THE EMPIRICAL QUALITY MANAGEMENT PRACTICES STUDY OF INDUSTRIAL COMPANIES IN THE CZECH REPUBLIC

Ondra P., Tuček D., Rajnoha R.*

Abstract: Monitoring, managing and sustaining the quality are crucial to the competitiveness of companies. In order to manage the quality, a variety of Quality Management tools and techniques can be used. The main objective of this study is to identify the use of selected Quality Management tools and techniques in industrial companies in the Czech Republic. This study summarizes the results of the online questionnaire survey (research sample of 200 industry companies). It has been found that the most commonly used Quality Management tools and techniques are Checksheets, Total Quality Management and Pareto Chart. Total Quality Management is currently the most commonly single-used Quality Management technique. Research findings also provide information about the quality tools using. The survey shows that basic (classical) Quality Management tools are used more than new Quality Management tools. The relationship between industrial specializations of companies and used Quality Management tools and techniques are found (The Pearson's Chi-square Test of Independence and the G-Test of Independence were used). Other relationships have been identified between the type of production and Quality Management tools and techniques.

Key words: Management, Quality Management, Quality Management Tools and Techniques, Manufacturing and Processing Industry, Czech Republic

DOI: 10.17512/pjms.2018.17.2.16

Article's history:
Received February 3, 2018; *Revised* April 11, 2018; *Accepted* May 13, 2018

Introduction

The global market competition is growing. Thus for each company, it is very important to achieve performance, success, and competitiveness, because otherwise, the future of the company may be at risk (Pribeanu and Toader, 2016). With regard to the competition, companies are generally forced to meet the customer demands better and faster than competitors do (Naumann and Jackson Jr., 1999). In order to achieve the performance of the company, it is necessary to define the customer requirements and needs, to fulfil these demands and thus to achieve customer satisfaction, which influences the strengthening of the competitive position of the company (Aguwa et al., 2012).
According to Dale (2003) and Dale et al. (2016), the quality of the product is one of the most important factors for the customer, because it has an impact on customer satisfaction. However, the customers are not the only ones who want to

* **Ing. Pavel Ondra**, **doc. Ing. David Tuček, Ph.D.**, **doc. Ing. Rastislav Rajnoha, PhD.**, Tomas Bata University in Zlín, Faculty of Management and Economics
✉ Corresponding author: ondra@utb.cz
✉ tucek@utb.cz; rajnoha@utb.cz

maintain or improve the quality. The authors (Dale, 2003; Dale et al., 2016) have stated that companies themselves have an internal need to sustain a certain level of quality and improve it. Companies are looking for ways to improve quality. Quality is the basis for their survival on the market. Kristianto et al. (2012) agree with this, claiming that companies should benefit from quality management systems, ISO standards, and certification, to improve the performance of the company.

Every company aims to low cost, high quality, and competitiveness (Jones, 2014; Kahraman and Yanik, 2015). Monitoring, managing and sustaining the quality are crucial to the competitiveness of the company. In order to manage the quality, a variety of Quality Management tools and techniques (QMTs) can be used in practice. Quality management (QM) and quality itself have been a top subject for years (Dale et al., 2016).

Based on the research of scientific publications, it is possible to state that many researchers have explored the use of QMTs and examined the implementation of QMTs in different countries, companies, industries and situations, such as QM in brewing industry (Vrellas and Tsiotras, 2015), manufacturing (Starzynska, 2014), education (Mehra and Rhee, 2009) or banking (Ngo and Nguyen, 2016). In addition, some researchers have explored relationships between QM and other factors, such as business performance (Heras et al., 2011), new product development (Sun et al., 2009) or project management (Barad and Raz, 2000).

However, there is not much empirical research about the use of QMTs in industrial companies in the Czech Republic. Authors usually focus on a particular industry, thus there is no examination of the relationship between used QMTs and other factors, such as a type of production or industrial specialization. The main objective of this study is to identify the use of selected Quality Management tools and techniques in industrial companies in the Czech Republic.

Literature Review

Christensen et al. (2013) have stated that there are instruments that help with analysing and improving the quality and performance of companies. Under these instruments, QMTs can be understood. According to McQuater et al. (1995), QMTs are methods, mechanisms and means for the appropriate implementation of the company quality program. QMTs enable improvements and positive changes in companies. McQuater et al. (1995) add that it is appropriate to distinguish tools and techniques. The tool is a simple instrument with a clear purpose. Such tools are focused on specific quality-problem solutions and can be used separately on their own. On the other hand, techniques have a wider application than tools and may include some of them, which means that QM techniques can be understood as sets of QM tools (McQuater et al., 1995).

