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Quality Culture of Manufacturing Enterprises: A Possible Way to Adaptation to Industry 4.0

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Abstract: The concept of Industry 4.0 means a new paradigm of modern manufacturing. This phenomenon requires continuous innovation processes and technological development from each enterprise. Traditional concepts of quality must absorb changes and prepare themselves for new challenges. The studies linked to successful adaptation to Industry 4.0 focus mostly on technical dimensions and forget the impact of organisational culture. One should, however, remember that quality culture plays a crucial role in the organisational culture of manufacturing enterprises with elements of quality management implemented. Developed quality cultures support the innovation environment, which is why it is necessary for the enterprises to identify the current level of their quality culture and detect significant factors that differentiate individual quality cultures and focus on them. Given this fact, the aim of the paper is to analyse the typical cultures and quality concepts and to detect the factors that differentiate individual quality cultures in Slovakia. We use data from our own survey; dependences were indicated by means of correspondence analysis and the test of proportion. The improvement and assurance of quality, the use of information and the overall effectiveness are significant factors detected by the discriminant analysis. The conclusions of the survey may be used by scientific researchers but especially by manufacturing enterprises interested in quality which are coming to terms with the era of Industry 4.0.

Keywords: Industry 4.0; quality culture; quality concepts; manufacturing enterprises

1. Introduction

Quality management is an evergreen research theme in the contemporary world (Gunasekaran et al. 2019) and quality itself has been a top subject for years (Ondra et al. 2018). The world is at the threshold of the fourth industrial revolution that has already begun. This is the fourth milestone which is fundamentally changing enterprises (Mohelska and Sokolova 2018). Within a modern enterprise, change is a constant process that can be managed and predicted (Sujova and Remen 2018). All sectors have to move toward Industry 4.0 (Hamid et al. 2018). Although quality management became popular in the 1980s and 1990s, 21st-century enterprises in the era of Industry 4.0 are still struggling with the concept (Gunasekaran et al. 2019). Industry 4.0 significantly changes products and production systems concerning design, processes, operations and services. Certainly, the implementation of this concept has further consequences for management and future jobs through the creation of new business models

(Moravcikova et al. 2017; Meyer 2018; Slusarczyk 2018) and in the cases when it is not appropriately managed, financial losses may occur (Meyer et al. 2017). Since the primary impact of Industry 4.0 is perceived in value-creating processes, and has so far had the greatest transformative effect in this area, the model can be considered to be appropriate (Nagy et al. 2018).

Industry 4.0 and its other synonyms such as Smart Manufacturing, Smart Production or the Internet of Things have been identified as major contributors in the context of the digital and automated manufacturing environment or projects aimed at the creation of zones of economic activity related to economic support and high level of economic efficiency (Pierzyna 2019). The term Industry 4.0 comprises a variety of technologies to enable the development of the value chain resulting in reduced manufacturing lead times, as well as improved product quality and organisational performance (Kamble et al. 2018). Dalenogare et al. (2018) consider Industry 4.0 a new industrial stage in which vertical and horizontal manufacturing process integration and product connectivity can help companies to achieve a higher level of industrial performance. Most studies discuss technical aspects, but do not pay attention to managerial approaches and organisational culture, which are a major factor influencing the success of this concept. It is especially interesting to find out whether, how and to what extent these knowledges are embedded into the business world and market (Domańska 2018). Implementing the Industry 4.0 concept requires continuous innovation and education that not only depend on people's abilities, but also on organisational culture (Mohelska and Sokolova 2018). Barney (1986) indicates that organisational culture was a source of sustained competitive advantage for enterprises almost 35 years ago, and Jancikova and Brychta (2009) also consider organisational culture a significant factor in ensuring competitive advantage, an argument which is still highly relevant nowadays. Positive organisational culture is an essential principle of a successful enterprise. Muras (2017) emphasises that modern enterprises are constantly searching for an optimal enterprise infrastructure and culture, as well as changing their managerial approach to pave the way for innovative culture; quality culture is that innovative culture. Wu et al. (2011) reiterate that quality culture plays a critical role in organisational culture and appropriate quality makes management programs more effective. Industry 4.0 can be recognised as a great opportunity for the development and improvement of competitiveness, although the state of preparations for its implementation varies widely depending on country, sector, or even an individual company (Slusarczyk 2018); developed quality culture can facilitate implementation of this concept. The key to success is to understand customer needs, and fulfill them with the highest quality, adapting at the same time to the expected changes in market demand (Kovács and Kot 2017).

Definitions by authors that have been interested in quality culture vary quite widely. Quality culture encompasses organisational practices, central values and philosophy and can be defined as the concentration of all people and resources in a never-ending quest for greater quality and service in every dimension of the organisation (Viljoen and van Waveren 2008). Quality culture is the pattern of habits, beliefs and behaviour concerning quality (Watson and Gryna 2001; Palus et al. 2014; Popescu 2018). The quality culture of an organisation is a subset of the organisation's overall culture. It reflects the general approach, the values, and the orientation to quality that permeate organisational actions (Cameron and Sine 1999). Leadership emphasis, message credibility, peer involvement, and employee ownership are attributes which predict the corporate culture focused on quality (Srinivasan and Kurey 2014).

