POLISH JOURNAL OF MANAGEMENT STUDIES
Gálová K., Rajnoha R., Ondra P.
2018
Vol.17 No.1

THE USE OF INDUSTRIAL LEAN MANAGEMENT METHODS IN THE ECONOMICS PRACTICE: AN EMPIRICAL STUDY OF THE PRODUCTION COMPANIES IN THE CZECH REPUBLIC

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Abstract: Companies are encouraged to make changes and improve business processes to achieve performance and competitiveness. For these purposes, industrial engineering methods can be used in business practice. The main aim of this paper is to identify the most frequently used industrial engineering methods in Czech manufacturing companies. The secondary aim is to compare the use of individual industrial engineering methods in selected industrial areas. The necessary data were collected through online questionnaire (N=118). The results shows, that the most commonly used industrial engineering method are standardization, Material Requirements Planning (MRP I), Manufacturing Resource Planning (MRP II), 5S and Kaizen. This study confirms that the use of standardization, 5S, Kaizen, and MRP I depends on the type of industry in which the company operates; the industry focus does not affect whether or not TQM or MRP II are used.

Key words: business performance management, industrial engineering methods, business process improvement, lean management

DOI: 10.17512/pjms.2018.17.1.08

Article history:
Received January 4, 2018; *Revised* March 11, 2018*; Accepted* April 4, 2018

Introduction

The current competitive environment is characterized by increased competition resulting from market saturation and growing demands for customer-driven production. Continuing competition, customization, shortening product lifecycles or continuous technological innovation have a significant impact on the competitive environment and dramatically alter the character of both business and production itself (Salvendy, 2001).

In order to achieve and maintain competitiveness in the markets, manufacturing companies have to produce high-quality low-cost products with increasing diversity because the quality consciousness alone would not be enough for sustained business growth (Corbett, 2011). It is precisely the tools of industrial engineering (IE) that represent an instrument that can influence these areas, and therefore performance and own competitiveness through processes innovation.

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In this research, analyzes the use of selected IE methods in different industries. The main aim is to find out key methods of IE for each of selected industries that are most frequently implemented.

Literature Review

The philosophy of IE methods and tools is based on the assumption that an enterprise works with a limited amount of time in which it can meet the needs of its customers. Any activity that is unnecessarily in the production process (or any other process) is waste of time (Anand and Kodali, 2009).

Meeting customer requirements require a high degree of production flexibility, reducing production costs and production batch size and shortening delivery times (Ghalayini et al., 1997). In this context, innovations in the organizational, technological and manufacturing process are perceived as a critical factor influencing product innovation (Rajnoha and Lorincová, 2015; Mahmud et al., 2017; Illmeyer et al., 2017; Mir-Babayev et al., 2017). Similarly, Sahin (2000) has described four systems to improve his competitive position in the market. These systems are specialized factories, lean production, mass customization and flexible production. The breakthrough of all these strategies is in the four groups of activities that are common for each system, namely continual improvement; simple, reliable and flexible devices; employee involvement; reducing machine settings and changeover times (Sahin, 2000).

The use of IE methods is most often found in literature in two formats. The first is a general description of the LEAN philosophy - the IE methods are included in this concept (Miller et al., 2010; Wee and Wu, 2009; Domingo et al., 2007; Dahlgaard and Dahlgaard-Park, 2006; Dahlgaard-Park and Pettersen, 2009). The second large group in the literature consists of case studies focused on implementing a specific tool of IE under specific conditions of a particular company or industry (Rahman et al., 2013; Sjoberg et al., 2012; Tsang and Chan, 2000; Singh et al., 2013; Chan et al., 2005; Farris et al., 2015; Kaushik and Khanduja, 2009). Although the way of using and influencing the enterprise of individual methods of IE deals with a great number of domestic and foreign literatures, studies dealing with the overall use of these methods are very few. An example may be a study that has been carried out among the Indian machine tool companies (Eswaramoorthi et al., 2011). Although these (and others) surveys and studies examine the use of IE methods in practice, they are usually focused on specific industry, and do not look for the relationship of the methods with other factors such as the industry, size of company or competitiveness.