Researchers have identified a number of QMTs. Ishikawa (1985), Imai (1986), Juran and Gryna (1988), Dale (2003), Evans and Lindsay (2005) and Dale et al. (2016) have identified and proposed QMTs for quality process improvement and problem-solving. Ishikawa (1985) have identified the seven QM tools: Cause and

Effect diagram, Checksheet, Control chart, Histogram, Pareto chart, Scatter diagram and Stratification. According to Sokovic, Jovanovic, Krivokapic, and Vujovic (2009), several authors later replace the name Stratification with names Flowchart or Run chart. These original QM tools are also called seven basic, old, quality tools or quality control tools (Dounias et al., 2001; Kang and Park, 2000). The seven basic QM tools are simple, effective, easy to learn and use while identifying and analyzing existing problems and suggesting improvements of quality, and therefore widely used (Sokovic et al., 2009). Some authors define, that it is also necessary to train the staff in the context of quality and optimization methods (Chromjaková and Rajnoha, 2012). Dale and McQuater (1998) have identified the most commonly used QMTs: the seven basic QM tools, the new seven QM tools (Affinity diagram, Arrow diagram, Matrix data analysis, Matrix diagram, Process decision programme chart, Relations diagram and Tree systematic diagram), and QM techniques (Design of experiments, Failure mode and effects analysis, Fault tree analysis, Problem-solving methodology, Quality costing, Quality function deployment, Quality improvement teams and Statistical process control). With the new seven QM tools, it is possible to identify quality issues and their root causes and to formulate comprehensive solutions to specific issues (Siva et al., 2016; Terziovski and Sohal, 2000).
Using a single QM tool is sufficient to identify, analyze, and solve a specific quality issue. In other operations of companies, however, it may be necessary to use multiple QM tools at once and combine them, or use a more complex QM technique (Christensen et al., 2013). Dahlgaard et al. (2013) have stated that the diversity of quality process improvement and problem-solving methodologies causes that QMTs and their mission in operations of companies differ from each other.
With QMTs, companies can achieve improvements, increase of pro-quality awareness, productivity, customer satisfaction, and promoting work in teams and facilitating communication (Bamford and Greatbanks, 2005; Herbert et al., 2003; Lagrosen and Lagrosen, 2005).
In addition to classify and sort QMTs, several studies and researches have been carried out to use these QMTs, their application, and exploration of relationships with other factors. Adams and Dale (2001) have studied the implementation of QMTs in manufacturing companies. Prajogo (2005) indicates no significant difference in the level of most of TQM practices and quality performance between the two sectors. Bayazit (2003) has stated that in Turkish manufacturing companies, the most frequently used QMTs are the Pareto chart, Statistical process control, and Cause&Effect diagram. The most frequently used QMTs in Malaysia are Check sheets and Stratification (Ahmed and Hassan, 2003). In terms of results, it is consistent with Curry and Kadasah (2002) from Saudi Arabia. Sousa et al. (2005) have obtained similar results from Portuguese SMEs - the most commonly used QMTs are simple, such as Checksheet, Process flowchart and Histogram.

Tariand Sabater (2004) have studied the relationship between the use of QMTs and TQM.

Methodology

The main objective of this study is to identify the use of selected QMTs in industrial companies in the Czech Republic. The secondary objective of this study is to examine the dependence of QMTs on industrial specialization and type of production. Based on the stated objectives, the following research questions (RQs) were defined:
RQ1: Does the extent of use of selected QMTs differ among industrial companies in the Czech Republic?
RQ2: Are some QMTs used together with other QMTs?
RQ3: Are some QMTs used separately without other QMTs?
RQ4: Does the extent of use of selected QMTs differ among industrial specializations?
RQ5: Does the extent of use of selected QMTs differ among types of production?

In order to answer the RQs and achieve the objectives, the research work was carried out. The necessary data about companies in the Czech Republic were obtained using a questionnaire method. A comprehensive questionnaire was created primarily from closed questions and focused on various issues of processes, production, and quality. The questionnaire was largely focused on the use of selected QMTs. The full list of QMTs that were examined was as follows: Affinity Diagram, Arrow Diagram, Cause & Effect Diagram (C&E Diagram), Control Chart, EFQM Excellence Model (EFQM), Histogram, Checksheet, Matrix Data Analysis, Matrix Diagram, Pareto Chart, PDPC Diagram (PDPC), Process Capability Analysis (PCA), Quality Circles, Quality Function Deployment (QFD), Relations Diagram, Scatter Diagram, Six Sigma, Statistical Process Control (SPC), Stratification, Total Quality Management (TQM) and Tree Diagram. In order to avoid confusion and differences in the understanding of individual QMTs in companies, all QMTs have been described in the questionnaire and the names were in both English and Czech versions.
The questionnaire was created online using Google Forms and distributed by e-mail, between April 2017 and July 2017, to the production and quality managers in companies in the Czech Republic. The aim was to reach as many companies as possible from different sectors of the national economy, sizes, ages, and with focusing on the manufacturing and processing industry. After two rounds of sending questionnaires, totally 252 valid responses were collected. Approximately 5% of the contacted companies participated in the survey.
The collected data were converted from Google Forms to MS Excel workbook. The original dataset included answers from all the surveyed companies (252 subjects). Due to the focus on industrial companies, companies primarily focused on services were excluded from the original dataset. The final dataset included

answers from a sample of 200 companies with different specializations: mining and processing of materials (33.0%), production of machinery (32.5%), production of chemical products (13.0%), production of electrical components (12.0%) and agricultural and food production (9.5%). The sample was composed of companies with a piece (40.0%), serial (39.5%) and mass (20.5%) production.
In order to summarize the current use of QMTs, some statistical techniques were used. Basic descriptive statistics were processed in MS Excel. Statistical data analysis was performed through SPSS 23. The Pearson's Chi-square Test of Independence and the G-Test of Independence were conducted to explore the relationships between QMTs and industrial specializations and type of production. For the purpose of pointing out the dependence influencing factors, the Column Proportions Z-Tests were conducted. The G-Test of Independence was used primarily in cases where the Pearson's Chi-square Test of Independence could not be used due to low expected counts.

