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ASSESSMENT OF PRODUCTION PROCESSES ON THE BASE OF THE SECOND TOYOTA MANAGEMENT PRINCIPLE – CASE STUDY

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Abstract: The article presents a case study of the practical use of BOST surveys to identify the most important areas in the production process. It was made the identification of areas from the second Toyota's management principle point of view. This principle is based on the conviction that appropriate process leads to appropriate results. If the process is designed properly, then good results will come automatically. The research object is company producing the mineral water and carbonated drinks. Some production workers of the company with the help of BOST questionnaire survey showed, which factors are the most important. In frames of the work it was made short characteristics of the research object - producer of mineral water, the presentation of research methodology and content second Toyota's management principle. Based on the survey results of carried out on the population of production workers, a series of importance areas for improvement was formulated. The aim of the analysis is to present which factors are the most important by building the significance sequences of obtained results. In the article were presented results of analysis with using some statistical tools. The results obtained for the type of small and medium-sized enterprises overlap with the results of tests verified in other enterprises.

Keywords: BOST method, improvement, importance hierarchy, Toyota's management principle, statistical analysis

1. INTRODUCTION

The Toyota Production System is based on the assumption that all separate elements work well for the benefit of the entirety. One of its main goals is also to support and encourage employees to continuously improve their work. Toyotarity is a scientific discipline examining human - machine and human - human relationships with the inclusion of a process-based approach, Japanese culture, especially of Toyota, oriented to continuous improvement with the use of knowledge. This definition details two dipoles: human – machine and human – human. Human appears in three out of four components of the above definition thus underlining the meaning of a human in a Japanese culture and consequently in the culture of Toyota. Survey and research method determined as BOST (Borkowski, S., 2016) was formed as a result of author's fascination in Toyota Motor Company (Gao and Low, 2015), in its management and production system, enhanced after reading a book by Jeffrey Liker “The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer” (Amasaka, 2012; Liker and Franz 2011). BOST studies known also as Toyota's management principles in questions, were drawn up in order to assess in practice the approach to management principles amongst many manufacturing companies and service in Poland (Borkowski et al., 2014). The BOST method allows assessing the significance of factors describing the 14 Toyota management principles. Toyota's management principles in BOST method are described with some characteristic where set of factors was called “areas” (Borkowski et al., 2013). Some principles are divided into two or even three areas. This method describes Toyota’s management principles with its characteristic factors (Knop and Mielczarek, 2018). The presented questionnaire has a ranking scale. Respondents may assess the significance of a given factor by placing one of the numbers within the range of scale in an appropriate box. After the description of the main part of this method its further elements will be outlined briefly.

2. PRESENTATION OF RESULTS

Constant improvement of organization is possible through application of small steps approach. Succeeding and improving competitiveness is only possible in self-learning organization and by continuous improvement of an organization culture. It was proved that modern economic processes consist in 90% of losses and only 10% of actions contain added value. For this reason it is necessary that quality is built in the processes already on the initial stage of production. Processes shall be reorganized so that their course is fluent and uniform. The flow should be organized according to appropriate time (LIKER J.K. 2005). Constant improvement of organization is possible through application of small steps approach. Succeeding and improving competitiveness is only possible in self-learning organization and by continuous improvement of an organization culture. The research was carried out in the company that producing the mineral water and carbonated drinks. The company is situated in southern Poland. Additionally the land on whom the company is situated and the district contains natural resources such as iron, molybdenum and coal. In the half of 20th century state institutions strongly became interested in these resources and many boreholes in 70 years was made. The depth some boreholes reached over 1000 meters. In one of such boreholes gushed water about the crystalline cleanness. An effect of this event was idea to build a company of water production. Constant investments as well as new methods of management caused that today the company is one of the largest producers of drinks in Poland. At present at the unit 4 bottling lines are working, one is the most modern in Poland. The assortment of the workshop is about 80 products in containers about 5 different capacities. An organizational structure of the company can determine as linear, flat. There are not a large number of managerial ranks what quicken the flow of information and the procedure of making a decision. In every department there is one manager who has the smaller or larger group of workers under itself. Production managers are responsible for the course of an entire production process and for creating and correct implementing of new ideas or the technology.

