sodhi et al., 2020; Valence, 2020; Ramadas & Satish, 2021; Salma et al., 2021). Therefore, by identifying the strengths and weaknesses and taking into account the specificities of SME enterprises, attempts are made to create LM implementation models that are mainly targeted at this type of enterprise (Alexander et al., 2021). Most often, the issue of Lean Manufacturing in the SME sector described in the literature refers mainly to

medium-sized enterprises characterized by serial and small batch production, and not too small enterprises often engaged in small-batch or unitary production (Nogalski & Walentynowicz, 2011 ; Tyagia et al., 2015).

There are tens of different tools within the Lean concept, making it challenging to create one precise classification. The wide range of Lean tools leads to the fact that companies may not implement most of these tools at one time (Tyagia, 2015). Therefore, a phased approach to implementing Lean concepts is increasingly recommended (Chauchan & Chauhan, 2019; Basu & Dan, 2020), and various universal models are being developed to indicate how Lean concepts can be implied in companies (Nguyen, 2015; Ng & Ghobakhloo, 2018).

The purpose of this study was to review and conceptualize a framework for lean manufacturing (LM) implementations to effectively manage manufacturing processes in the context of organizational development and gaining customer satisfaction. The study is based on a survey on the awareness of the Lean concept among organizations located in Central and Eastern Europe (Poland, Czech Republic, Slovakia).

***Reseach Part***

An analysis was carried out based on survey research included 16 questions created in an expert way, i.e. after literature review (e.g. Shah & Ward, 2003, Yung et al. 2011; Nowicka-Skowron et al. 2016) and after consultation with five quality management system representatives. The questions were created to differentiate according to enterprise size:

-reasons, method, and effectiveness from LM system implementation,

-groups of implemented LM instruments and their effectiveness,

-waste areas and problems during implementation of system, as in works e.g., (Mazur & Momeni 2019; Tuan-Anh et al. 2020; Ulewicz et al. 2019).

In research took part 129 Central and Eastern Europe (Poland, Czech Republic, Slovakia) organizations from micro, small, medium, and large enterprises (Tambunan, 2011), which number was considered as enough following studies of authors (Ulewicz & Ulewicz, 2020; Ulewicz & Kucęba, 2016). Among the respondents were: micro (11.63%), small (16.28%), medium (40.31%) and large (31.78%). Among analysis, enterprises were manufacturing (57.32%), trading (20.12%), service (18.90%) and other companies (3.66%). More than half of surveyed organizations were companies (52%), by which a slightly lower percentage were private companies (about 24%). Small groups were constituted administrations and cooperatives (1.32%). The answers were provided by the respondents who were employees of higher, middle and lower level, e.g. management, technologist, constructor, quality supervision engineer. production specialist. The presented results included only response rate, because not all organizations responded to each of questions, and also not declared implemented LM system. Therefore, to achieve the number of responses allows obtaining reliability and significance of the results, the adopted combination of techniques was used, i.e. normalization of response for category of organization size (Ghram, Frikha, 2018), and scale of category

importance in scale from 0 to 1 (Mane, Dongale, Bapat, 2014). The purpose of normalization technique was to unification disproportionate measure categories to their comparison, and to ensure reliability and relevance of the results (Kiselakova et al. 2020; Tarka, 2015). Following to (Ghram, Frikha, 2018) for the different number of answers, where the more answers, the more important category, was used formula (1):

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} {x_{ij}}^{q}} \quad (1)$$

where: $\bar{x}_{ij}$ – normalized weight $i_{th}$ category in $j_{th}$ question, $x_{ij}$ – number answers for $i_{th}$ category in $j_{th}$ question, ${x_{ij}}^{q}$ – summary number of answers in analysed question for category (size) enterprise in $j_{th}$ question, i, j = 1, 2, …, n.

As result, category values of each question were normalized. These values should be in rank from 0 to 1. According to formula (2) it is possible to determine correctness of calculations:

$$\sum_{i=0}^{i} \bar{x}_{ij} = 1 \quad (2)$$

where: $\bar{x}_{ij}$ – normalized weight $i_{th}$ category in $j_{th}$ question, i, j = 1, 2, …, n.

If the sum of normalized values for all categories in question is equal to 1, it is possible to show that answer values for category were correct normalized.

Based on normalized values of category weights ($\bar{x}_{ij}$), it was possible to identify important categories, i.e. percentage of the highest number of responses provided. Therefore, the range of category weight values for any questions was different. To identify important category it was necessary adjustment of importance scale of these categories to range of category values for each answer. Following of authors (Mane, Dongale, Bapat, 2014), the importance scale of categories was developed and used (Tabela 1).

**Table 1. Importance scale of category.**

| Condition | Describe | Weight |
|---|---|---|
| If category weights are in rank <0.0; 0.5) | Unimportant | 0.0 |
| | Strongly imporntant | 0.1 |
| | Very important | 0.2 |
| | Highly imporntant | 0.3 |
| | Extremply important | 0.4 |
| If category weights are in rank <0.5; 0.6) | Medium imporntant | 0.5 |
| If category weights are in rank <0.6; 1.0> | Quite important | 0.6 |
| | Strongly imporntant | 0.7 |
| | Very important | 0.8 |
| | Highly imporntant | 0.9 |
| | Extremply important | 1 |

**Source:** Own study based on (Mane, Dongale, Bapat, 2014).

According to importance scale identified importance categories with distinction size of enterprises from micro, small, medium, and large enterprises. Follows to the authors (Ghram, Frikha, 2018; Mane, Dongale, Bapat, 2014), maximum weight from all category weights for any question from micro, small, medium and large enterprises were determined. Then, according to importance scale was determined in which number range is maximum category weight. As assumed in (Mane, Dongale, Bapat, 2014) difference between values included in the range (so-called weights of important category) was equal to 0.10 for compartment closed on both sides. Categories included in this number range were important, i.e. the most important among identified (have important weight, so has the highest percentage of the answers given).