Empirical Results: The Use of Selected QMTs among Industrial Companies

Figure 1 shows the structure of utilization of QMTs expressed by the amount of used QMTs. More than 37% of the companies do not use any of the selected QMTs. The surveyed companies had a choice to add other QMTs they use. However, none of the companies took this opportunity. Approximately 56% of companies use one to five QMTs to manage quality within their business processes. Only 7% of companies use six or more QMTs. The results of percentage use of individual QMTs are shown in Figure 2. Percentage data refers to the entire sample of 200 companies. It has been found that the most commonly used QMT are Checksheets. The companies obviously prefer the simplicity and applicability of this QMT. Checksheet is a basic tool for well-arranged data collection of quality in processes and simplify post-processing of collected data. The second most commonly used QMT is Total Quality Management and the third is Pareto Chart.

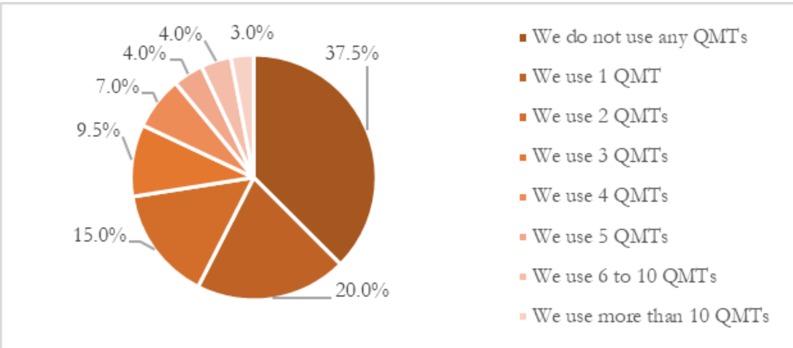

Figure 1. Amount of used QMTs

More than 10% of companies also use Tree Diagram, Histogram, C&E Diagram, SPC, QFD and Control Chart. Based on the survey, it can be stated that the basic QMTs are used more than the new QMTs. Basic QMTs are simple and it is possible to work quite quickly with them. Basic QMTs are easier to use than the new QMTs. As a result, the basic QMTs are well usable in business practice. Due to the extent of using TQM, which is primarily built with the pillars of the basic QMTs and complemented by the new QMTs, it is surprising that none of the surveyed companies indicated the use of EFQM. On the other hand, a pleasant surprise is the extent of use of customer-oriented product development using QFD principles. Similarly, the extent of use of the Six Sigma concept is greater than expected.

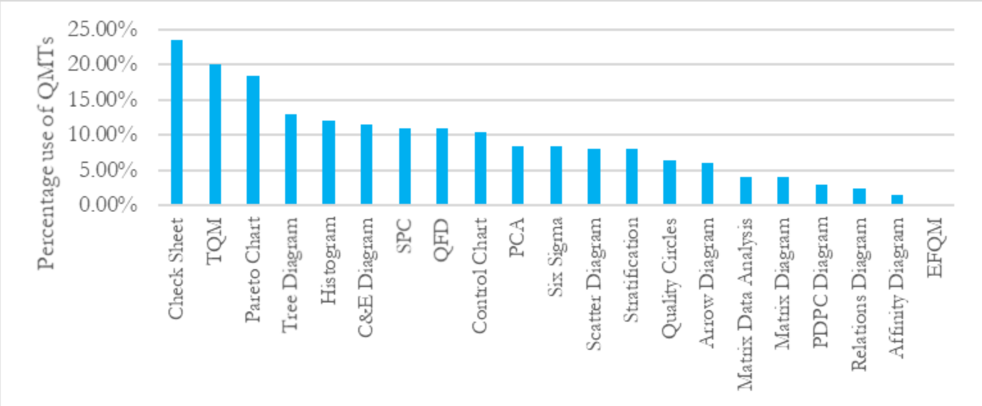

Figure 2. Use of Individual QMTs

In addition to the extent of use of selected QMTs, it can be stated that most of the selected QMTs are not used alone in business practice. Overall, 42.5% of companies use more than one QMT. All these combinations of use of individual QMTs are shown in Table 1. The most common combination (19 times) of these tools was found between Pareto Chart and C&E Diagram. It is quite logical since these two QMTs are linked to each other.

Table 1. Combining used QMTs with each other

	Affinity Diagram	Arrow Diagram	C&E Diagram	Checksheet	Control Chart	Histogram	Matrix Data Analysis	Matrix Diagram	Pareto Chart	PDPC Diagram	PCA	Quality Circles	QFD	Relations Diagram	Scatter Diagram	Six Sigma	SPC	Stratification	TQM
Arrow Diagram	0																		
C&E Diagram	1	0																	
Check Sheet	2	5	12																
Control Chart	1	2	8	13															
Histogram	1	4	10	12	9														
Matrix Data Analysis	0	1	3	3	3	4													
Matrix Diagram	0	2	1	2	1	3	2												
Pareto Chart	0	2	19	15	7	14	6	3											
PDPC Diagram	0	0	4	4	3	5	2	0	4										
PCA	0	0	9	8	7	8	4	2	11	5									
Quality Circles	0	2	5	6	7	5	2	2	6	2	4								
QFD	0	3	6	10	5	4	2	2	7	5	7	4							
Relations Diagram	0	2	1	2	1	3	2	2	3	0	1	0	2						
Scatter Diagram	1	1	9	7	2	6	0	2	8	2	4	1	2	1					
Six Sigma	0	3	5	5	2	2	0	3	7	0	3	2	2	1	3				
SPC	0	0	10	10	3	8	3	2	11	4	13	4	8	1	5	5			
Stratification	1	4	4	10	5	5	2	1	4	3	3	2	5	1	3	3	5		
TQM	0	5	9	11	5	10	7	5	13	5	9	5	10	3	3	8	10	4	
Tree Diagram	1	11	4	11	8	9	1	3	6	3	4	3	8	2	4	5	5	8	10