In this study the BOST method was used during tests (BORKOWSKI S. 2012b). Respondents were asked to answer the following question: Which factor is the most important in the production process? (fill the blanks with 1; 2; 3; 4; 5; 6; 6 – the highest factor)

CP		Continuous system of problem detection
PE		Production layoff after quality problem detection
SZ		Standard tasks, processes, documents
EU		Granting authorization to subordinates
ST		Usage of only reliable technology
SW		Usage of visual control

The questionnaire survey was carried out in the researched enterprise producing mineral water amongst 40% production workers. i.e. more than half of workers it this department. Such a large research group of directly production workers will allow to precise identification the most important areas the surveyed enterprise. Table 1 present a percentage list of significance rates of the second Toyota management principle (E3 area) factors in the enterprise producing different type of water and

Table 1.
Elements of the second Toyota management principle. Percentage list of factors' significance rates

Evaluation	**Indicating the factors**					
	CP	**PE**	**SZ**	**EU**	**ST**	**SW**
1	0.0	0.0	26.5	38.2	14.7	20.6
2	2.9	20.6	44.1	26.5	0.0	5.9
3	2.9	17.6	14.7	23.5	35.3	5.9
4	8.8	41.2	11.8	5.9	20.6	11.8
5	41.2	8.8	2.9	5.9	8.8	32.4
6	44.1	11.8	0.0	0.0	20.6	23.5

The results of the study were detailed in the analysis. At the beginning was made an analysis of the structure of granted assessments to individual factors. The percentage structure of assessments was presented in Fig. 1.

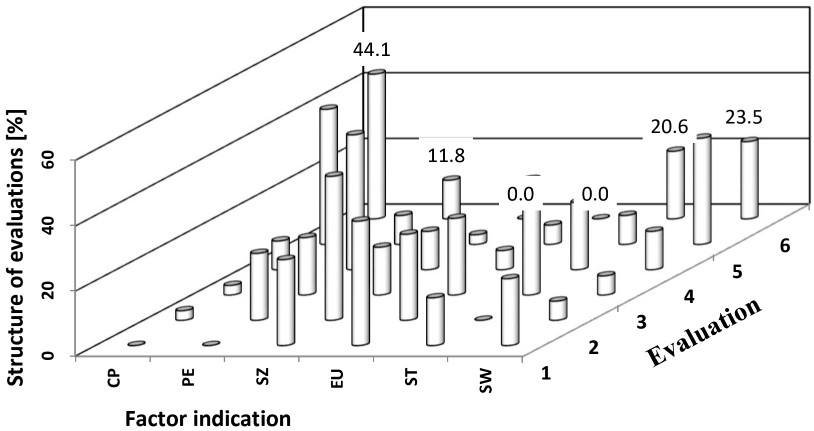

Fig. 1. Principle 2. The spatial presentation of research results – the structure of evaluations

Based on the prepared structure of ratings for separate factors it was found that *Continuous system of problem detection* (CP) was the most important factor for 44.1% of respondents. In case of the next factor *Production layoff after quality problem detection* (PE) the answers were different, because 41.2% have granted this factor the rate "4". *Standard tasks, processes, documents* (SZ) has been assessed by respondents as a not significant factor. The next factor was *Granting authorization to subordinates* (EU). 38.2% of respondents gives this factor rate “1”. *Usage of only reliable technology* (ST) has been assessed as follows: none of the respondents has granted it rate “2” and 35.3% received “5”. *Usage of visual control* (SW) 32.4% have given rate “5” to this factor. Fig. 2 presents the structure of average significance rates of the E3 area.