## Research Results

Initially, as part of survey research, was verified to approach organizations to continuous improvement by using the LM tools. After normalization of survey results (accordance with formula 1) and verification obtained category values (accordance with importance scale), it was shown that micro, small and medium organizations considered that exists a system continuous improvement (kaizen) in which lean tools are using (about 0.57). On the other hand, large-scale organizations have overwhelmingly considered that lean management exists, as part of is kaizen approach (0.62). Therefore, it was adequate to verify factors implemented in the LM system in these organizations. The implementation factors were expertly developed, then verified, and corrected as part of consultations with five Plenipotentiaries. As result, fourteen possible deployment factors were proposed. Based on (Krok, 2015), it was assumed, that each of respondents had opportunity to point maximum of two answers, in that proposed own factors. Results are shown in Table 2, where weights were determined according to assume method, i.e. normalized category values in each survey question according to organizations' sizes (according to formula 1) and verification of the results according to developed significance scale.

**Table 2. Factors implementation of Lean Manufacturing system in organization**

| Factors implementation of LM in organizations | Micro | Small | Medium | Large |
|---|---|---|---|---|
| need of reducing production loss | 0.06 | 0.24 | 0.25 | 0.19 |
| less investment for the same production level | 0.00 | 0.03 | 0.05 | 0.02 |
| increasing production with a constant level of investment | 0.00 | 0.18 | 0.05 | 0.06 |
| need to increase production efficiency | 0.12 | 0.15 | 0.12 | 0.16 |
| providing high-quality products and services | 0.35 | 0.15 | 0.18 | 0.13 |
| fashion related to introduction of the Lean Manufacturing system | 0.00 | 0.00 | 0.00 | 0.01 |
| increasing financial results by reducing production costs | 0.00 | 0.00 | 0.06 | 0.07 |
| shortening delivery times | 0.12 | 0.06 | 0.02 | 0.05 |
| increasing customer satisfaction | 0.18 | 0.06 | 0.06 | 0.08 |
| optimization of production processes | 0.06 | 0.09 | 0.06 | 0.09 |
| continuous improvement of production processes | 0.06 | 0.03 | 0.08 | 0.07 |
| implementation of the production plan | 0.00 | 0.03 | 0.04 | 0.02 |
| improvement and increase of work safety, improvement of health and safety conditions | 0.06 | 0.00 | 0.02 | 0.04 |
| Sum of normalized values | 1.00 | 1.00 | 1.00 | 1.00 |

**Table 3. Problems associated with implemented of the Lean Manufacturing system**

| Problems associated with implemented of the LM | Micro | Small | Medium | Large |
|---|---|---|---|---|
| employee workload | 0.04 | 0.08 | 0.13 | 0.13 |
| need to reorganize the organization | 0.08 | 0.11 | 0.07 | 0.10 |
| insufficient number of trainings or their poor quality | 0.08 | 0.03 | 0.08 | 0.03 |
| no time | 0.29 | 0.21 | 0.20 | 0.10 |
| too short implementation period | 0.08 | 0.08 | 0.07 | 0.05 |
| lack of suitably qualified personnel | 0.13 | 0.08 | 0.01 | 0.04 |
| complicated implementation procedure | 0.04 | 0.11 | 0.07 | 0.02 |
| difficulties in understanding language and requirements of standard | 0.04 | 0.05 | 0.02 | 0.05 |
| too little commitment from management | 0.00 | 0.03 | 0.06 | 0.03 |
| too little involvement of employees | 0.00 | 0.11 | 0.07 | 0.09 |
| employees' fear of changes | 0.13 | 0.05 | 0.09 | 0.18 |
| reluctance of employees to introduce changes | 0.08 | 0.05 | 0.10 | 0.11 |
| non-compliance by employees with rules of operation tools | 0.00 | 0.03 | 0.04 | 0.05 |
| Sum of normalized values | 1.00 | 1.00 | 1.00 | 1.00 |

Organizations from micro, small, and medium groups had pointed that important problem of implementation of LM was lack of time (average 0.23). In turn, organizations of large sizes declared that base problems were: reluctance of employees to introduce changes (0.11), employee workload (0.18), employees' fear of changes (0.13). None of the organizations mentioned their own problems with LM implementation. Then, it was checked which LM instruments were implemented and which problems were eliminated after their these implementations. The results are shown in Table 4, in which values were determined according to formula (1), and analyzed based on the importance scale.

**Table 4. Effects of implementing Lean Manufacturing tools in the organization - weight share.**

| Type of elimination | | Tools of LM | Overproduction | Waiting time | Redundant movement | Wrestling | Unnecessary transport | Repairs and shortages |
|---|---|---|---|---|---|---|---|---|
| Declared implementations | | VSM | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.00 | | - | - | - | - | - | - |
| Small | 0.00 | | - | - | - | - | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Medium | 0.16 | | 0.14 | 0.21 | 0.21 | 0.21 | 0.14 | 0.00 |
| Large | 0.52 | | 0.21 | 0.16 | 0.16 | 0.18 | 0.21 | 0.08 |
| Declared implementations | | 5S | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.31 | | 0.00 | 0.50 | 0.25 | 0.00 | 0.25 | 0.00 |
| Small | 0.50 | | 0.08 | 0.15 | 0.38 | 0.08 | 0.15 | 0.15 |
| Medium | 0.56 | | 0.04 | 0.27 | 0.33 | 0.07 | 0.16 | 0.13 |
| Large | 0.91 | | 0.09 | 0.25 | 0.27 | 0.11 | 0.07 | 0.21 |
| Declared implementations | | SMED | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.00 | | - | - | - | - | - | - |
| Small | 0.17 | | 0.25 | 0.50 | 0.25 | 0.00 | 0.00 | 0.00 |
| Medium | 0.30 | | 0.00 | 0.42 | 0.16 | 0.05 | 0.00 | 0.37 |
| Large | 0.35 | | 0.00 | 0.43 | 0.22 | 0.17 | 0.04 | 0.13 |
| Declared implementations | | Poka-Yoke | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.31 | | 0.00 | 0.50 | 0.25 | 0.00 | 0.25 | 0.00 |
| Small | 0.33 | | 0.00 | 0.25 | 0.38 | 0.00 | 0.13 | 0.25 |
| Medium | 0.30 | | 0.11 | 0.06 | 0.17 | 0.11 | 0.06 | 0.50 |
| Large | 0.81 | | 0.03 | 0.09 | 0.06 | 0.09 | 0.03 | 0.70 |
| Declared implementations | | TPM | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.08 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Small | 0.28 | | 0.00 | 0.14 | 0.29 | 0.14 | 0.00 | 0.43 |
| Medium | 0.56 | | 0.03 | 0.29 | 0.15 | 0.00 | 0.06 | 0.47 |
| Large | 0.70 | | 0.03 | 0.26 | 0.10 | 0.10 | 0.06 | 0.45 |
| Declared implementations | | QRM | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.15 | | 0.00 | 0.50 | 0.00 | 0.00 | 0.50 | 0.00 |
| Small | 0.11 | | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 0.50 |
| Medium | 0.09 | | 0.00 | 0.25 | 0.00 | 0.25 | 0.25 | 0.25 |
| Large | 0.15 | | 0.13 | 0.25 | 0.13 | 0.25 | 0.13 | 0.13 |
| Declared implementations | | Kanban | weight share of problems eliminated after implementation of the LM tool | | | | | |
| Micro | 0.08 | | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| Small | 0.00 | | - | - | - | - | - | - |
| Medium | 0.12 | | 0.29 | 0.00 | 0.14 | 0.57 | 0.00 | 0.00 |
| Large | 0.47 | | 0.08 | 0.31 | 0.15 | 0.35 | 0.12 | 0.00 |