For example, when solving quality issues - worker or manager can specify the problem spots using Pareto Chart, and then use C&E Diagram, worker or manager can look for the root cause of these problems. A similar situation occurs in the case of the second most common combination (15 times) between Pareto Chart and Checksheet, because these QMTs are also linked to each other. In the same sample situation, Checksheet is used, for example, while collecting data about quality issues. In addition, the third most common combination (14 times) is Pareto Chart and Histogram. These two QMTs are also interconnected and both can be used to analyse quality issues. It is possible to say that the Pareto Chart is based on the histogram principle because Pareto Chart is a specific type of histogram that ranks the issues by their influence.

Assuming that EFQM is excluded from the set of selected QMTs because of zero usage, it is generally possible to say that each of the selected QMTs is used concurrently with at least one other QMT. Therefore, all the selected QMTs in the set are used in combination with others. Differences are mainly in the frequencies of these combinations. Assuming that company uses QMTs, the company will likely use multiple QMTs. However, 20% of the samples of companies use only one single QMT. Figure 3 shows QMTs that are single-used in some companies. However, their individual shares of the entire sample of 200 companies are quite small.

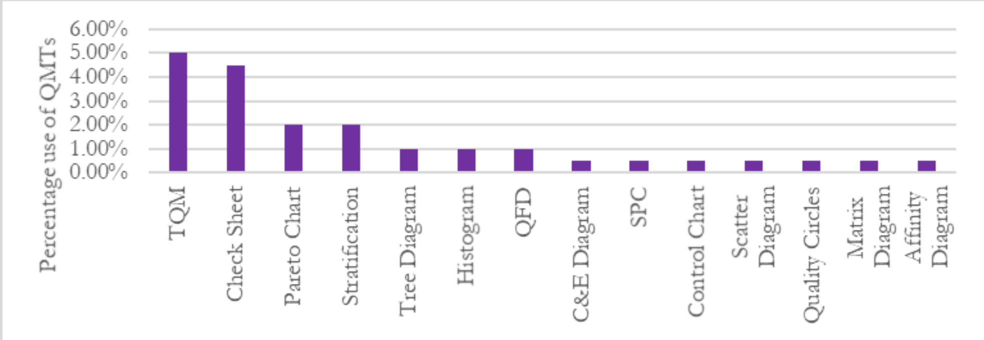

Figure 3. Single-used QMTs

In ten cases, the TQM was marked as a single-used QMT. These are mainly SMEs with up to 50 employees, with an annual turnover up to 10 million euros and all of them are certified by ISO 9001. In this context, TQM can be understood as the main concept of quality management in these companies. At the same time, TQM is a comprehensive concept that should include a number of other QMTs. However, the companies did not specify these sub-tools. The Check Sheet was marked as a single-used QMT in the case of nine companies. These companies have different sizes according to the number of employees and different levels of annual turnover. They matched primarily in a source of purely domestic capital, and their production process has a serial character.

Empirical Results: Relationships between the Use of Selected QMTs and Industrial Specializations

In order to answer the fourth RQ *(RQ4: Does the extent of use of selected QMTs differ among industrial specializations?)*, it was necessary to use the statistical tests of independence between used QMTs and industrial specializations. With regard to the expected values of the use of individual QMTs, the G-Test of Independence was used. The following statistical hypotheses were defined:
H0 hypothesis: There is no statistically significant relationship between used QMTs and industrial specializations.
H1 hypothesis: There is a statistically significant relationship between used QMTs and industrial specializations.
For the purpose of failing to reject or rejecting the null hypothesis, the significance level was set to $\alpha = 0.05$. Based on the p-value, the study rejected or failed to reject the null hypothesis. The results are shown in Table 2.

Table 2. Tests of Independence between QMTs and Industrial Specializations

QMT	G-Test of Independence		Test result
	Likehood Ratio	p-value	
Affinity Diagram	6.71785	0.15157	Fail to reject H0
Arrow Diagram	6.07322	0.19375	Fail to reject H0

C&E Diagram	14.68345	0.00540	Reject H0
CheckSheet	3.04222	0.55078	Fail to reject H0
Control Chart	13.65581	0.00848	Reject H0
Histogram	18.02623	0.00122	Reject H0
Matrix Data Analysis	12.07335	0.01681	Reject H0
Matrix Diagram	4.51484	0.34079	Fail to reject H0
Pareto Chart	26.70786	0.00002	Reject H0
PDPC	5.00218	0.28707	Fail to reject H0
PCA	10.72745	0.02980	Reject H0
QFD	6.80706	0.14644	Fail to reject H0
Quality Circles	4.18186	0.38195	Fail to reject H0
Relations Diagram	2.49793	0.64501	Fail to reject H0
Scatter Diagram	2.16637	0.70519	Fail to reject H0
Six Sigma	5.20666	0.26674	Fail to reject H0
SPC	25.01692	0.00005	Reject H0
Stratification	14.71381	0.00533	Reject H0
TQM	9.94212	0.04141	Reject H0
Tree Diagram	8.00456	0.09141	Fail to reject H0