In addition, many recent studies realized in V4 countries, Czech Republic, Slovakia or Poland, have been focused also on measuring the impact of the financial and strategic management methods (not only IE methods) such as Lean accounting or BSC (Balanced Scorecard) on overall business performance (Hornungová, 2017; Gavurová et al., 2017; Wnuk-Pel, 2016; Afonina, 2015; Knápková et al., 2014;

Rajnoha and Lesníková, 2016; Korauš et al., 2015; Šoltés and Gavurová, 2015; Tuček et al., 2013; Gavurová, 2011).

Research Objectives

The primary aim of this study is to identify most frequently used IE methods in Czech manufacturing companies. The secondary aim is to compare the use of individual industrial methods in selected industrial areas. To analyze the relationship between the use of IE methods and the type of industry, the following hypotheses are framed:

H1*: We assume that the extent of the use of selected IE methods in the practice of manufacturing companies in the Czech Republic is different.*

H2*: We assume that the use of IE methods is dependent on the type of industry.*

Data Collection and Methodology

For the purposes of the currently presented research, and in order to achieve the objectives, the proposed work has decided to obtain the necessary data from the companies in the Czech Republic with the help of online questionnaire. The recipients of the email were primarily production managers or owners and managers. The aim was to reach the largest number of companies from various sectors of the national economy from all regions of the Czech Republic, of various sizes (in terms of number of employees – micro companies, SMEs, large companies), of different ages, including companies partly or wholly financed by foreign capital.

The questionnaire was distributed in three successively rounds. In the first and second round, potential participants were addressed via email. In the third round, the participants were called for telephone and face-to-face interview. After these three rounds, 216 companies completed the questionnaires correctly. We consider the size of the research sample as being sufficiently representative.

The initial data group consisted of all the surveyed companies (216 subjects). An initial analysis of the use of IE methods was carried out for all the participants involved in the research. In the next steps, we created groups specifically aimed at companies from Mechanical Engineering (51 subjects), Electrotechnics (27 subjects), Wood Processing (20 subjects) and Automotive industry (20 subject). Selected industries together represented 118 companies.

After completion of the questionnaire collection, replies were automatically converted to a database in MS Excel (the questionnaire was created through google forms). Basic descriptive statistics were processed in this program via PivotTables. Statistical data analysis was performed through XLStatistics by Rodney Carr. This set of sheets in MS Excel allows the user to perform large quantities of statistical tests. For our purpose, we used a workbook focused on chi-squares. The Chi-square test defines the basic hypothesis H_0 (Null hypothesis assumes that there is no relevant association between analyzed variables) and H_1 (alternative hypothesis

assumes that there is an association between analyzed variables). To accept or reject zero hypotheses, a level of significance must be defined. For our needs, we set the level of significance at $\alpha = 0.05$.

Research Results

The Use of Selected IE Methods in the Business Practice

The Table 1 presents the results of the usage of IE methods in whole production companies involved in our research.

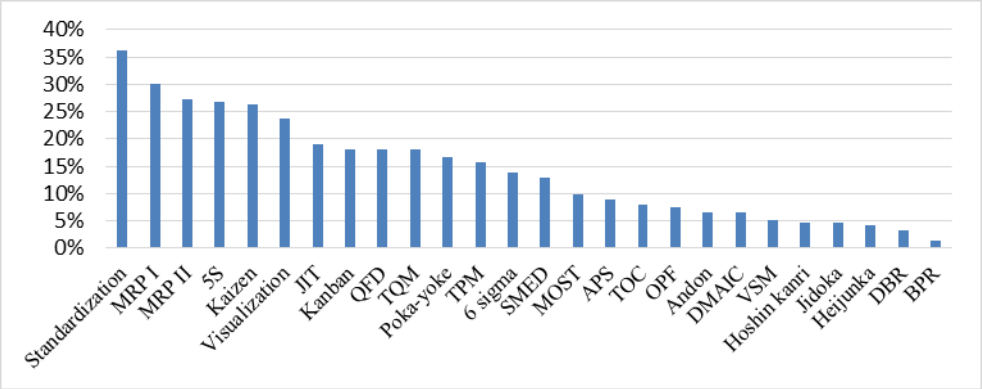
Table 1. IE methods – Frequency Response *(all industries)*