As shown in Table 4, the sum of category values was equal to 1. Therefore, it was shown correctness calculation. Initially, the implementations of the VSM (value stream mapping) tool were analyzed. Analysis was shown lack of implementation this tool in micro and small organizations. Few such implementations were in medium-size organizations (0.16), simultaneously declared that implementation of VSM contributed mainly to eliminate (0.21): waiting time as well as unnecessary

movement and inventory. The most number of implementation of VSM was identified in large organizations (0.52), which by this tool eliminated mainly overproduction and unnecessary transport (0.21).

Then, it was verified implemented of the 5S tool (the concept of standardization of work positions). It was observed the overwhelming number of declared implementations in large organizations (0.91), which were pointed that eliminated mainly: redundant traffic (0.27), waiting time (0.25), repairs and deficiencies (0.21). A similar number of implementations were observed in small (0.50) and medium (0.56) organizations, which had declared that eliminated mainly redundant traffic (average 0.36). A relatively smaller number of implementations of this tool occurred in micro organizations (0.31), which were eliminated mainly waiting time (0.50).

Then, implementations of the SMED tool (Single Minute Exchange of Die) were analyzed. It was shown a lack of implementation of these tools in micro organizations. Relatively few implementations occurred in small organizations (0.17), then medium (0.30), and large (0.35), which simultaneously shown that the SMED tool allows eliminating waiting time (average 0.45).

Next, the implementation of the Poka-Yoke tool (method of preventing mistakes) was verified. A similar number of implementations (about 0.31) declared micro, small, and medium organizations, which eliminated mainly: waiting time - micro organizations (0.50), redundant movement - small organizations (0.38), repairs and shortages - medium organizations (0.50). The largest number of Poka-Yoke implementations was observed in large organizations (0.81), which declared that this tool allowed to eliminate repairs and shortages (0.70).

Then, implementations of the TMP tool (Total Productivity Maintenance) were analyzed. It was shown, that a small percentage of micro organizations (0.08) implemented this tool, by which relatively few more implementations have been observed in small organizations (0.28). More than half of medium organizations (0.56) implemented TPM, where the largest number of implementations indicated large organizations (0.70). All of these organizations identified, that implementation of the TMP allowed mainly to eliminate repairs and shortages.

Then, it was verified of implementation of QRM (Quick Response Manufacturing) tool. It was shown, that these implementations were relatively little in MSME organizations (average 0.13), where these organizations declared in a similar way that eliminated mainly: waiting time, inventory, unnecessary transportation, repairs and shortages.

The last of the analyzed tools is Kanban, for which a lack of implementations in small organizations was observed, and a small percentage of implementations were in micro organizations (0.08). Relatively few more implementations were declared in medium organizations (0.12), where the largest of implementations were in large organizations (0.47). Both micro, average, and large organizations showed that the Kanban tool allowed mainly to eliminate waste. In turn, large organizations also indicated that implementing Kanban resulted in elimination of waiting time. Additionally, in this context, the efficiency of implemented LM tools was verified.

The organizations from groups of micro, small, and medium shown that effectiveness depends on the type of tools (average weight 0.44). In turn, large organizations stated that the LM tools are effective (0.58).
In the next stage of the survey results analysis, it was verified what types of waste were eliminated in the organization's MSME group. Micro organizations showed that eliminated mainly the unused potential of the employee (0.33). Small organizations declared that eliminated mainly unnecessary transport (0.12). Relatively similar results were obtained for medium and large organizations, which indicated that they eliminated mainly: inventories, excessive traffic, shortages, unused potential of an employee and waiting. In addition, large organizations indicated the elimination of overproduction and unnecessary transport.
In the next stage of analysis, it was verified internal and external benefits from implemented the LM tools. According to assumed method, the category values included in each question were normalized depends on the size of organizations (as in formula 1), and verified these values were based on the importance scale. Results are shown in Table 5.

**Table 5. The most important observed internal and external effects from the implementation of Lean Manufacturing tools.**

| The most important effects observed | Micro | Small | Medium | Large |
|---|---|---|---|---|
| internal | | | | |
| reduction / elimination of organizational problems | 0.11 | 0.20 | 0.16 | 0.21 |
| reduction / elimination of labor conflicts | 0.11 | 0.12 | 0.09 | 0.05 |
| reduction / elimination of downtime / failure | 0.17 | 0.20 | 0.29 | 0.23 |
| reduction / elimination of other factors | 0.06 | 0.00 | 0.05 | 0.16 |
| improving communication and information flow | 0.17 | 0.16 | 0.19 | 0.16 |
| improving the comfort of work | 0.33 | 0.20 | 0.21 | 0.12 |
| I don't know / can't define | 0.06 | 0.12 | 0.02 | 0.05 |
| Sum of normalized values | 1.00 | 1.00 | 1.00 | 1.00 |
| external | | | | |
| acquiring new customers | 0.39 | 0.17 | 0.32 | 0.27 |
| retaining existing customers | 0.17 | 0.25 | 0.28 | 0.33 |
| improving the image of local administration bodies | 0.06 | 0.13 | 0.08 | 0.10 |
| better cooperation with subcontractors and suppliers | 0.33 | 0.21 | 0.24 | 0.17 |
| better contact with local media | 0.06 | 0.13 | 0.00 | 0.04 |
| I don't know / I can't define | 0.00 | 0.13 | 0.06 | 0.08 |
| Sum of normalized values | 1.00 | 1.00 | 1.00 | 1.00 |