Popescu et al. (2018a) declare that even if sophisticated technologies of Industry 4.0 have been embraced, productivity growth is still moderate. Georgescu et al. (2018) explain that adopting the overall quality system is a profound transformation involving changes at all levels of the enterprise, starting with the management system as a whole, continuing with the change in attitudes and behaviours among the employees of the enterprise. Goetsch and Davis (2013) consider the ultimate, anticipative result of endeavour in the quality culture, the environment of continuous improvement of quality in all areas of the enterprise. Fielden et al. (2018) mention that news stories that are rapidly shared through social media can generate important advertising returns. In our case, in the quality culture, news stories about continuous improvement of the quality shared through employees can generate the most important advertisement of the enterprise. Popescu et al. (2018b) point out that underperforming individuals confront a deep supervisory exigency, but Kuo and Tsai (2019) demonstrate—from the perspective of employees—that this innovative culture also has a positive effect on performance and underperformance and the supervisory exigency has disappeared. The positive influence on operational performance is confirmed by the empirical study of Gambi et al. (2015). The study by Hebbar and Mathew (2017) interprets the significance in harnessing the quality culture of the enterprise to enhance the overall quality of performance. Abakumova and Primierova (2018) and Ahmad et al. (2018) support the importance of the quality culture of the enterprise and its consequence of quality performance because, as a rule, households with a high level of earnings prefer high-quality and exclusive goods.

Numerous studies can be found which focus on bankruptcy prediction in Slovakia (Kovacova et al. 2018), Slovak research on identifying significant sources of enterprise goodwill (Kliestik et al. 2018a), or using controlling as a competitiveness tool on the Slovak market (Vagner 2016), but detection of the existence and the development of quality cultures in the context of Industry 4.0 is still lacking. It is necessary to examine these facts, as Kanovska (2018) notes that smart manufacturing is still developing and taking place in different forms. Krajcsak (2018) finds ISO standards and Total Quality Management (TQM) only appropriate organisational cultures, not quality culture; this is another scientific gap when it comes to determining a representative culture quality for traditional quality concepts. Those are sectoral standards, ISO standards and TQM philosophy (Konecny 2017). Classical quality-orientated managements change, learn and adapt to innovation brought about by Industry 4.0 (Bourke and Roper 2017).

Given the deliberations presented, the aim of this paper is to analyse the typical dependence between quality cultures and quality concepts and to detect the factors that differentiate individual quality cultures in Slovakia. Our paper is structured as follows. Firstly, we present the literature review, concentrating on analyses of different aspects associated with quality culture in contemporary enterprises. Secondly, we present the materials and methods that were applied in this research. The appropriately methods of mathematical statistics are used and described to fulfil the aim. These methods were run: Person chi-square test, Cramer's V and Pearson contingency coefficient, correspondence analysis, test of a proportion, Kaiser-Meyer-Olkin (KMO) measure of adequacy, Bartlett's test of sphericity, Varimax with Kaiser normalisation, Cronbach's alpha, the test of Box's M, Wilks' Lambda test, and discriminant analysis. The next part of our paper presents the research results and analyses the results in detail. We use data from our own survey. It was made purposive sample of 2909 "respondents", it must be manufacturing enterprises, which implementing at one quality management system. The enterprises were addressed electronically by emails and was required to fill the survey by quality managers, technical managers or supervisors. Based on provided data medium dependence between the quality concepts and the quality cultures is indicated, typical relations between individual quality concepts and individual quality cultures are characterised, and three significant factors (the improvement and assurance of quality, the use of information and the overall effectiveness) are detected that differentiate individual quality cultures in Slovakia. Finally, we present the conclusions and limitations of our study.

Literature Review

The topic of quality culture is a matter of interest for a number of scholars representing a variety of scientific institutions who have analysed it from different points of view. For example, Sinclair and Collins (1994) discuss the quality culture, whilst Dellana and Hauser (1999) went even further in carrying out a study defining the quality culture. Woods (1997) detects six values of quality culture and Harvey and Stensaker (2007) link understandings and the boundaries of the quality culture. Tari et al. (2018) highlight that the quality culture can motivate the enterprise to adopt quality standards (sectoral standard and ISO standards). Gaigne and Larue (2016) study the impact that minimum quality standards have on industry structure, trade, and welfare when firms can develop their own private standard which is of a higher quality than the public standard. Vanagas (2005) evaluates the role of quality culture in the implementation of total quality management in agricultural companies. Panuwatwanich and Nguyen (2017) deal with the evidence from the Vietnamese construction industry considering the influence of culture on the implementation of TQM philosophy. The tangibility of quality culture is described by Porter (1997). Campos et al. (2014) test total quality culture in the enterprises of two subsectors of the tourism industry and show that leadership is a critical success factor for total quality culture, mainly if the manager is directly involved in quality, behaves unambiguously, and leads and motivates cultural changes. In addition, Meyer and Meyer (2016) found that leadership also contributes to the creation of enabling business environment in general. Industry 4.0 implementation for multinationals was the goal of the work of Telukdarie et al. (2018). Previous research into diagnosing and changing culture was undertaken by Handfield and Ghosh (1994); Cameron and Barnett (2000); Lo (2002); Cao et al. (2005); Kull and Wacker (2010); Baird et al. (2011). Changing and learning in enterprises oriented to quality in the era of Industry 4.0 is highlighted in the study by Bourke and Roper (2017). Iqbal and Asrar-ul-Haq (2018) examine the relationship between TQM practices and employee performance in the dynamic technological sector in Pakistan. Amin et al. (2017) show that TQM constructs have significant relationships to employee satisfaction. A new TQM model in the environment of innovation is delivered by Shan et al. (2018a, 2018b). The relationship between TQM and quality culture has been examined by Hildebrandt (1991); Hauser and Dellana (1998); Kujala and Lillrank (2004); Prajogo and McDermott (2005); Wu et al. (2009); Gimenez-Espin et al. (2013); Todorut and Bojnica (2013); and Pakurár et al. (2019). Hebbar and Mathew (2017) identify the critical TQM practices or factors and the impact of the quality culture on these practices and quality of performance in automotive enterprises in India. The results obtained support the significant positive relationship between quality culture and all critical factors. TQM practices have a positively significant relationship to quality culture, which plays a major role in boosting the quality of performance in the enterprise (Androniceanu 2017). Another study from India carried out by Patyal and Koilakuntla (2017) explores the relationship between quality management and performance, specifically how the infrastructure and core quality management practices affect quality and business performance.