According to Table 2, it can be concluded that there is a statistically significant relationship between the use of C&E Diagram, Control Chart, Histogram, Matrix Data Analysis, Pareto Chart, PCA, SPC, Stratification, TQM, and industrial specializations. The use of these QMTs is dependent on the industrial specialization in which company operates. In order to determine which industry specialization causes the dependence, the absolute and relative residual values are calculated in Table 3.

According to Table 3, for all dependent QMTs in the mining and processing of materials specialization, all residues are negative, so that none of these QMTs is typically used in this field. On the other hand, in companies with machinery production, all of these QMTs are typically used. Matrix Data Analysis and PCA are typically used only in the production of machinery. Three of five industrial specializations typically use C&E Diagrams, Control Charts, and Histograms. With regard to the values of relative residues, Control Chart is the most typically used in agricultural and food production and Matrix Data Analysis with SPC is the most typically used in the production of machinery.

Table 3. Causes of Dependence between QMTs and Industrial Specializations

		Agricultural and food production	Mining and processing of materials	Production of electrical components	Production of chemical products	Production of machinery
C&E Diagram	Residual	-1.090	**-6.260**	0.360	2.140	**4.850**
	Residual (%)	-52.153	**-86.226**	13.636	74.825	**67.832**
Control Chart	Residual	**3.005**	-3.930	-2.520	0.270	3.175
	Residual	**150.627**	-56.710	-100.000	9.890	46.520

	(%)					
Histogram	Residual	1.720	**-6.920**	-1.880	1.880	**5.200**
	Residual (%)	75.439	**-87.374**	-65.278	60.256	**66.667**
Matrix Data Analysis	Residual	-0.950	-2.300	-1.200	-0.300	**4.750**
	Residual (%)	-100.000	-69.697	-100.000	-23.077	**146.154**
Pareto Chart	Residual	**-3.515**	**-8.210**	**3.560**	**-0.810**	**8.975**
	Residual (%)	**-100.000**	**-67.240**	**80.180**	**-16.840**	**74.636**
PCA	Residual	-0.615	-1.610	-2.040	-1.210	**5.475**
	Residual (%)	-38.080	-28.699	-100.000	-54.751	**99.095**
SPC	Residual	0.910	**-6.260**	-2.640	-0.860	**8.850**
	Residual (%)	43.541	**-86.226**	-100.000	-30.070	**123.776**
Stratification	Residual	1.480	-2.280	-1.920	-2.080	**4.800**
	Residual (%)	97.368	-43.182	-100.000	-100.000	**92.308**
TQM	Residual	-1.800	-5.200	0.200	-1.200	**8.000**
	Residual (%)	-47.368	-39.394	4.167	-23.077	**61.538**

Based on the Column Proportions Z-Test, significant differences in proportions are highlighted in Table 3 above. In the case of companies in machinery production, it can be concluded that the proportion of using C&E Diagram in this industrial specialization is statistically more significant than the proportion of not using C&E Diagram in this industrial specialization. A similar conclusion can be applied to the field of mining and processing of materials. In this case, however, the proportion of not using C&E Diagram in this industrial specialization is statistically more significant. It is worth mentioning that, in the case of companies in machinery production, the proportions of using almost all the dependent QMTs (except Control Chart) in this industrial specialization is statistically more significant than the proportions of not using them. However, all these QMTs are typically used in machinery production. These results are not surprising. The use of many QMTs is a typical in the production of machines, especially when it comes to automobile production. It is one of the fields, where quality plays an important role. In non-marked cases, the Column Proportions Z-Test did not prove the statistical significance of the proportions.

Empirical Results: Relationships between the Use of Selected QMTs and Type of Production

In order to answer the fifth RQ *(RQ5: Does the extent of use of selected QMTs differ among types of production?)*, it is necessary to use the statistical tests of independence between used QMTs and type of production. With regard to the

expected values of the use of QMTs, the Pearson's Chi-square Test of Independence and the G-Test of Independence were used. The following statistical hypotheses were defined:
H0 hypothesis: There is no statistically significant relationship between used QMTs and type of production.
H1 hypothesis: There is a statistically significant relationship between used QMTs and type of production.
For the purpose of failing to reject or rejecting the null hypothesis, the significance level was set to α = 0.05. Based on the p-value, the study rejected or failed to reject the null hypothesis. The results are shown in Table 4.