		We have implemented	We are just implementing	We do not use it but we plan to	We do not use it and it is not planned
1	**Standardization**	78	20	15	103
2	**MRP I**	65	9	25	117
3	**MRP II**	59	11	22	124
4	**5S**	58	14	32	112
5	**Kaizen**	57	17	28	114
6	**Visualization**	51	12	19	134
7	**JIT**	41	9	20	146
8	**Kanban**	39	11	22	144
9	**QFD**	39	6	17	154
10	**TQM**	39	16	33	128
11	**Poka-yoke**	36	16	28	136
12	**TPM**	34	15	26	141
13	**6 sigma**	30	17	26	143
14	**SMED**	28	10	17	161
15	**MOST**	21	6	19	170
16	**APS**	19	11	31	155
17	**TOC**	17	11	33	155
18	**OPF**	16	6	15	179
19	**Andon**	14	3	18	181
20	**DMAIC**	14	8	25	169
21	**VSM**	11	9	22	174
22	**Hoshin kanri**	10	4	20	182
23	**Jidoka**	10	5	23	178
24	**Heijunka**	9	6	20	181
25	**DBR**	7	6	22	181
26	**BPR**	3	10	22	181

The Figure 1 shows the percentage of these frequencies. Respondents were offered a list of IE methods with the most widely used names.
The most commonly used method is standardization. This method is used by 36% of respondents from all industries. Frequency of use of this method is mainly related to the position of standardization among other methods of IE. Standardization is the first step for successful implementation of more demanding IE methods (e.g. TPM, SMED). Standardization is closely related to the fourth most commonly used method - 5S. After the cleaning and organizing the workplace, standardization in the fourth "S" helps to ensure that the previous steps

are maintained. Out of fifty-eight companies that have established 5S, 81% said they have implemented or just implementing the standardization.

Figure 1. IE methods – Percentage Frequency *(all industries)*



The second and the third most common used method are MRP I and MRP II. 30% and 27% of respondents selected these two resources planning concepts. These two concepts are, similar to 5S and standardization, often used together. Eighty-nine percent of companies that use MRP I already use or just implementing MRP II.
The fifth and the sixth most common IE methods are Kaizen (26%) and visualization (25%). Visualization represents one of the methods that can be used for standardization (especially when maintaining order in the workplace). 68% companies with implemented 5S also implemented or just implementing visualization. We also compared the use of IE methods between industries. The Table 2 presents the results of the usage of IE methods in selected industries.

Table 2. IE Methods – Frequency Response

	Mechanical		Electrotechnics		Wood Processing		Automotive	
Standardization	20	39%	14	52%	9	45%	11	55%
MRP I	17	33%	8	30%	12	60%	11	55%
MRP II	16	31%	8	30%	10	50%	10	50%
Visualization	15	29%	9	33%	5	25%	11	55%
Kaizen	14	27%	5	19%	7	35%	13	65%
5S	17	33%	9	33%	2	10%	10	50%
Kanban	6	12%	10	37%	4	20%	11	55%
JIT	8	16%	8	30%	4	20%	9	45%
Poka-yoke	6	12%	7	26%	3	15%	10	50%
QFD	8	16%	5	19%	6	30%	7	35%
TPM	7	14%	6	22%	4	20%	9	45%
TQM	10	20%	6	22%	4	20%	5	25%
SMED	6	12%	2	7%	6	30%	8	40%
Six sigma	6	12%	4	15%	5	25%	2	10%
MOST	5	10%	5	19%	2	10%	1	5%
OPF	3	6%	4	15%	0	0%	5	25%
VSM	0	0%	3	11%	1	5%	4	20%
Jidoka	1	2%	1	4%	1	5%	4	20%

The number of implemented IE methods is generally higher in case of automotive industry companies. These results are not surprising. The automotive industry is actually one of the first industries in which use of IE methods was started. Over the years, companies in this field have demonstrated the use of a large number of methods implemented together as a whole package. The use of many IE methods is a standard in the automotive industry.