Garvin (1988) points out that quality cultures have developed over time in enterprises. He labels four major quality cultures: inspection culture, statistical control culture, quality assurance culture and strategic quality management culture. Cole (1999) identifies two main quality cultures that typify manufacturing enterprises: a new quality paradigm and an old quality paradigm. Cameron and Sine (1999) and Cameron and Quinn (1999) made a comprehensive classification of quality culture (QC) and divided QC into levels depending on their development: the absence of emphasis on quality (QC1), error detection culture (QC2), error prevention culture (QC3) and creative quality culture (QC4). Based on this proposed classification, Gimenez-Espin et al. (2013) introduce an alternative type of culture: the mixed culture or culture for quality, which can be between adhocratic and clan cultures. It can have a double orientation—external and internal—and can promote flexibility. The culture of operational excellence through Industry 4.0 is monitored by Quezada et al. (2017). Shan et al. (2018a, 2018b) develop a model of a prominent paradigm to improve manufacturing performance in order to gain further competitive advantage.

Empirical evidence of the impact of quality culture on quality or operational performance was provided by Adam et al. (1994) in Korea, New Zealand and the USA, Kanji and Wong (1998) in the construction industry, Ogbonna and Harris (2000) in UK enterprises, Barrett and Waddell (2001a, 2001b) in Australia, and Corbett and Rastrick (2000) in New Zealand. Watson and Gryna (2001) analyse the quality culture in small businesses. Wu (2015) empirically assesses the path from quality culture to infrastructure practices, core practices, and finally to quality performance using data collected from Chinese manufacturing enterprises in a structural equitation model. The results indicate a chain effect that quality culture serves as an antecedent of infrastructure practices to take effect and infrastructure practices providing a supporting foundation for core practices to generate a positive impact on quality performance. Ilies et al. (2015), based on evidence from metal construction industry organisations from northwestern Romania, develop regression models explaining and making predictions about the variation of variables which synthesise the quality culture. Another study from the Romanian metal construction industry, undertaken by Ilies et al. (2017), obtains a surprising result concerning the leadership style favourable to the development of the quality culture. The managers from the organisations analysed, who have an authoritarian leadership style, favour the development of the quality culture more than managers who adopt a democratic style. It is worth to add that a part of the organisational culture is also the intergenerational collaboration of employees. As the majority of developed countries faces changing transition towards older population structure, it has to be reflected also in organisations and the organisational culture (Kubíčková et al. 2018).

Cronemyr et al. (2017) indicate the need for a tool that measures not only the quality values but also behaviour that supports or obstructs the quality culture. They suggest how a measuring tool which measures quality culture can be designed and structured in Swedish conditions. Ko and Stein (2018) propose two methodologies to catalyse and sustain continuous improvement within an enterprise to adopt a positive quality culture. Key factors of manufacturing enterprise development in the context of Industry 4.0 in Russia are assessed by Tolstykh et al. (2018).

A systematic literature review identifying the current trends and future perspectives of Industry 4.0 is undertaken by Kamble et al. (2018). Ghobakhloo (2018) provides a strategic roadmap for the future of the manufacturing industry toward Industry 4.0. Gunasekaran et al. (2019) present a research pathway towards Industry 4.0 for quality management in 21st-century enterprises. Mohelska and Sokolova describe management approaches for Industry 4.0 from an organisational culture perspective in the Czech Republic. Sujova and Remen (2018) evaluate the management of changes in business processes affected by Industry 4.0 in Slovak conditions. A review of service-oriented manufacturing paradigms is carried out by Siderska and Jadaan (2018). Luthra and Mangla (2018) as well as Ohanyan and Androniceanu (2017) comprehensively evaluate the challenges of Industry 4.0 in emerging economies. Oliff and Liu (2017) integrate methods of Industry 4.0 with emerging paradigms of existing manufacturing processes to quality improvement. The use of ISO standards in Big Data analytics cloud services is analysed by Roy et al. (2017). Slusarczyk (2018) inspects the attitudes to and preparation of entrepreneurs for Industry 4.0. The expected contribution of Industry 4.0 technologies for industrial performance is discussed by Dalenogare et al. (2018).