Table 4. Tests of Independence between QMTs and Type of Production

QMT	Pearson's Chi-square Test of Independence		G-Test of Independence		Test result
	Chi-square	p-value	Likehood Ratio	p-value	
Affinity Diagram	-	-	1.72172	0.42280	Fail to reject H0
Arrow Diagram	-	-	3.29673	0.19236	Fail to reject H0
C&E Diagram	10.103	0.00640	-	-	Reject H0
Checksheet	8.286	0.01587	-	-	Reject H0
Control Chart	6.186	0.04537	-	-	Reject H0
Histogram	4.908	0.08597	-	-	Fail to reject H0
Matrix Data Analysis	-	-	0.00196	0.99902	Fail to reject H0
Matrix Diagram	-	-	0.50305	0.77761	Fail to reject H0
Pareto Chart	2.867	0.23850	-	-	Fail to reject H0
PDPC	-	-	8.97714	0.01124	Reject H0
PCA	1.254	0.53426	-	-	Fail to reject H0
QFD	6.372	0.04134	-	-	Reject H0
Quality Circles	5.727	0.05706	-	-	Fail to reject H0
Relations Diagram	-	-	4.27412	0.11800	Fail to reject H0
Scatter Diagram	7.953	0.01875	-	-	Reject H0
Six Sigma	1.444	0.48571	-	-	Fail to reject H0
SPC	10.355	0.00564	-	-	Reject H0
Stratification	6.509	0.03860	-	-	Reject H0

TQM	5.397	0.06732	-	-	Fail to reject H0
Tree Diagram	1.935	0.38013	-	-	Fail to reject H0

Based on the research, it can be stated that there is a statistically significant relationship between the use of C&E Diagram, Checksheet, Control Chart, PDPC, QFD, Scatter Diagram, SPC, Stratification, and type of production. The use of these QMTs is dependent on the type of production. In order to determine which type of production cause the dependence, the residual values are calculated in Table 5.

According to Table 5, all residues are negative in case of all dependent QMTs in companies with piece production, so that none of these QMTs is typically used within this type of production. On the other hand, all of these QMTs are typically used in companies with mass production. PDPC, QFD, and Stratification are typically used only in mass production. These results are not surprising. QMTs would be useful for all types of production. However, due to characteristics of the production, it is more appropriate to the mass production. Most of these QMTs are useful for repeated use under approximately the same conditions. This may not be achieved in piece production because many processes and products are unique.

Table 5. Causes of Dependence between QMTs and Type of Production

		Piece production	Serial production	Mass production
C&E Diagram	Residual	**-6.800**	**5.310**	1.490
	Residual (%)	**-77.273**	**61.105**	33.038
Control Chart	Residual	**-4.400**	0.705	**3.695**
	Residual (%)	**-52.381**	8.499	**85.830**
Checksheet	Residual	**-7.000**	1.225	**5.775**
	Residual (%)	**-38.889**	6.892	**62.602**
PDPC	Residual	-0.400	**-2.370**	**2.770**
	Residual (%)	-16.667	**-100.000**	**225.203**
QFD	Residual	-1.800	-2.690	**4.490**
	Residual (%)	-20.455	-30.955	**99.557**
Scatter Diagram	Residual	**-4.400**	0.680	**3.720**
	Residual (%)	**-68.750**	10.759	**113.415**
SPC	Residual	**-6.800**	3.310	3.490
	Residual (%)	**-77.273**	38.090	77.384
Stratification	Residual	-0.400	-3.320	**3.720**
	Residual (%)	-6.250	-52.532	**113.415**

According to the Column Proportions Z-Test, significant differences in proportions are highlighted in Table 5. In the case of companies with mass production, it can be concluded that the proportion of using Checksheets in this type of production is statistically more significant than the proportion of not using Checksheets.

A similar conclusion can be applied to the piece production. In this case, however, the proportion of not using Checksheets within piece production is statistically more significant. In non-marked cases, the Column Proportions Z-Test did not prove the statistical significance of the proportions.

Conclusion

The main objective is to identify the use of selected QMTs in industrial companies in the Czech Republic. The secondary objective is to examine the dependence of QMTs on industrial specialization and type of production. Based on the results, the study can summarize several conclusions with respect to research questions.

RQ1: It is clear that the extent of use of selected QMTs is different. It has been found that the most commonly used QMTs are Checksheets, Total Quality Management, and Pareto Chart. Unlike Ishikawa (1985), that has identified up to the seven QM tools: Cause and Effect diagram, Checksheet, Control chart, Histogram, Pareto chart, Scatter diagram and Stratification, which are widely used (Sokovic et al., 2009). Due to the extent of using TQM, it is surprising that none of the surveyed companies has indicated the use of EFQM. However, no statistical hypothesis has been defined for RQ1 and no statistical testing has been carried out. The answer is based on descriptive statistics.

RQ2: Assuming that EFQM is excluded from the set of selected QMTs, all the other selected QMTs are used in combination. The most common combinations of QMTs are found between Pareto Chart and the C&E Diagram (19 times), Pareto Chart and Checksheet (15 times), and Pareto Chart and Histogram (14 times). Similarly, according to Christensen, in companies it may be necessary to use multiple QM tools at once and combine them, or use a more complex QM technique (Christensen et al., 2013). There is no case of one QMT used only with just another one specific QMT. However, no statistical hypothesis has been defined for RQ2 and no statistical testing has been carried out. The answer to RQ2 is based on descriptive statistics.

RQ3: In some companies, QMTs such as TQM, Checksheet, Pareto Chart, Stratification, Tree Diagram, Histogram, QFD, and others, are used separately without the use of other QMTs. On the other hand, some companies use them separately and other companies use them in combination. We did not identify QMTs that would be used only on their own. Therefore, it can not be said that these QMTs are used only separately. Similarly, according to Christensen also eventually McQuater, in companies it may be necessary to use multiple QM tools at once and combine them (Christensen et al., 2013; McQuater et al., 1995). However, no statistical hypothesis has been defined for RQ3 and no statistical testing has been carried out. The answer to RQ3 is based on descriptive statistics.