The most used methods, in the mechanical engineering, automotive and electronics industry, are very similar and correspond to the most commonly used methods of our research sample. These methods include standardization, visualization, 5S method, MRP I, MRP II and Kaizen. The main difference between these methods in these industries is in the scope of use. In the mechanical engineering, these methods are used by approximately 30% to 40% of companies, in the electrotechnics industry, it is approximately 30% to 50% of companies and in the automotive industry, and it is 50% to 65% of companies.

The biggest difference between the mechanical engineering and automotive industry can be seen in the use of methods such as Kanban, Kaizen and Poka-yoke. In the automotive industry, these methods are used on average 40% more than in the mechanical engineering. Another significant difference is the rank of Kaizen. The Kaizen concept is used by 65% of companies in the automotive industry. In this case, we can see a clear effort to continually improve business processes as well as whole companies. For comparison, only 19% of the electrotechnics companies are using this continuous improvement method.

The list of the most used methods in the wood processing industry is slightly different. Companies in this field are primarily focused on proper resource planning, so the most used methods are resources planning concepts, such as MRP I and MRP II. These methods are further complemented by appropriate standardization, the concept of continuous improvement and customer engagement in product development (QFD).

Statistical Relations between the Use of IE Methods and the Industry

Another step of our research is the statistical evaluation of the relationship between used IE methods and industry focus. Five most frequently used methods were selected for this analysis such as standardization, MRP I, MRP II, kaizen and 5S.

For the needs of this analysis, the responses from the questionnaire were divided into two variants – it is used (options we have implemented, we are just implementing) and not implemented (we do not use it but we plant to, we do not use it and it is not planned). For the purposes of this analysis, it was not necessary to distinguish whether an enterprise does or does not intend to implement a given method in the future.

According to Table 3, at the level of significance $\alpha = 5\%$, the zero hypothesis of independence for standardization was rejected. The relationship between this method and the industry is strong statistically significant.

Table 3. The Use of Standardization x Industry - Statistics

The use of standardization p-value = 0.038514	Mechanical	Automotive	Electrotechnics	Wood processing	Row total
The observed frequency					
Standardization is not used	25	3	11	11	50
Standardization is used	26	17	16	9	68
Total	51	20	27	20	118
Expected frequency					
Standardization is not used	21,6102	8,4746	11,4407	8,4746	50
Standardization is used	29,3898	11,5254	15,5593	11,5254	68
Total	51	20	27	20	68
Observed minus the expected frequencies (residue)					
Standardization is not used	3,3898	-5,4746	-0,4407	2,5254	
Standardization is used	-3,3898	5,4746	0,4407	-2,5254	

Residue levels showed that the standardization is typically used in automotive industry. Standards are mainly used by those who focus on improving their processes or just looking for ways to ensure the best possible match with customer requirements. Given the negative values of residues in the mechanical and wood processing industry, it can be concluded that the use of standardization in these two sectors is not typical.

Table 4. The Use of 5S x Industry - Statistics

The use of 5S p-value = 0.007722	Mechanical	Automotive	Electrotechnics	Wood processing	Row total
The observed frequency					
5S is not used	27	8	17	18	70
5S is used	24	12	10	2	48
Total	51	20	27	20	118
Expected frequency					
5S is not used	30,254	11,864	16,017	11,864	70
5S is used	20,746	8,136	10,983	8,136	48
Total	51	20	27	20	68
Observed minus the expected frequencies (residue)					
5S is not used	-3,254	-3,864	0,983	6,136	
5S is used	3,254	3,864	-0,983	-6,136	

The relationship between 5S (table 4) and the industry is a strong statistically significant. According to Table 4, the use of 5S is typical in automotive and mechanical engineering industry. Conversely, the method is not typically used in wood processing industry.

Kaizen is also dependent on the industry. According to the residues value (Table 5), the use of this method is typical in automotive. Kaizen is not typically used in mechanical and electrotechnics industry.

MRP I (Table 6) is dependent on the industry. According to the residues value (Table 6), the use of this method is typical in automotive and wood processing industry.