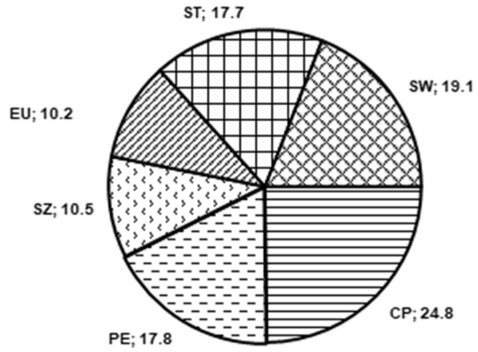

Fig. 2. Principle 2. Circular chart - significance rates for factors of the E3

The data in this figure allows the creation of the following significance sequence of analyzed factors. In the research enterprise the factor *Continuous system of problem detection* (CP) is the most important in the realization of the production process. In such conditions of production there is no place for an individual interpretation of procedures or management, therefore the factor *Granting authorization to subordinates* (EU) takes the last place in the sequence.

3. CORRELATION STATISTICAL ANALYSIS OF THE RESULTS FROM THE BOST QUESTIONNAIRE

Making statistical analysis of studied area six statistical tools were used: arithmetic average, variance, standard deviation, the coefficient of variation, skewness and kurtosis (Fig. 3). The aim of application of this statistical tool is to show distribution of evaluation for individual factors. The aim of application of this statistical tool is to show distribution of evaluation for individual factors.

The average level of the measurable feature was presented with the help of the average. Analyzing Fig. 3a concerning the result of average it was taken the conclusion that majority of respondents judged the response concerning *Continuous system of problem detection* (CP) on the level 5.21. The lowest average rate has been acquired by *Granting authorization to subordinates* (EU) which has been assessed on the level 2.15. Standard deviation (Fig. 3b) is the biggest for the factor *Usage of visual control* (SW) – on the level 1.87 and the smallest for *Continuous system of problem detection* (CP) – 0.95. In order to assess factors with the use of variation coefficient it is necessary to prepare the following statement: 0 - 20% – weak variation of feature, 20 - 40% - moderate variation of feature, 40 - 60% - strong variation of feature, 60% and more – very strong variation of feature (Borkowski and Ulewicz, 2009, Wheeler, 2000).

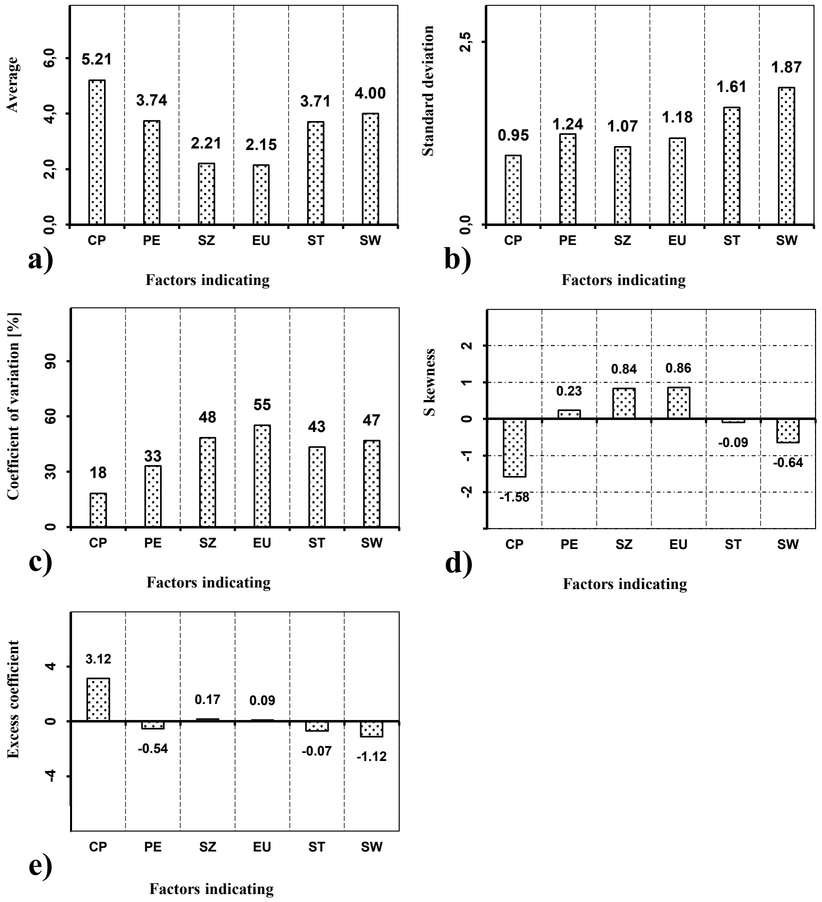

Fig. 3. Principle 2. Comparison: a) average, b) standard deviation, c) coefficient of variation, d) skewness, e) excess coefficient for E3 area factors