2. Materials and Methods

A detailed analysis of the literature allows us to formulate the following hypotheses:

Hypothesis 1. *A significant dependence exists between quality culture and quality concept.*

Hypothesis 2. *Error detection culture is implemented in more than 50% of enterprises with sectoral standards.*

Hypothesis 3. *Error prevention culture is implemented in more than 50% of enterprises with ISO standards.*

Hypothesis 4. *Creative quality culture is implemented in more than 50% of enterprises with TQM.*

Hypothesis 5. *A significant discriminant function exists in differentiating quality cultures.*

All details regarding the materials and methodology are as follows:

1. The information (primary source) used in this article was gained from the survey undertaken by the authors. The content and the trend of the questions were taken from the American research carried out by Cameron and Sine (1999) and modified to Slovak conditions because of the subsequent possibility of comparing the results. The survey was carried out in 2018 to detect the level of the development of a quality culture in Slovak manufacturing enterprises. The decision was made to provide non-probability sampling (purposive sampling). Two required conditions must be met by

the enterprises: it had to be a manufacturing enterprise and at least one of the quality management systems had to be implemented in the enterprise.

2. After determining the attributes of the purposive sampling of the enterprises, the sample size is determined, meaning the number of responses from each quality culture. The decision was made to connect two recommendations. Saunders et al. (2012) state in their book that sample size determination is specific for each case and must reflect a number of factors. They specify minimum sample sizes for different study characters, specifically 12 to 30 responses for heterogeneous samples. Singh and Masuku (2014), quoting Sudman (1976), suggest that each minor group of the sample should necessarily contain 20 to 50 elements.

3. There is no database in Slovakia that would meet the conditions demanded; because of this, the researchers compiled their own database based on data from the Slovak Society for Quality, the Slovak Office of Standards, Metrology and Testing, participants of the National Quality Award of the SR, the Slovak National Accreditation Service and Certification companies. The final database created by authors consists of 2909 enterprises. 2909 questionnaires were sent electronically, and the number of correctly recorded responses in the given time was 126, representing the completion of approximately every 23rd questionnaire and a return rate of 4.33%.

4. The survey determined the level of the development of quality culture and implemented the quality concept. Cross-tabulation of quality culture and quality concept was undertaken to identify the possibility of the use of the Person chi-square test and to test the dependence between nominal variables. The assumption of 20% of cells having less than five expected (theoretical) observations is satisfied. The strength of dependence and its statistical significance were tested by Cramer's V and Pearson contingency coefficient according to Rezankova (2017).

5. Subsequently, the authors undertook the correspondence analysis with an overview and correspondence map of row points, an overview and correspondence map of column points, and a correspondence map of row and column points as well, in order to detect the relationship between categories of quality culture and the quality concept. Correspondence analysis is a method used to detect groups of similar categories. Its main advantage is the ability to analyse the relationship between the categories of two variables at the same time (Rezankova 2017). Correspondence analysis examines the internal structure by means of correspondence maps showing variable categories in a reduced two-dimensional coordinate system. Kral et al. (2009) discuss the fact that row and column points can be considered as coordinates of the point in r(s)—dimensional space, and from the viewpoint of the practical application, their visual representation uses two-dimensional correspondence maps.

6. The hypothesis is determined to identify the relations between categories of variables. To test the hypothesis, a test of a proportion is used, where test statistics *T* (Equation (2)) to the critical value of standard normal distribution are compared. There are two approaches to verify the range of the test (due to the approximation of the normal distribution) and none of them has a significant preference. Thus, the validity of both approaches is verified (Equations (3) and (4)).

$$\mathrm{T} = \frac{\frac{\mathrm{m}}{\mathrm{n}} - \pi 0}{\sqrt{\frac{\pi 0(1 - \pi 0)}{\mathrm{n}}}} \quad (1)$$

$$\mathrm{n}\pi 0(1 - \pi 0) > 5 \quad (2)$$

$$\mathrm{n}\pi 0 \geq 5 \text{ and } (1 - \pi 0) \geq 5 \quad (3)$$

7. The survey contained 97 questions measured by a 6-point Likert scale, where point 1 corresponds to 'strongly disagree' and 6 'strongly agree'. Questions were labelled from Q18 to Q114. All questions have the same positive coding. The set of questions is reduced to 8 heterogeneous components (factors, variables) by factor analysis, and it assessed percentages of total variance explained not the criterion of convergence of eigenvalue to the value 1. The adequacy of the use of factor analysis is checked by the KMO measure and Bartlett's test of sphericity. The extraction method is a principal component analysis,

the rotation method is Varimax with Kaiser normalisation and rotation converged in 10 iterations. The reliability of the factors is tested by Cronbach's alpha. The values of internal consistence of factors are made both with and without outliers and for divided parts of the sample, by the Pareto principle (80:20).

8. The use of canonical discriminant analysis is conditional on fulfilling some assumptions. It is necessary to check assumptions concerning independent variables (created by factor analysis) and the dependent variable (detected quality culture). All observations are assumed to be independent and have identical distribution (Sadaf et al. 2018). Factor analysis prevents the occurrence of multicollinearity between dependent variables. The assumption of the multivariate normal distribution is not met, but the discriminant analysis is quite robust in order to break this assumption. The outliers, identified by box-plots, have to be removed. The equality of covariance matrices of individual groups retained in the test of Box's M and the equality among groups of the independent variables is rejected by Wilks' Lambda test.