The main internal benefit for micro, small and medium organizations was improving the comfort of work, where also small and medium organizations pointed to reduction/elimination of downtime/failure. Also, important internal effects in small and medium organizations were considered reduction (elimination) of organization problems. In turn, mainly external benefits were: obtained new customers (micro and large organizations), better cooperation with subcontractors and suppliers (micro and small organizations), and retaining existing customers (small and large organizations). Analyze of mentioned effectiveness, efficiency, and productivity of LM was carried out by used in organizations among others: audits, 8D report, gemba walk, surveys, diagnostic surveys, analysis in the ERP system, TPM indicators, Pareto analysis, Kaizen, FMEA, inventory calculations or V-shape layout.
At the last stage of the analysis, it was verified whether the percentage of organizations from the MSME group that did not declare the implemented LM tools planned to implement them in the future. Micro, small and large organizations have indicated that it is difficult for them to determine at present whether there will be such implementations. In turn, medium-sized organizations predominantly indicated that they do not plan such implementations in the future.

## Discussion

The scope of application of the Lean concept in Central and Eastern Europe enterprises depends mainly on: the nature of the business activity, the type of production, the size of the organization and the stage of implementation of the concept and professionalism in the use of LM tools. Focusing on different aspects of LM implementation (e.g., reasons for LM implementations, accompanying impediments, benefits, LM tools implemented), one can see differences in the size of organizations. Based on our research and literature sources (Bednarek 2015), it can be concluded that the model of LM implementation in Central and Eastern Europe enterprises is similar to the Shingo model (The Singo Model version 14, Utah State University, 2020), which is a global standard. In this case, the culture of conduct as in the 4Ps (Liker 2004) model of divination relates directly to internal stakeholders and their partners. For MSME sector organizations, a paradigm can be formulated that an ideal outcome requires a viable system with established rules.
The research conducted identified the main reasons for implementing LM in organizations with a distinction of their size. The main reason for LM implementations in micro organizations was the need to ensure high-quality products and services, while in small and medium organizations, the critical reason was the need to reduce production losses. This may be because production systems in SMEs are more adaptable due to their smaller size and their ability to produce products in small batches to meet the diverse requirements of their customers (Lee, 1995). Large-sized organizations indicated the exact reasons for implementing LM, but with a significant emphasis on increasing production efficiency. What results from their specifics - designed for economies of scale in terms of product manufacturing (Alkhoraif et al., 2019).

When analyzing the problems occurring in the process of LM concept implementation, the surveyed micro, small and medium organizations indicated that a significant problem related to LM implementation was lack of time. Other barriers cited in the literature regarding Lean implementation are operational level problems, including inefficient processes and quality control systems (Lee, 1995; Alkhoraif et al., 2019, Ulewicz et al., 2021). Further barriers to applying Lean in SMEs were identified by (Shrimali et al., 2018), who cite lack of top management support and resistance to change from middle management. For SME, the weak point is the organizational culture, as it most often adopts an autocratic management style, which does not favour the improvement of (Achanga i in., 2006). On the other hand, the surveyed organizations of significant size declared that the main problems in implementing the LM concept were employees' reluctance to make changes, the burden of employees, and the fear of employees to change. The results indicated in studies (Hausner, 2009, Żebrucki & Kruczek, 2018; Hensel, 2015; Sahu et al., 2020) overlap with the barriers identified in the study. Lack of proper understanding and interpretation of Lean concepts can introduce chaos in the company, resistance from employees and lack of trust (Podobinski, 2015; Sisson JA., 2019), which results from employees mistakenly identifying Lean activities, with a decrease in employment. (Fullerton i in., 2014). The solution to the identified problems seems to be the creation, both in micro, small, medium and large organizations, of an appropriate organizational culture that would include more than just a plan to improve operations (Panizzolo et al., 2021; Atkinson, 2010; Bortolottia et al., 2015). In addition, it should be noted that the research carried out by (Abu et al., 2021) revealed a synergistic effect between three key factors - culture and human attitude, knowledge and resources - which play a crucial role in implementing lean and eliminating a significant number of revealed barriers. However, most studies do not consider the importance of organizational culture, focusing more on operations rather than considering any cultural issues and factors that should be managed simultaneously. (Achanga et al., 2006; Dora et al., 2013; Kumar et al., 2014; Testani & Ramakrishnan, 2011). Another way to avoid or reduce the number of potential problems in the implementation of the LM concept seems to be the use of an external consultant.

From the conducted research on the type of LM tools implemented, it can be concluded that due to financial and human resource constraints experienced by SMEs (apart from implementing organisational improvements such as performance and criteria evaluation systems), the implementation of the LM concept is most often based on introducing uncomplicated and low-cost lean tools (e.g. visual management, 5S/6S, VSM and standard operation). While more complex tools (TPM) and support initiatives (IT) that require more money, time and training (productivity investment) are being introduced in most of the large organisations participating in the survey. The literature also confirms the identified trend (Walentynowicz, 2013; Revers et al., 2015; Chiarini, 2012; Alkhoraif et al., 2019, Dziuba et al. 2021). The primary determinant of selecting these tools should be their

usefulness for the implementation of the fundamental objectives of Lean - improving the organisation's effectiveness in the areas of quality, cost and time and the elimination of waste. However, tools (methods and techniques) of a "soft" nature (Lean Thinking) can be applied universally, regardless of the type of activity of the organization. The implementation of Lean is a long-term process, which SMEs should undertake through incremental steps to improve their production processess. When considering the benefits of implementing LM, attention was paid to differentiating the size of the organisation. The main internal benefit for organisations in the micro, small and medium group was the improvement in the organisation's comfort, where additionally small and medium organisations indicated a reduction (elimination) of downtime/failures. Besides, reducing (elimination) of organisational problems has been considered an important internal effect in small and large organisations (Wolniak, 2013; Wolniak, 2014; Wolniak et al., 2018). Implementing the Lean Manufacturing concept enables organisations to increase efficiency and flexibility towards customers and reduce costs (Grycuk, 2016). Companies that operate according to LM are characterised by less inventory and finished products, better product quality and simplified processes (Nogalski, 2010); in addition, Lean can positively affect stability and mitigate the company's response to the crisis (Krasiński, 2015). In turn, the main external benefits were: gaining new customers (micro and large organizations), retaining existing customers (small and large organizations) and better cooperation with subcontractors and suppliers (micro and small organizations). Numerous literature studies indicate that the abovementioned benefits convince organizations to implement LM (Żebrucki & Kruczek, 2018; Sahoo, 2020; Mora et al., 2017).