Table 5. The Use of Kaizen x Industry - Statistics

The use of Kaizen p-value = 0.040966959	Mechanical	Automotive	Electrotechnics	Wood processing	Row total
The observed frequency					
Kaizen is not used	33	6	18	11	68
Kaizen is used	18	14	9	9	50
Total	51	20	27	20	118
Expected frequency					
Kaizen is not used	29,3898	11,5254	15,5593	11,5254	68
Kaizen is used	21,6102	8,4746	11,4407	8,4746	50
Total	51	20	27	20	118
Observed minus the expected frequencies (residue)					
Kaizen is not used	3,6102	-5,5254	2,4407	-0,5254	
Kaizen is used	-3,6102	5,5254	-2,4407	0,5254	

The opposite situation occurred with MRP II. At the level of significance $\alpha = 0.05$, the zero hypothesis was confirmed. This means, that there is not a relevant relationship between these method and industry. This means that the use of MRP II is typical in all industries. MRP II is used in the conditions of Czech Republic for a relatively long time so method has expanded to all sectors and is used in some form in almost every manufacturing company.

Table 6. The Use of MRP I x Industry - Statistics

The use of MRP I p-value = 0.039845917	Mechanical	Automotive	Electrotechnics	Wood processing	Row total
The observed frequency					
MRP I is not used	31	7	19	8	65
MRP I is used	20	13	8	12	53
Total	51	20	27	20	118
Expected frequency					
MRP I is not used	28,0932	11,0169	14,8729	11,0169	65
MRP I is used	22,9068	8,9831	12,1271	8,9831	53
Total	51	20	27	20	118
Observed minus the expected frequencies (residue)					
MRP I is not used	2,9068	-4,0169	4,1271	-3,0169	
MRP I is used	-2,9068	4,0169	-4,1271	3,0169	

Table 7 shows the results of the Pearson test for the remaining analyzed IE methods. In general, with increasing the added value of the product, the complexity of the processes and the required production quality, increase the need for the implementation of IE methods. For methods where p-value is less than 0.05 and the zero hypothesis is rejected at the level of significance $\alpha = 5\%$, applies: the method is dependent on the industry in which the company operates – the use of specific IE method is typical in some of the industries.

For methods where p-values is greater than 0.05 and the zero hypothesis is confirmed, applies: the method is independent on the industry in which the company operates – the use of specific IE method is typical in all industries.

Table 7. Pearson's Chi-square Test – All Methods

IE Method	p-value	Research results (H_0 is confirmed/rejected)
MRP II	0,14729817	Confirmed
Visualization	0,11501348	Confirmed
JIT	0,08875992	Confirmed
Kanban	0,00685311	Rejected
QFD	0,43649397	Confirmed
TQM	0,69092496	Confirmed
Poka-Yoke	0,00001028	Rejected
TPM	0,06600416	Confirmed
6 sigma	0,82171917	Confirmed
SMED	0,00862622	Rejected
MOST	0,34944155	Confirmed
APS	0,29111491	Confirmed
TOC	0,12419056	Confirmed
OPF	0,00037554	Rejected
Andon	0,00637086	Rejected
DMAIC	0,69710877	Confirmed
VSM	0,00241072	Rejected
Hoshin Kanri	0,02497666	Rejected
Jidoka	0,01125039	Rejected
Heijunka	0,00185218	Rejected
DBR	0,17820106	Confirmed
BPR	0,31798329	Confirmed