Coefficients of variation presented in Fig. 3c show, a weak variation for *Continuous system of problem detection* (CP), a strong variation for four factors. The measurement of skewness is (Fig. 3d) a classic coefficient of asymmetry: (0.0 - 0.4) - very weak distribution asymmetry, (0.4 - 0.8) – weak distribution asymmetry, (0.8 - 1.2) - moderate distribution asymmetry, (1.2 - 1.6) - strong distribution asymmetry, (more than 1.6 – very strong distribution asymmetry) (Fouad and Mukattash, 2010). The distribution of rates for *Continuous system of problem detection* (CP) indicate strong negative skewness. The distribution of rates for the rest of factors indicates weak and moderate skewness. The last factor for analyzing is kurtosis (Fig. 3e). It determines the measure of distribution and concentrating the results in surroundings of the average (Ignaszak and Sika, 2012; Uçurum et al., 2016). For appropriate interpretation of results the following statement is necessary: We < 0 – distribution is characterized by lower than standard peakedness, We = 0 distribution is characterized by standard peakedness, We > 0 – distribution is characterized by peakedness higher than standard. For factors *Continuous system of problem detection* (CP), *Standard tasks, processes, documents* (SZ) and *Granting authorization to subordinates* (EU) the distribution of rates is characterized by higher than standard peakedness. This statistical tool confirm that distribution of results is logical and can be helpful for evaluation actual state in enterprise.

4. EXAMINATION OF VARIOUS FACTORS RANKS

Fig. 4 shows the histograms of the structure of the evaluations for individual factors.

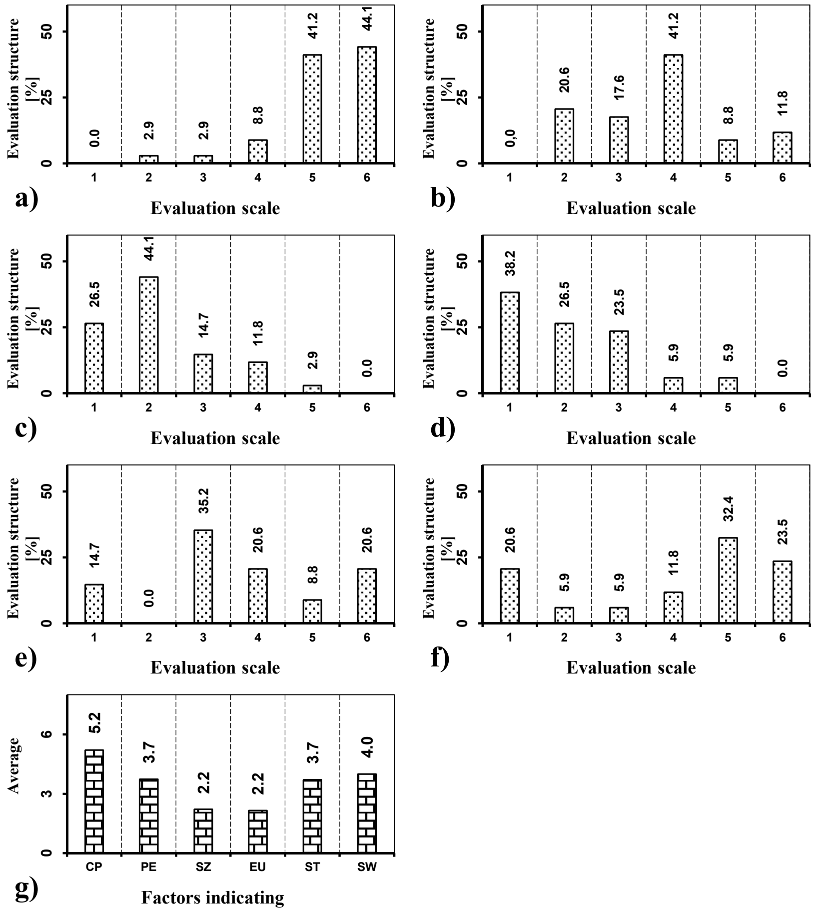

Fig.4. Principle 2. Histograms – the structure of the evaluations of the factors: a) CP, b) PE, c) SZ, d) EU, e) ST, f) SW, g) average.