The review of the literature on the subject and the results of the conducted survey indicate that the implementation of Lean Manufacturing practices in large enterprises is growing, while the implementation in micro, small and medium enterprises (SMEs) is still slow. (Chakraborty et al., 2019).

## Conclusion

Every economic entity, functioning in competitive conditions, is confronted with the necessity of changes in the scope of provided activities or internal changes. Customers will evaluate the effectiveness of implemented changes. In case of approval, it will be the beginning of continuous improvement and implementation of further effective changes. The concept of Lean Manufacturing is one of the paths an organization can take to build competitiveness and increase innovation in the global market.

The purpose of this study was to review and conceptualize a framework for lean manufacturing (LM) implementations to effectively manage manufacturing processes in the context of organizational development and gaining customer satisfaction. The research indicates that micro, small and medium-sized enterprises are overcoming significant barriers in implementing Lean concepts. The most common problems include a barrier in the relationship between management and

employees, lack of standardization, short-term financial goals, lack of information about the effects of actions, and lack of knowledge, equating Lean with a decrease in employment. Unfortunately, this approach called short-term is a common mistake made by micro, small and medium enterprises. Lack of knowledge of the techniques and tools used in Lean is also a significant obstacle. This is presumably the result of inadequate training (inconsistent with practice) or lack thereof.. The problems of micro, small and medium enterprises during the Lean implementation process are less about technical issues and more about management and control processes. This phenomenon is related to the fact that solutions used within stable production are characteristic for large companies and cannot be applied in SMEs. However, it is essential to note that implementing Lean is a long-term process and that SMEs need to take a forward-looking approach by gradually improving organisational processes. According to the authors, the critical activities in overcoming the barriers to Lean implementation are management education and the development of a set of procedures and guidelines facilitating the implementation of the tools of this concept in a specific group of entities such as SMEs.

The analysis of the questionnaires and the analysis of changes taking place in the organization's culture showed that there is a great potential and demand for Lean solutions for Central and Eastern Europe organizations regardless of their size and the nature of their business.

## References

Abu, F., Gholami, H., Saman, M.Z.M., Zakuan, N., Streimikiene, D., Kyriakopoulos, G.L. (2021). An SEM Approach for the Barrier Analysis in Lean Implementation in Manufacturing Industries. *Sustainability*, 13, 1978. https://doi.org/10.3390/su13041978

Achanga, P., Shehab, E., Roy, R., Nelder, G. (2006). Critical success factors for Lean implementation within SMEs, *Journal of Manufacturing Technology Management*, 17(4), 460-471.

Aleksander P., Antoniusz J., Cudney E. (2021). A novel and practical conceptual framework to support Lean Six Sigma deployment in manufacturing SMEs, Total Quality Management & Business Excellence, Routledge Journals, Taylor & Francis Ltd2-4 Park Square, Milton Park, Abingdon Ox14 4rn, Oxon, England.

Alkhoraif A., Rashidb H., McLaughlina P. (2019). Lean implementation in small and medium enterprises: Literature review, *Operations Research Perspectives*, 6, 100089. DOI: 10.1016/j.orp.2018.100089

Andriani, M., Samadhi, T.M.A.A., Siswanto, J. and Suryadi, K. (2019). Knowledge management strategy: an organisational development approach, *Business Process Management Journal*, 25 (7), 1474-1490. DOI: 10.1108/BPMJ-07-2018-0191

Atkinson, P., 2010, *Lean is a cultural issue*. Management Services, 54, 35-44.

Baird, K., Hu, K., Reeve, R. (2011). The relationships between organizational culture, total quality management practices and operational performance, *International Journal of Operations & Production Management*, 31(7), 789-814.

Basu P., Dan PK. (2020). A comprehensive study of manifests in lean manufacturing implementation and framing an administering model, *International Journal Of Lean Six Sigma*, 11, I. 4, 797-820.

Bednarek M. (2015). Zastosowanie Lean Manufacturing w Polce I Meksyku, Modele praktyka, doświadczenia, Difin 2015.

Bortolotti, T., Boscari, S., Danese, P. (2015). Successful Lean implementation: Organizational culture and soft Lean practies, *International Journal Production Economics*, 160, 182-201.

Brzóska J., Karbownik A., Kruczek M., Szmal A., Żebrucki Z. (2011). Strategiczna karta wyników w teorii i praktyce. Wydawnictwo Politechniki Śląskiej, Gliwice.

Chakraborty A., Mutingi M., Vashishth A. (2019). Quality management practices in SMEs: a comparative study between India and Namibia, *Benchmarking An International Journal*, 26, I. 5, 1499-1516.

Chauhan G., Chauhan V. (2019). A phase-wise approach to implement lean manufacturing, *International Journal of Lean Six Sigma*, 10, I. 9, 106-122.

Chiarini A. (2012). Lean production: mistakes and limitations of accounting systems inside the SME sector. *J. Manuf Technol Manag*, 23(5), 681–700. DOI: 10.1108/17410381211234462.

Danko, J., Soltes, V., & Bindzar, T. (2022). Portfolio Creation Using Graph Characteristics and Testing Its Performance. *Montenegrin Journal of Economics*, *18*(1), 7-17

Deshmukh G., Patil C.R., Deshmukh M.G. (2017). Manufacturing industry performance based on lean production principles, *International Conference on Nascent Technologies in Engineering* (Icnte-2017).

Ding B.J., Hernandez X.F., Jane N.A. (2021). Combining lean and agile manufacturing competitive advantages through Industry 4.0 technologies: an integrative approach, Production Planning & Control, Taylor & Francis Ltd2-4 Park Square, Milton Park, Abingdon Or14 4rn, Oxon, England.

Dora M, Kumar M, Van Goubergen D, Molnar A, Gellynck X. (2013). Operational performance and critical success factors of lean manufacturing in European food processing SMEs. *Trends in Food Science & Technology*, 31(2), 156–64. DOI: 10.1016/j.tifs.2013.03.002

Dziuba S.T., Ingaldi M., Kozina A., Hernes M. (2021). Using the FMEA Method as a Response to a Customer Complaint: a Case Study. *Revista Gestao & Tecnologia-Journal of Management and Technology*, 21(1), 73-88, DOI: 10.20397/2177-6652/2021.v21i1.2017

El-Khalil R. (2020). Lean manufacturing alignment with respect to performance metrics multinational corporations case study, International Journal Of Lean Six Sigma, Emerald Group Publishing Ltdhoward House, Wagon Lane, Bingley Bd16 1wa, W Yorkshire, England.