RQ4: According to statistical tests of independence, it can be concluded that there is a statistically significant relationship between the use of C&E Diagram, Control Chart, Histogram, Matrix Data Analysis, Pareto Chart, PCA, SPC, Stratification, TQM, and industrial specializations. The use of these QMTs is dependent on the

industrial specialization in which company operates. In the case of other QMTs, no dependence on industrial specialization has been demonstrated and it can be concluded that these other QMTs are used across all areas of specialization. A similar finding brings also Prajogo (2005).
RQ5: According to statistical tests of independence, it can be concluded that there is a statistically significant relationship between the use of C&E Diagram, Checksheet, Control Chart, PDPC, QFD, Scatter Diagram, SPC, Stratification, and type of production. The use of these QMTs is dependent on the type of production. In the case of other QMTs, no dependence on the type of production has been demonstrated and it can be concluded that these other QMTs are used in all types of production.
Finally, the study recommends for industrial companies to apply selected QMTs in different industries of Czech Republic. By applying selected QMTs it can be achieved a higher performance of companies, high quality, and competitiveness. This research has been processed with the limitation in research sample of 200 companies. In further research, the authors will consider also using the other classification parameters for evaluation of QMTs use.

Acknowledgement

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.

References

Adams A.B.J., Dale B.G., 2001, *The use of quality management tools and techniques: A study in plastic injection moulding manufacturing*,"Proceedings of the Institution of Mechanical Engineers", 215(6).

Aguwa C.C., Monplaisir L., Turgut O., 2012, *Voice of the customer: Customer satisfaction ratio based analysis*,"Expert Systems with Applications", 39(11).

Ahmed S., Hassan M., 2003, *Survey and case investigations on application of quality management tools and techniques in SMIs*,"The International Journal of Quality & Reliability Management", 20(7).

Bamford D.R., Greatbanks R.W., 2005, *The use of quality management tools and techniques: A study of application in everyday situations*,"The International Journal of Quality & Reliability Management", 22(4).

Barad M., Raz T., 2000, *Contribution of quality management tools and practices to project management performance*,"The International Journal of Quality & Reliability Management", 17(4/5).

Bayazit O., 2003, *Total quality management (TQM) practices in Turkish manufacturing organizations*, "The TQM Magazine", 15(5).

Christensen C., Betz K.M., Stein M.S., 2013, *The certified quality process analyst handbook* (2nd ed.). Milwaukee, Wisconsin: ASQ Quality Press.

Chromjakova F., Rajnoha R., 2012, *Potentials of Information and Organizational Process Improvement Through Trained Office Staff,* "Journal of Competitiveness", 4(1).

Curry A., Kadasah N., 2002, *Focusing on key elements of TQM-evaluation for sustainability*, “The TQM Magazine”, 14(4).

Dahlgaard J.J., Chen C., Jang J., Banegas L.A., Dahlgaard-Park S.M., 2013, *Business excellence models: Limitations, reflections and further development*,“Total Quality Management & Business Excellence”, 24(5-6).

Dale B.G., 2003, *Managing quality* (4th ed.). Malden, Massachusetts: Wiley-Blackwell.

Dale B.G., Bamford D., van der Wiele T., 2016, *Managing quality: An essential guide and resource gateway* (6th ed.). Chichester, United Knigdom: Wiley.

Dale B.G., McQuater R., 1998, *Managing business improvement and quality: Implementing key tools and techniques*. Oxford, England: Wiley-Blackwell.

Dounias G., Tselentis G., Moustakis V.S., 2001, *Machine learning based feature extraction for quality control in a production line*, “Integrated Computer-Aided Engineering”, 8(4).

Evans J.R., Lindsay W.M., 2005, *The management and control of quality* (6th ed.). Mason, Ohio: Thomson.

Heras I., Marimon F., Casadesús M., 2011, *Impact of quality improvement tools on the performance of firms using different quality management systems*, “Innovar”, 21(42).

Herbert D., Curry A., Angel L., 2003, *Use of quality tools and techniques in services*, “The Service Industries Journal”, 23(4).

Imai M., 1986, *Kaizen: The key to Japan's competitive success*. New York, NY: McGraw-Hill.

Ishikawa K., 1985, *What is total quality control? The Japanese way*, Englewood Cliffs, NJ: Prentice-Hall.

Jones M.R., 2014, *Identifying critical factors that predict quality management program success: Data mining analysis of Baldrige award data*, “The Quality Management Journal”, 21(3).

Juran J.M., Gryna F.M., 1988, *Juran's quality control handbook* (4th ed.). New York, NY: McGraw-Hill.

Kahraman C., Yanik S., 2015, *Intelligent decision making in quality management: Theory and applications*. Heidelberg, Germany: Springer.

Kang B., Park S., 2000, *Integrated machine learning approaches for complementing statistical process control procedures*, “Decision Support Systems”, 29(1).

Kristianto Y., Ajmal M.M., Sandhu M., 2012, *Adopting TQM approach to achieve customer satisfaction*,“TQM Journal”, 24(1).