The results contained in Fig. 4 shows that the largest number of votes for *Continuous system of problem detection (*Cp) factor was in the note “6”. Regarding the *Production layoff after quality problem detection* (PE) factor 41.2% of respondents rated the evaluation “4”. *Standard tasks, processes, documents* (SZ) factor received 44.1% of the respondents to evaluation “2”. Most of the respondents (38.2%) rated the factor *Granting authorization to subordinates* (EU) on evaluation “1”. For factor *Production layoff after quality problem detection* (PE) most of respondents rated evaluation “3”. The last factor *Usage of visual control* (SW) attributed evaluation “5”. In Fig. 4g it is shown that the highest average evaluation received factor *Continuous system of problem detection (*Cp), while the lowest average *Granting authorization to subordinates* (EU) and *Standard tasks, processes, documents (SZ).*

On the basis of Fig. 4 was presented importance series of factors for average evaluations. Summing up, a range of important factors in examined enterprise is following:

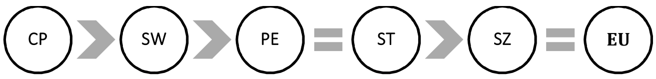

Fig. 5. The importance series of the factors for elements of second Toyota management principle

From analysis of the averages of important factors it results that *Continuous system of problem detection (*Cp) is a key factor according to respondents.

5. CORRELATION ANALYSYS

Respondents differ in terms of their personal features: gender, education, age, work experience, mobility, mode of employment. To determine the influence of these features, correlation coefficients were calculated and presented in the form of graphs in Fig. 6. Each of these Figures also contains three characteristic lines on each side of the 0 axis. It should be noted that their distance from the 0 axis is the same in all the Figures, because they represent the value of a critical coefficient for various levels α (0.05; 0.10; 0.2). Correlation, between two variables, is a measure of the connection occurring between these variables (Knop, 2018).