9. The sample is divided 80%/20%; data is stratified and divided according to the individual group based on Kral et al. (2009). The larger part of the sample is used to construct the model, and the smaller part to validate the model. A significant canonical discriminant function was created in the discriminant analysis; this function was run by means of the stepwise method in three steps. The stepwise method of the discriminant analysis was applied to find the linear combination of those variables that best discriminate the groups of cases (Kliestik et al. 2018b). Three significant factors were identified; the value of intercept and the equation of the model were also written.

10. The final model (Z-score) differentiates individual quality cultures in Slovak manufacturing enterprises; the selection of the enterprise to individual quality culture is based on a comparison of counted scores to centroids.

11. The validation of the model formed was carried out on the origin sample, from which the model was created, cross-validation and test sample.

IBM SPSS Statistics v. 25 software was used, rented from Kivuto Solutions Inc., Naas, Co. Kildare, Ireland.

3. Results

This section involves all results concerning the quality culture of manufacturing enterprises in Slovak conditions.

3.1. Quality Culture and Quality Concept

In this subsection, we test the dependence between quality culture and quality concept, detect the intensity of the dependence, and identify the typical quality culture for each quality concept.

3.1.1. The Dependence of Quality Culture and Quality Concept

Firstly, we created the cross-tabulation Table 1 of the quality cultures and the quality concepts. Observed counts determined from the survey are contained therein. To test the dependence of the variables by Pearson chi-square, it is necessary to check the condition of theoretical (expected) counts. 80% of the cells have to have an expected count higher than 5. In our case, it is 83.33% of the cells. This fact is confirmed by Table A1 in the Appendix A.

Testing of Hypothesis 1. We test the hypothesis of dependence between the quality culture and the quality concept at the significance level of 0.05, which is compared to the significance (p-value). Based on data from Table 2, we reject the hypothesis of the independence of the variables analysed and accept the significant dependence of the quality culture and the quality concept.

The Pearson chi-square test confirms the dependence between these nominal variables. Based on data from the Mantel–Haenszel test shown in Table 3, we repeatedly confirm the dependence. It would be useful to observe the problem of this dependence after excluding QC1 (absence of the emphasis on quality).

Table 1. Cross-tabulation of quality culture and quality concept (observed counts).

Quality Concept	Quality Culture				Total
	Quality Culture 1 (Absence of Emphasis on Quality)	Quality Culture 2 (Error Detection Culture)	Quality Culture 3 (Error Prevention Culture)	Quality Culture 4 (Creative Quality Culture)	
Sectoral Standards	2	17	3	0	22
ISO standards	13	9	48	11	81
Total Quality Management	0	3	2	18	23
Total	15	29	53	29	126

Table 2. Pearson chi-square test.

Pearson Chi-Square	df	Number of Valid Cases	Significance
92.878	6	126	0.000

Table 3. Mantel–Haenszel test.

Mantel-Haenszel Test	df	Number of Valid Cases	Significance
30.219	6	126	0.000

We identified the significant dependence of the nominal variables. Rezankova (2017) recommends indicating the intensity of the dependence by means of Cramer's V and Pearson contingency coefficient according to this scale:

0.0 < the value of the coefficients ≤ 0.3	weak dependence
0.3 < the value of the coefficients ≤ 0.8	medium dependence
0.8 < the value of the coefficients ≤ 1.0	strong dependence

The values of Cramer's V and Pearson contingency coefficient determine a medium level of dependence between the quality cultures and the quality concepts. The significance of the coefficients should be below the determined significance level. Based on the comparison of the significance from Table 4 to the significance level of 0.05, we assess that both of the contingency coefficients are statistically significant.

Table 4. Cramer's V and Pearson contingency coefficient.

Nominal by Nominal	Value	Number of Valid Cases	Significance
Cramer's V	0.607	126	0.000
Pearson contingency coefficient	0.651	126	0.000

3.1.2. The Detection of Typical Quality Culture for Quality Concept

We detected the dependence between variables and, following analysis, focus on searching for internal dependence between the categories of the quality culture and the quality concept. Kral et al. (2009) state that, if dependence between the qualitative (nominal or ordinal) factors is confirmed, it is worth carrying out the correspondence analysis.

The first outputs of the correspondence analysis are the row and the column points which are found in Tables 5 and 6. The column labelled Total in the point tables indicates the contribution of the row (column) points in total inertia. The inertia represents the degree of the quality with which the points of the multidimensional space have been transformed into the correspondence map. In both cases, the individual contributions were assigned the value 1, which reflects the fact that the two-dimensional map correctly corresponds to the analysed categories.