Lagrosen Y., Lagrosen S., 2005, *The effects of quality management – a survey of Swedish quality professionals*, “International Journal of Operations & Production Management”, 25(10), 940-952. DOI: 10.1108/01443570510619464

McQuater R.E., Scurr C.H., Dale B.G., Hillman P.G., 1995, Using quality tools and techniques successfully,“The TQM Magazine”, 7(6).

Mehra S., Rhee M., 2009, *On the application of quality management concepts in education: An example of a Korean classroom*,“The International Journal of Quality & Reliability Management”, 26(4).

Naumann E., Jackson Jr.D., 1999, *One more time: How do you satisfy customers?* “Business Horizons”, 42(3).

Ngo Vu M., Nguyen H.H., 2016, *The Relationship between Service Quality, Customer Satisfaction and Customer Loyalty: An Investigation in Vietnamese Retail Banking Sector*, “Journal of Competitiveness”, 8(2).

Prajogo D.I., 2005, *The comparative analysis of TQM practices and quality performance between manufacturing and service firms*,"International Journal of Service Industry Management", 16(3).

Pribeanu G., Toader C., 2016, *The success in business in the context of sustainable development*, "Agricultural Management / Lucrari Stiintifice Seria I, Management Agricol", 18(2).

Siva V., Gremyr I., Bergquist B., Garvare R., Zobel T., Isaksson R., 2016, *The support of quality management to sustainable development: A literature review*, "Journal of Cleaner Production", 138(2).

Sokovic M., Jovanovic J., Krivokapic Z., Vujovic A., 2009, *Basic quality tools in continuous improvement process*, "StrojniskiVestnik/Journal of Mechanical Engineering", 55(5).

Sousa S.D., Aspinwall E., Sampaio P.A., Guimaraes Rodrigues A., 2005, *Performance measures and quality tools in Portuguese small and medium enterprises: Survey results*, "Total Quality Management & Business Excellence", 16(2).

Starzynska B., 2014, *Practical applications of quality tools in Polish manufacturing companies*, "Organizacija", 47(3).

Sun H., Zhao Y., Yau H.K., 2009, *The relationship between quality management and the speed of new product development*,"The TQM Journal", 21(6).

Tari J.J., Sabater V., 2004, *Quality tools and techniques: Are they necessary for quality management?*,"International Journal of Production Economics", 92(3).

Terziovski M., Sohal A.S., 2000, *The adoption of continuous improvement and innovation strategies in Australian manufacturing firms*, "Technovation", 20(10).

Vrellas C.G., Tsiotras G., 2015, *Quality management in the global brewing industry*, "The International Journal of Quality & Reliability Management", 32(1).

EMPIRYCZNE STUDIUM PRAKTYK ZARZĄDZANIA JAKOŚCIĄ PRZEDSIĘBIORSTW PRZEMYSŁOWYCH W REPUBLICE CZESKIEJ

Streszczenie: Monitorowanie, zarządzanie i utrzymanie jakości mają kluczowe znaczenie dla konkurencyjności przedsiębiorstw. W celu zarządzania jakością można stosować różnorodne narzędzia i techniki zarządzania jakością. Głównym celem tego badania jest identyfikacja wykorzystania wybranych narzędzi i technik zarządzania jakością w przedsiębiorstwach przemysłowych w Republice Czeskiej. Niniejsze badanie podsumowuje wyniki ankiety internetowej (próbka badawcza 200 firm z branży). Stwierdzono, że najczęściej używanymi narzędziami i technikami zarządzania jakością są arkusze kontrolne, kompleksowe zarządzanie jakością i wykres Pareto. Kompleksowe zarządzanie jakością jest obecnie najczęściej używaną techniką zarządzania jakością. Wyniki badań dostarczają również informacji o wykorzystywanych narzędziach jakości. Badanie pokazuje, że podstawowe (klasyczne) narzędzia do zarządzania jakością są częściej wykorzystywane niż nowe. Stwierdzono związek między specjalizacjami przemysłowymi firm a używanymi narzędziami i technikami zarządzania jakością (wykorzystano test niezależności chi-kwadrat Pearsona i test niezależności G). Zidentyfikowano inne zależności między rodzajem produkcji a narzędziami i technikami zarządzania jakością.

Słowa kluczowe: zarządzanie, zarządzanie jakością, narzędzia i techniki zarządzania jakością, przemysł wytwórczy i przetwórczy, Republika Czeska.

捷克共和国工业企业经验质量管理实践研究

摘要：监控，管理和维持质量对企业的竞争力至关重要。为了管理质量，可以使用各种质量管理工具和技术。本研究的主要目标是确定捷克共和国工业公司使用选定的质量管理工具和技术。本研究总结了在线问卷调查的结果（200家行业公司的研究样本）。已经发现，最常用的质量管理工具和技术是检查表，全面质量管理和帕累托图表。全面质量管理是目前最常用的一次性质量管理技术。研究结果还提供了有关使用质量工具的信息。该调查显示，基本（经典）质量管理工具不仅仅是新的质量管理工具。公司的行业专业化与使用过的质量管理工具和技术之间的关系被发现（使用Pearson卡方独立检验和独立G检验）。生产类型与质量管理工具和技术之间已经确定了其他关系。

关键词：管理，质量管理，质量管理工具和技术，制造业和加工业，捷克共和国。