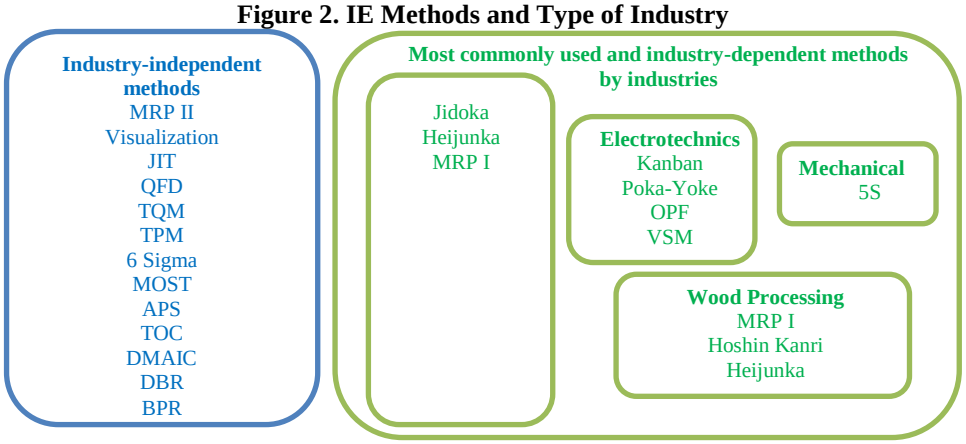
Summary

Based on the results of the analyses presented in the previous chapter, it can make the following conclusions regarding the definition of the initial hypotheses formulated in the chapter 3 Research objectives and methodology.
H1: Differences in the use of IE methods in the various fields of the national economy have been confirmed. However, this hypothesis was not tested by statistical tests; it was only verified by descriptive statistics.
H2: We assume that the type of industry affects IE methods that are implemented in the companies. The solution to this statement is ambiguous. To accept or reject this statement it was necessarily to examine the relationship of individual methods on the industry focus of the company.

Managerial Implication

Based on the above, the following recommendations for managerial practice have been defined: It is inappropriate to use IE methods, regardless of the field in which company operates. The following scheme (Figure 2) summarizes that IE methods are typically used in Czech Republic in selected industries. Generally, the more complex the product is manufactured and the higher its value added, the more methods are used.

Figure 2. IE Methods and Type of Industry



Authors are thankful to the Internal Grant Agency of FaME TBU No. IGA/FaME/2017/015 "Impact of selected industrial engineering methods on the overall business performance and process efficiency" for financial support to carry out this research.

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ZASTOSOWANIE PRZEMYSŁOWYCH METOD LEAN MANAGEMENT W PRAKTYCE EKONOMICZNEJ: EMPIRYCZNE BADANIE FIRM PRODUKCYJNYCH W CZECHACH

Streszczenie: Firmy są zachęcane do wprowadzania zmian i ulepszania procesów biznesowych w celu osiągnięcia wydajności i konkurencyjności. W tym celu w praktyce biznesowej można stosować metody inżynierii przemysłowej. Głównym celem tego artykułu jest identyfikacja najczęściej stosowanych metod inżynierii przemysłowej w czeskich zakładach produkcyjnych. Drugim celem jest porównanie wykorzystania poszczególnych metod inżynierii przemysłowej w wybranych obszarach przemysłowych. Niezbędne dane zebrano za pomocą kwestionariusza internetowego (N=118). Wyniki pokazują, że najczęściej stosowaną metodą inżynierii przemysłowej jest standaryzacja, planowanie zapotrzebowania materiałowego (MRP I), planowanie zasobów produkcyjnych (MRP II), 5S i Kaizen. Badanie to potwierdza, że zastosowanie normalizacji, 5S, Kaizen i MRP I zależy od rodzaju branży, w której działa firma; koncentracja na branży nie ma wpływu na to, czy stosuje się TQM, czy MRP II.

Słowa kluczowe: zarządzanie wydajnością biznesową, metody inżynierii przemysłowej, doskonalenie procesów biznesowych, Lean Management

在经济实践中使用工业精益管理方法：对捷克共和国生产企业的实证研究

摘要：鼓励公司改变和改善业务流程以实现业绩和竞争力。为了这些目的，工业工程方法可以用于商业实践。本文的主要目的是确定捷克制造企业中最常用的工业工程方法。次要目标是比较选定工业领域个别工业工程方法的使用情况。通过在线问卷收集必要的数据（N=118）。结果表明，最常用的工业工程方法是标准化，物料需求计划（MRPI），制造资源计划（MRPII），5S和Kaizen。这项研究证实标准化，5S Kaizen和MRPI的使用取决于公司运营的行业类型;行业关注不会影响是否使用TQM或MRPII。

关键词：业务绩效管理，工业工程方法，业务流程改进，精益管理。