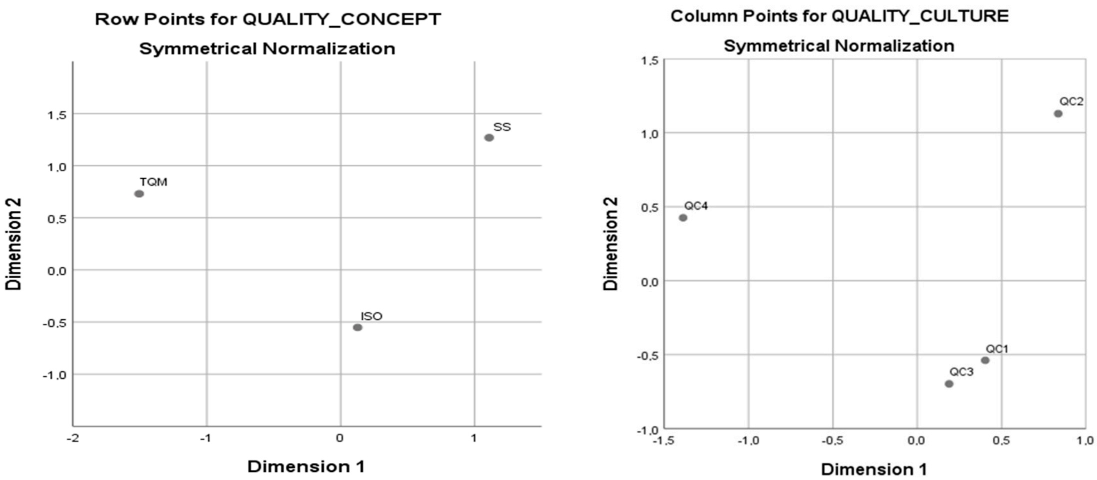
Table 5. Overview of row points.

Quality Concept	Mass	Score in Dimension		Inertia	Contribution				
					of Point to Inertia of Dimension		of Dimension to Inertia of Point		
		1	2		1	2	1	2	Total
SS	0.175	1.109	1.268	0.298	0.336	0.489	0.459	0.541	1.000
ISO	0.643	0.126	−0.552	0.119	0.016	0.341	0.055	0.945	1.000
TQM	0.183	−1.505	0.730	0.320	0.648	0.170	0.825	0.175	1.000
Active total	1.000			0.737	1.000	1.000			

Table 6. Overview of column points.

Quality Culture	Mass	Score in Dimension		Inertia	Contribution				
					of Point to Inertia of Dimension		of Dimension to Inertia of Point		
		1	2		1	2	1	2	Total
QC1	0.119	0.403	−0.539	0.032	0.030	0.060	0.384	0.616	1.000
QC2	0.230	0.835	1.129	0.271	0.251	0.511	0.379	0.621	1.000
QC3	0.421	0.189	−0.698	0.127	0.023	0.357	0.075	0.925	1.000
QC4	0.230	−1.388	0.425	0.307	0.695	0.072	0.922	0.078	1.000
Active total	1.000			0.737	1.000	1.000			

In Figure 1 the categories of the quality culture and the quality concept transformed into two-dimensional correspondence maps are shown.



(**a**) (**b**)

Figure 1. Correspondence maps of quality concepts (row points) and quality culture (column points). (**a**) Correspondence map of row points (**b**) Correspondence map of column points.

We derived the relationship between the categories of analysed variables based on a common correspondence map of row and column points (Figure 2). The enterprises which have implemented sectoral standards prefer the approach of QC2, while the enterprises managed by ISO standards prefer the approach of QC3. The enterprises that follow the TQM philosophy prefer the approach of QC4. However, we must not forget the fact, emphasised by Kral et al. (2009), that the correspondence analysis is only a descriptive method, and does not provide an apparatus for verifying the conclusions. For this reason, we have decided to verify the indicated dependencies by testing a portion. The result of the test of the portion did not serve to confirm the random occurrence, but rather marked the systematic phenomenon of Slovak manufacturing enterprises having implemented at least one of the quality management systems.

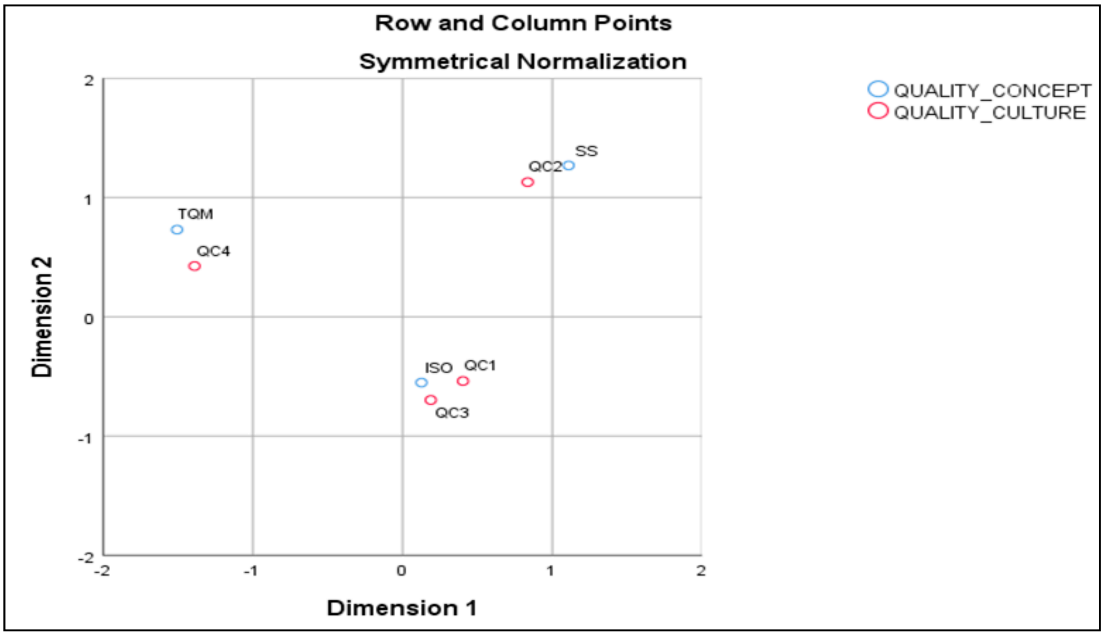


Figure 2. Common correspondence map of the quality concepts and the quality culture.