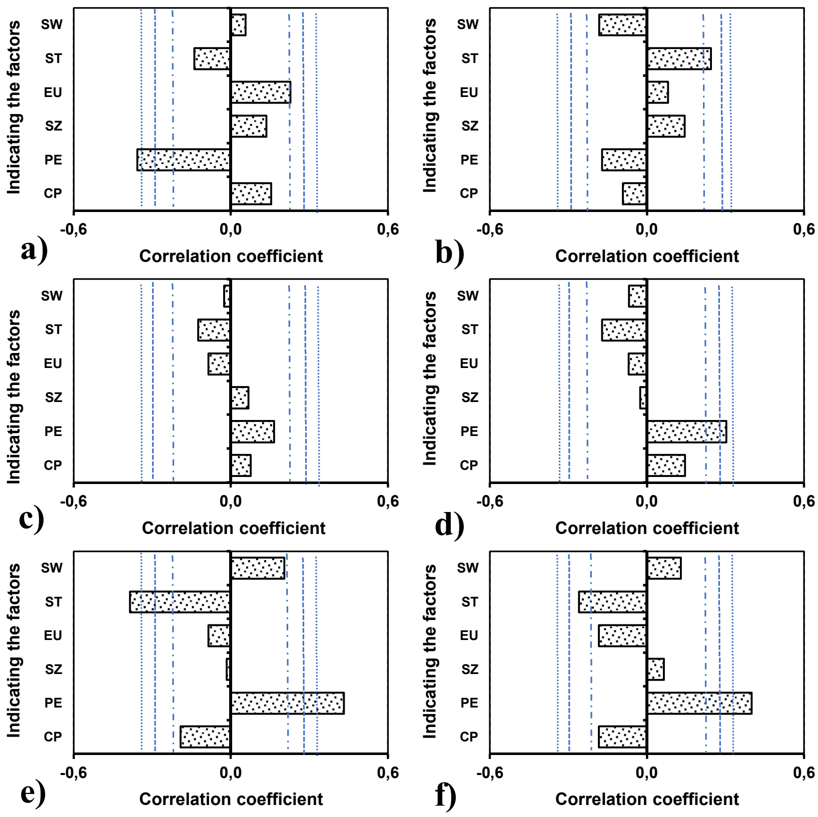

Fig. 6. Principle 2. Correlation graphs of evaluations in E3 area depending on the respondents feature: a) gender, b) education, c) age, d) work experience, e) mobility, f) mode of the employment. α = 0,2 (internal lines), α = 0,1 (central lines), α = 0,05 (external lines)

Value most often assumes the strength of the interdependence of two variables from the range. It should be remembered, that value close to the zero not always mean a lack of the relation, but only a lack of the linear relation between variables.
Analyzing the correlation graph for E3 area depending on the respondents' gender (Fig. 6a), it is possible to notice that *Production layoff after quality problem detection* (PE) factor demonstrated the relation of levels of the significance (α=0.2; α=0.1; α=0.05) between results of the assessment and gender of respondents. From Fig. 6b results, that *Production layoff after quality problem detection* (PE) factor demonstrated the relation between results of the assessment and educating respondents on the level α=0.2. Examining Fig.2c it is possible to state, that none of six factors demonstrated any the relation of levels of the significance (α=0.2; α=0.1; α=0.05) between results of the assessment and age of respondents. In the case of the correlation graph depending on the work experience of respondents (Fig. 6d) factor *Production layoff after quality problem detection* (PE) demonstrating the correlation relationship. In Fig. 6e it is possible to observe that two factors are demonstrating the relation between results of the assessment and the mobility of respondents on levels of the significance. It should be emphasize that correlation between the mobility and the assessment of the factor *Production layoff after quality problem detection* (PE) and *Production layoff after quality problem detection* (PE) exists even on the level α=0.05. Mode of employment has influence on the assessment of *Production layoff after quality problem detection* (PE) and *Production layoff after quality problem detection* (PE)

6. CONCLUSION

Innovative BOST questionnaire survey, which are an attempt to convert Toyota's management principles into questions was described. The starting point for changes (improvement) is recording the existing condition. The present situation is definitely known best by participants of the processes implemented in a given enterprise. Data obtained from BOST analysis allowed to know the opinions of the representative group of workers in the topic of functioning of the enterprise concerning the competent organization of a production process and its influence on the quality of produced goods. Research was carried out amongst production workers of the company. It allowed detailing factors which in the greatest degree can contribute for improvement processes in the company and the ones which have this smallest contribution. The practical use of BOST surveys gives the opportunity to benefit from the practical knowledge of employees at the company's production level. This may contribute to the identification of key areas for the functioning of the enterprise. As a result of the research work, it was found that the most important factor in production process is connected with system of problem detection. It is an important element of research for small and medium enterprises. The results of research are consistent with the research carried out in other such enterprises.
The analysis of significance of factors describing the second Toyota management principle states that the factor *Continuous system of problem detection (*Cp) is the most important. This factor has acquired 24.8% of choices. The second position, almost on the same level, exceeding 18% was taken by the following three factors – *Usage of visual control* (SW), *Production layoff after quality problem detection* (PE), continuous system of problem detection (CP) and *Application of reliable technology* (ST). These are the factors closely connected with technological aspects of production relating to fluent production rhythm with simultaneous application of reliable methods and

technologies. The last place in the respondents' classification was taken by the factor of *Granting authorization to subordinates (*EU) and *Standard tasks, processes, documents* (SZ). The above fragment of analysis has revealed diversity in the significance of factors describing the second Toyota management principle. In this way the usefulness of the presented BOST method has been proved for assessing a production process of goods of high quality requirements.

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