Fredriksson G., Larsson H. (2012). An analysis of maintenance strategies and development of a model for strategy formulation - A case study. Göteborg: Chalmers University of Technology.

Fullerton, R.R., Kennedy, F.A., Widener, S.K. (2014). Lean manufacturing and firm performance: the incremental contribution of Lean management accounting practices. *Journal of Operations Management*, 32(7-8), 414-428.

Gavriluta A. (2019). Study on improvement of a manufacturing system using Lean Manufacturing, *Quality-Access To Success*, 20, 365-370.

Gazda, A., Pacana, A., Malindzak, D. (2013), Study on improving the quality of stretch film by Taguchi method, *Przemysl Chemiczny* 92 (6), 980-982.

Ghouat M., Haddout A., Benhadou M. (2021). Impact of Industry 4.0 Concept on the Levers of Lean Manufacturing Approach in Manufacturing Industries, *International Journal of Automotive And Mechanical Engineering*, 18 (1), 8523-8530.

Ghram M., Frikha H. (2018). A new procedure of criteria weight determination within the aras method, *Multiple Criteria Decision Making*, 13, 56-73. DOI: 10.22367/mcdm.2018.13.03

Grabowska S. (2017). Kluczowe wskaźniki efektywności – studium przypadku, *Zeszyty Naukowe Politechniki Śląskiej*, Seria: Organizacja i Zarządzanie z. 108.

Grycuk, A. (2016). Bariery w stosowaniu Lean Management, *Kwartalnik Nauk o Przedsiębiorstwie*, 3.

Gupta S., Jain S.K. (2013). A literature review of lean manufacturing, *International Journal Of Management Science And Engineering Management*, 8(4), 241-249.

Haseeb, M., Hussain, H.I., Ślusarczyk, B., Jermsittiparsert, K. (2019). Industry 4.0: A solution towards technology challenges of sustainable business performance, *Social Sciences*, 8(5), 154.

Hausner J. (2009). Instytucje kultury w czasach kryzysu. Wyzwania i zagrożenia – w jakich warunkach możliwa jest transformacja i nowoczesny model funkcjonowania instytucji, In: J. Sójka, P. Kieliszewski, P. Landsberg, M. Poprawski (ed.), Instytucje kultury w czasach kryzysu, Bogucki Wydawnictwo Naukowe, Poznań.

Heckova, J., Kolesarova, S., Chapcakova, A., & Kascakova D.R. (2021). Research of Comparative Advantages in the Context of Determinants of CrossBorder Mergers and Acquisitions in the European Area. *Montenegrin Journal of Economics*, 17(4), 181-188.

Hensel P. (2015). Konkurujące logiki instytucjonalne w zarządzaniu kulturą. *Zarządzanie w Kulturze*, 16 (3).

Kumar M. K., Rajan A. J., Navas R. K. B., Rubinson S. S. (2014). Application of lean manufacturing in mass production system: A case study in Indian manufacturing unit. *Proceedings of the international conference on industrial engineering and engineering management, IEEE*; DOI: 10.1109/ieem.2014.7058729.

Ingaldi, M. (2021). Assessment of the service provision process as a business process management tool, *Polish Journal of Management Studies* 23(1), 204-223.

Kiselakova D., Stec M., Grzebyk M., Sofrankova B. (2020). A Multidimensional Evaluation of the Sustainable Development of European Union Countries – An Empirical Study, *Journal of Competitiveness*, 12(4), 56–73. DOI: 10.7441/joc.2020.04.04

Ko Y.J., Mamo L. (2019). Forming a firm innovation strategy through commitment-based human resource management, *International Journal of Human Resource Management*, 30, I. 12, 1931-1955.

Koch T. et al., (2006). *Przegląd wdrażania Lean Manufacturing w różnych branżach*, VI Konferencji Lean Manufacturing, WCTT-CAMT Politechniki Wrocławskiej, Wrocław.

Krasiński M. (2015). Lean Management w zapobieganiu i przezwyciężaniu kryzysu w Przedsiębiorstwie, *Marketing i Rynek*, 5.

Krok E. (2015). Budowa kwestionariusza ankietowego a wyniki badań, *Zeszyty Naukowe Uniwersytetu Szczecińskiego, Studia Informatica*, 37(874), 55-73. DOI: 10.18276/si.2015.37-05

Krynke, M. (2021). Management optimizing the costs and duration time of the process in the production system, *Production Engineering Archives* 2021, 27(3), 163-170, DOI: 10.30657/pea.2021.27.21.

Lai N.Y.G, Wong K.H., Halin D., Lu, J.W., Kang H.S. (2019). Industry 4.0 Enhanced Lean Manufacturing, Proceedings of 2019 8th International Conference on Industrial Technology and Management (Icitm 2019), 206-211.

Lee G.L. (1995). The "pros" and "cons" of total quality management for smaller firms in manufacturing: Some experiences down the supply chain. *Total Quality Management*, 6(4), 413–26. DOI: 10.1080/09544129550035341

Liker J.K., The Toyota Way, McGarw Hill 2004.

Mazur M., Momeni H. ( 2019), Lean Production Issues In The Organization Of The Company – Results, *Production Engineering Archives 22*, 50-53, DOI: 10.30657/pea.2019.22.10

Maszke A., Dwornicka R., Ulewicz R. (2018). Problems in the implementation of the lean concept at a steel works-Case study, MATEC Web of Conferences, EDP Sciences, 183.

Matharu M., Sinha N., (2019). Lean implementation in Indian manufacturing MSMES*: a sap-lap analysis*, *Management and Production Engineering Review*, 10, I. 1, 68-78.

Mednikov M.D., Sokolitsyn A.S., Ivanov M.V., Sokolitsyna N.A., Yuryev V.N. (2018), *Forming Optimal Industrial Enterprise Management Strategy*, Vision 2020: Sustainable Economic Development And Application Of Innovation Management, 32nd Conference of the International-Business-Information-Management-Association.