Testing of Hypothesis 2. Based on the data shown in Table 7, we accept the hypothesis that error detection culture is implemented in more than 50% of enterprises with sectoral standards.

Table 7. The enterprises with sectoral standards implemented.

The Enterprises with Sectoral Standards Implemented	
Null hypothesis (H_0):	$\pi0 = 0.5$; QC2 is implemented in 50% of enterprises with SS.
Alternative hypothesis (H_1):	$\pi0 = 0.5$; QC2 is implemented in more than 50% of enterprises with SS.
Level of significance (α) =	0.05
Distribution of the sample can be approximated by a normal distribution:	Yes, both conditions are met.
Test statistic (T) =	2.5584
Critical value of standard normal distribution ($Z_{2\alpha}$) =	1.6449
Comparison T to $Z_{2\alpha}$ value:	$\|2.5584\| > 1.6449$
Decision:	H0 rejected and H1 accepted, QC2 is implemented in more than 50% of enterprises with SS.[1]

Testing of Hypothesis 3. Based on the data shown in Table 8, we accept the hypothesis that error prevention culture is implemented in more than 50% of enterprises with ISO standards.

[1] *p*-value = 0.00526 for 60.10% of the enterprises with sectoral standards.

Table 8. The enterprises with ISO standards implemented.

The Enterprises with ISO Standards Implemented	
Null hypothesis (H_0):	π0 = 0.5; QC3 are implemented in 50% of enterprises with ISO standards.
Alternative hypothesis (H_1):	π0 = 0.5; QC3 is implemented in more than 50% of enterprises with ISO.
Level of significance (α) =	0.05
Distribution of the sample can be approximated by a normal distribution:	Yes, both conditions are met.
Test statistic (T) =	1.6667
Critical value of standard normal distribution ($Z_{2\alpha}$) =	1.6449
Comparison T to $Z_{2\alpha}$ value:	|1.6667| > 1.6449
Decision:	H0 rejected and H1 accepted, QC3 is implemented in more than 50% of enterprises with ISO standard.[2]

Testing of Hypothesis 4. Based on the data shown in Table 9, we accept the hypothesis that creative quality culture is implemented in more than 50% of enterprises with TQM.

Table 9. The enterprises with TQM philosophy implemented.

The Enterprises with TQM Philosophy Implemented	
Null hypothesis (H_0):	π0 = 0.5; QC4 is implemented in 50% of enterprises with TQM.
Alternative hypothesis (H_1):	π0 = 0.5; QC4 is implemented in more than 50% of enterprises with TQM.
Level of significance (α) =	0.05
Distribution of the sample can be approximated by a normal distribution:	Yes, both conditions are met.
Test statistic (T) =	2.7107
Critical value of standard normal distribution ($Z_{2\alpha}$) =	1.6449
Comparison T to $Z_{2\alpha}$ value:	|2.7107| > 1.6449
Decision:	H0 rejected and H1 accepted, QC4 is implemented in more than 50% of enterprises with TQM.[3]

Durana (2018) detected that the most preferable quality concept in Slovak manufacturing enterprises is ISO standards. We indicate that the characteristic quality culture for this quality management system is error prevention culture, which is why this type of development is the most commonly used quality culture among Slovak manufacturing companies.

3.2. Model of Quality Culture

Before running the discriminant analysis and forming the model of quality culture, it is necessary to identify input variables (factors) by factor analysis, check the reliability of created factors, divide the sample of the enterprises and test all required assumptions concerning discriminant analysis.

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[2] *p*-value = 0.04779 for 50.12% of the enterprises with ISO standards.
[3] *p*-value = 0.00335 for 61.58% of the enterprises with TQM.

3.2.1. Factor Analysis

The answers obtained by means of the survey were ordinal variables. Rimarcik (2007) recommends that social sciences take advantage of the possibility of using the methods of interval variables for analysing ordinal variables, if two assumptions are met. Namely, that there are at least five categories, a 6-point Likert scale is used, and at the same time there is no reason to predict significant differences in the distance between individual categories. We consider the answers of the statistical units as the interval input variable.

Before undertaking the factor analysis, it is necessary to calculate sampling adequacy. Factor analysis requires the correlation of original input variables (Kral et al. 2009). It is possible to use the KMO criterion to evaluate the dependence of the input variables. As shown in Table 9, a KMO value between 0.8 and 1 indicates the sampling is adequate, concretely, if the value is in the spread 0.80 to 0.89, adequacy is meritorious (Kaiser and Rice 1974). The correlation matrix is an identity matrix, which would indicate that variables are unrelated, which is the null hypothesis of Bartlett's test of sphericity. We reject the null hypothesis and accept an alternative hypothesis; the correlation matrix is not an identity matrix based on a comparison of the significance level 0.05 and significance in Table 10. The variables are related, and factor analysis is highly useful.