Mora E., Gaiardelli P., Resta B., Powell D. (2017). Exploiting Lean Benefits Through Smart Manufacturing: A Comprehensive Perspective, *Advances In Production Management Systems: The Path To Intelligent, Collaborative And Sustainable Manufacturing*, 513, 127-134.

Ng T.C., Ghobakhloo M. (2018). What Determines Lean Manufacturing Implementation? A Cb-Sem Model, *Economies*, 6 (1), 7.

Nguyen, D.M., (2015). A new Application model of Lean management in small and medium sized enterprises. *International Journal of Simulation Modelling*, 14(2), 289-298.

Nogalski B., Walentynowicz P. (2011). *Celowość zastosowania Lean Management w MSP, Zarządzanie rozwojem małych i średnich przedsiębiorstw*, Wydawnictwo Wolters Kluwer, Warszawa, Poland.

Nogalski, B. (2010). Lean Management. W M. Czerska, A. Szpitter (red.), Koncepcje zarządzania, C.H. Beck, Warszawa, Poland

Nowicka-Skowron M., Ulewicz R. (2016). *P*roblems in the implementation of lean concept in the metal industry companies, Metal, 25th-27th 2016, Brno, Czech Republic, EU.

Ojha R., Venkatesh U. (2021). Manufacturing excellence using lean systems - a case of an automotive aggregate manufacturing plant in India, *Journal of Advances In Management Research*, Emerald Group Publishing Ltdhoward House, Wagon Lane, Bingley Bd16 1wa, W Yorkshire, England.

Ostasz G., Czerwinska K., Pacana A. (2020). Quality management of aluminum pistons with the use of quality control points, *Management Systems In Production Engineering*, 28 (1), 29-33.

Pacana A., Ulewicz R. (2020). Analysis of causes and effects of implementation of the quality management system compliant with ISO 9001, *Polish Journal Of Management Studies*, 21 (1), 283-296.

Pacana A., Siwiec D., Bednarova L. (2019). Analysis of the incompatibility of the product with fluorescent method, *Metalurgija* 58 (3-4), 337-340.

Panizzolo R, Garengo P, Sharma M.K., Gore A. (2012). Lean manufacturing in developing countries: evidence from Indian SMEs, *Production Planning & Control*, 23:10-11, 769-788, DOI: 10.1080/09537287.2011.642155

Penalver A.J.B., Santos J.A.C., Conesa J.A.B., Santos M.C. (2018). Innovation Management and Strategy, *Journal Of Scientific & Industrial Research*, 77, 437-441.

Podobiński M. (2015). Bariery i ograniczenia wdrażania koncepcji Lean Management – wyniki badań, *Nauki o Zarządzaniu*, 3(24).

Ramadas T., Satish K.P. (2021). Identification and modeling of process barriers Implementing lean manufacturing in small-and medium-size enterprises, *International Journal of Lean Six Sigma*, 12(1), 61-77. DOI: 10.1108/IJLSS-09-2016-0044

Revers P., Trojanowska J., Chabrowski P. (2015). Analiza wykorzystania narzędzi Lean Manufacturing – wyniki badań, Logistyka, Sieć Badawcza Łukasiewicz – Instytut Logistyki i Magazynowania, 3, 5788-5791.

Roque A.F., Alves M.C., Raposo M. (2020). *Management control system design in innovation-related internationalization strategies (i-model), Revista Eletronica De Estrategia E Negocios-Reen*, 13(3), 218-236.

Sahoo S. (2020). Assessing lean implementation and benefits within Indian automotive component manufacturing SMEs, *Benchmarking-An International Journal*, 27(3), 1042-1084.

Sahu A.K., Padhy R.K., Dhir A. (2020). Determinants and barriers of implementing lean manufacturing practices in MSMEs: a behavioural reasoning theory perspective, *Production Planning & Control*, Taylor & Francis Ltd2-4 Park Square, Milton Park, Abingdon Or14 4rn, Oxon, England.

Salma A., Anas C., Mohammed E. (2021). Bibliographic Study on the Difficulties Encountered by SMEs During the Implementation of Lean Manufacturing, *Journal of Advanced Manufacturing Systems*, 20(1), 163-190.

Sandres A., Elangeswaran C., Wulfsberg J., (2016). Industry 4.0 Implies Lean Manufacturing: Research Activities in Industry 4.0 Function as Enablers for Lean Manufacturing, *Journal of Industrial Engineering And Management-Jiem*, 9 (3), 811-833.

Shah R., Ward P.T. (2003). Lean manufacturing: Context, practice bundles, and performance, *Journal of Operations Management*, 21(2), 129-149.

Shin D., Alam M.S. (2020). Lean management strategy and innovation: moderation effects of collective voluntary turnover and layoffs, *Total Quality Management & Business Excellence*, Routledge, Taylor & Francis Ltd2-4 Park Square, Milton Park, Abingdon Ox14 4rn, Oxon, Anglia.

Shrimali A.K., Soni V.K., Pawar S.S. (2018). Interpretive structural modelling of identified barriers to lean implementation in SMEs. Proceedings of the MATEC web of conferences. 183. EDP Sciences; p. 01008.

Sisson Ja. (2019). Maturing the lean capability of front-line operations supervisors, *International Journal of Lean Six Sigma*, 10 (1), 2-22.

Ślusarczyk B. (2018). Industry 4.0 – Are we ready? *Polish Journal of Management Studies*, 17(1), 232-248.

Sodhi H.S., Singh D., Singh B.J. (2020). A conceptual examination of Lean, Six Sigma and Lean Six Sigma models for managing waste in manufacturing SMEs, *World Journal Of Science Technology And Sustainable Development*, 17 (1), 20-32.

Sudhakara P.R., Sałek R., Venkat D., Chruzik K. (2020). Management of non-value-added activities to minimize lead time using value stream mapping in the steel industry, *Acta Montanistica Slovaca*, 25, 444–454

Tambunan, T. (2011). Development of Micro, Small and Medium Enterprises and Their Constraints: A story from Indonesia, *Gadjah Mada International Journal of Business*, 13(1), 21-43. DOI:10.22146/gamaijb.5492

Tarka P. (2015). Własności 5- i 7-Stopniowej skali Likerta w kontekście normalizacji zmiennych metodą Kufmana i Rousseeuwa, *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 25, 287-295. DOI: 10.15611/pn.2015.385.31

Testani M.V, Ramakrishnan S. (2011). Lean transformation leadership model: leadership's role in creating lean culture. Proceedings of the Industrial Engineering Research Conference. 3.

Tran,T.,Luu-Nhan,K.,Ghabour,R. Daroczi,M. (2020).The use of Lean Six-Sigma tools in the improvement of a manufacturing company – case study. *Production Engineering Archives*, 26(1), 30-35. DOI:10.30657/pea.2020.26.07

Tyagia, S., Caib, X., Yanga, K., Chambers, T. (2015). Lean tools and methods to support efficient knowledge creation. *International Journal of Information Management*, 35, 204-214.

Ulewicz R., Kucęba R. (2016). Identification of problems of implementation of lean concept in the SME sector, *Engineering Management in Production and Services*, 8(1), 19-25. DOI: 10.1515/emj-2016-0002

Ulewicz R., Mazur M., Novy F. (2019). The impact of lean tools on the level of occupational safety in metals foundries, *Metal*, May 22nd-24th 2019, Brno, Czech Republic, EU. DOI:10.37904/metal.2019.992

Ulewicz R., Ulewicz M. (2020). Problems in the Implementation of the Lean Concept in the Construction Industries, *Lecture Notes in Civil Engineering*, 47, 495-500.

Ulewicz R, Kleszcz D., Ulewicz M. (2021). Implementation of Lean Instruments in Ceramics Industries, *Management Systems in Production Engineering* 29 (3), 203-207

Valence C.M., Sousa P.S.A., Moreira M.R.A. (2020). Assessment of the Lean effect on business performance: the case of manufacturing SMEs, *Journal of Manufacturing Technology Management*, 31(3), 501-523.

Van der Steen M.P., Tillema S. (2018). Controlling lean manufacturing in multidivisional organisations: Highlighting local interests and constraints, *International Journal of Operations & Production Management*, 8(11), 2149-2168.

Walentynowicz P. (2013). Zakres zastosowania Lean Management w przedsiębiorstwach produkcyjnych – wyniki badań empirycznych. *Innowacje w zarządzaniu i inżynierii produkcji*, Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole, Poland.

Wolniak R. (2013). Metody i narzędzia Lean Production i ich rola w kształtowaniu innowacji w przemyśle, *Innowacje w zarządzaniu i inżynierii produkcji*. Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, 524-534.

Wolniak R. (2014). Relationships Between Selected Lean Management Tools and Innovations, *Zeszyty Naukowe. Organizacja i Zarządzanie / Politechnika Śląska*, 75, 157-166.

Wolniak R., Skotnicka-Zasadzień B., Gębalka-Kwiecień A. (2018). Identification of bottlenecks and analysis of the state before applying lean management, MATEC Web of Conferences, EDP Sciences.

Yang, M.G., Hong, P., Modi, S.B. (2011). Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms, *International Journal of Production Economics*, 129(2), 251-261.

Yu G.J., Park M., Hong K.H. (2020). A strategy perspective on total quality management, *Total Quality Management & Business Excellence*, 31(1-2), 68-81.

Żebrucki Z., Kruczek M. (2018). Uwarunkowania wdrożenia koncepcji lean management w sektorze MŚP, *Zeszyty Naukowe. Organizacja i Zarządzanie, Politechnika Śląska*,120, 257-272.

Zhou H.B., Ułan L.M., Jungst M. (2021). Knowledge management practices and innovation: A deliberate innovation management model for SMEs, *Journal of Small Business Management*, Taylor I Francis Inculica Orzech 530, Ste 850, Filadelfia, Pa 19106.

# ANALIZA SYSTEMOWEGO PODEJŚCIA DO KONCEPCJI LEAN MANUFACTURING – WYNIKI BADAŃ EMPIRYCZNYCH

**Streszczenie**: Produkcja szczupła to rozbudowany system zaprojektowany w celu zwiększenia wydajności każdej branży produkcyjnej poprzez redukcję odpadów dzięki uznanym na arenie międzynarodowej narzędziom i technikom. Przedsiębiorstwa niezależnie od wielkości i branży starają się przyjąć koncepcje Lean Manufacturing (LM) , aby zmaksymalizować swoje zasoby, takie jak personel, obiekty, materiały i harmonogramy działania, aby były ekonomicznie efektywne. Istnieje kilka modeli implementacji filozofii Lean w przedsiębiorstwach. Realizowane badania mają na celu dokonanie przeglądu i konceptualizacji ram wdrożeń systemu LM w przedsiębiorstwach w Europie Środkowo-Wschodniej. Analizę oparto na wynikach z badań ankietowych przeprowadzonych w mikro, małych, średnich i dużych przedsiębiorstwach, głównie w organizacjach produkcyjnych, handlowych i usługowych. W rezultacie wyłoniono m. in. główne przesłanki, sposoby oraz korzyści z wdrożeń systemu LM identyfikując dzięki temu specyfiki koncepcji w kontekście wielkości przedsiębiorstw oraz branży z których pochodzą. Oryginalnością jest przeanalizowanie skuteczności, efektywności oraz wydajności działań Lean w rozróżnieniu na wielkość organizacji z grupy mikro, małych, średnich i dużych organizacji (MSME). Wyniki badań skazują że model wdrożenia LM w przedsiębiorstwach z Europie Środkowo-Wschodniej oparty jest na modelu Shingo

**Słowa kluczowe:** Lean manufacturing, Lean production, narzędzia lean, wydajności operacyjna, wartość, zarzadzanie operacyjne

# 精益制造概念的系统方法分析——实证研究的结果

**摘要**：精益制造是一个深刻的系统，旨在通过国际公认的工具和技术减少浪费，从而提高每个制造业的效率。各种规模和行业的企业都努力采用精益制造 (LM) 概念，以最大限度地利用其资源，例如人员、设施、材料和运营计划，以实现经济高效。在企业中实施精益理念有几种模式。所进行的研究旨在审查和概念化中东欧企业的 LM 系统实施框架。该分析基于对微型、小型、中型和大型企业的调查结果，主要是生产、贸易和服务组织。结果，除其他外，指出了实施 LM 系统的主要前提、方法和好处，从而确定了在企业规模及其所在行业背景下概念的特殊性。独创性是对精益活动的有效性、效率和生产力的分析，将组织的规模与微型、小型、中型和大型组织（MSME）的群体区分开来。研究结果表明，中东欧企业的LM实施模型是基于Shingo模型的

**关键词:** 精益制造, 精益生产, 精益工具, 运营绩效, 价值, 运营管理