Table 10. Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test.

KMO Measure of Sampling Adequacy		**0.856**
Bartlett's test of sphericity	Approx. chi-square	13,927.553
	df	4656
	Significance	0.000

The number of factors was chosen according to total variance explained. Kral et al. (2009) write that in social science it is necessary to have 60% to 70% of total variance explained. Eight components that explained 66.034% of variability were determined, as shown in Table 11. Ideally, for interpreting any indicator should show saturation with just one factor. In practical situations, one indicator has high factor saturation with several factors. It is rotated and tried again repeatedly to ensure that each indicator has high saturation in one factor (Kral et al. 2009). In Table A2 in Appendix A is a rotated component matrix with all components made and all coefficients of used questions sorted by size. We named the factors according to the contents of the questions involved (Table 11) and used them as input variables in a discriminant analysis.

Table 11. Total variance explained.

Component	**Initial Eigenvalues**			**Content**
	Total	**% of Variance**	**Cumulative %**	
1	42.915	44.242	44.242	Improvement and assurance of quality
2	6.252	6.446	50.688	Assessment, rewarding and training of employees
3	3.503	3.611	54.299	Use of information
4	3.001	3.094	57.393	Satisfaction of customers and employees
5	2.447	2.523	59.916	Collection of information
6	2.259	2.329	62.245	Benchmarking
7	1.936	1.996	64.241	Overall effectiveness
8	1.739	1.793	66.034	Priorities of management

Rimarcik (2007) emphasises that answers to the individual questions do not have the same importance as the overall score of the factors. Furthermore, Rimarcik (2007) describes Cronbach's alpha as a possible method for determining the reliability of the method used. Cronbach's alpha is an index of internal consistency of the factor and can take values from 0 to 1. If the value converges to 1, it is a sign of a very high internal correlation between the items, and indicates that items are based on the same principle. Rimarcik (2007) states that a Cronbach's alpha value of at least 0.8 is required. The values of Cronbach's alpha are shown in Table 12. It is necessary to add that we gain values of Cronbach's alpha for four samples: the sample with outliers, the sample after elimination of the outliers and divided samples. The sample without outliers was stratified and divided. Detailed information about the stratification is demonstrated in Table A3 in Appendix A. We note that the high value of Cronbach's alpha means that the questions were appropriately linked to the factors and the factor creates a basis for the very reliable results of analyses which followed. We have not used a factor score, but the average of the questions. In further research the factor score could be used and the results can be compared if some differences occur.

Table 12. Cronbach's alpha.

Variable	Number of Items	Cronbach's Alpha			
		With Outliers	Without Outliers	80% of the Sample	20% of the Sample
Variable 1	22	0.966	0.967	0.965	0.977
Variable 2	18	0.959	0.959	0.960	0.962
Variable 3	13	0.913	0.912	0.869	0.897
Variable 4	17	0.947	0.949	0.952	0.941
Variable 5	8	0.905	0.905	0.924	0.886
Variable 6	9	0.922	0.920	0.917	0.899
Variable 7	6	0.876	0.881	0.898	0.812
Variable 8	4	0.898	0.900	0.882	0.839

3.2.2. Testing of Assumptions

First of all, it is important to ensure that the assumptions concerning independent variables and the dependent variable are met. Kral et al. (2009) states that we have a file, and the units in it are divided into N disjoint groups. In our case, we have N equal to 4. Furthermore, Kral et al. (2009) claim that the number of input variables must be at least two smaller than the number of statistical units. In our case, we have eight explanatory variables and 92 statistical units. It is recommended that 20 statistical units are applied to each variable, if it is difficult to follow, the recommendations say at least five units per variable. The final condition is that each group must necessarily be larger than the number of input variables, which is the case for each quality group.

The hypothesis of the equality covariance matrices was tested. Based on data from the Box's M test in Table 13, the significance is above the significance level of 0.05; we retain the hypothesis that covariance matrices of individual groups of the quality culture are equal.

Table 13. Box's M test.

Box's M		12.999
F	Approx.	1.183
	df1	9
	df2	320.184
	Significance	0.305

We tested the hypothesis of the equality of means among groups of the dependent variable at a significance level of 0.05. All values from the significance column should be below the determined significance level and thus may be used as relevant input variable in discriminant analysis. Comparing significance (Table 14) to the significance level; we reject the hypothesis of equality and accept the hypothesis that the means among the groups of the quality culture are not equal for all independent variables.

Table 14. Wilks' Lambda.

Variable	Wilks' Lambda	F	df1	df2	Significance
Variable 1	0.234	100.132	3	92	0.000
Variable 2	0.326	63.320	3	92	0.000
Variable 3	0.328	62.945	3	92	0.000
Variable 4	0.425	41.458	3	92	0.000
Variable 5	0.517	28.667	3	92	0.000
Variable 6	0.366	53.174	3	92	0.000
Variable 7	0.573	22.877	3	92	0.000
Variable 8	0.627	18.269	3	92	0.000

3.2.3. Discriminant Analysis

Testing of Hypothesis 5. We test the hypothesis of the existence of a significant discriminant function differentiating quality cultures at the significance level of 0.05, which is compared to the Sig. (Significance). Based on data in Table 15, we accept the hypothesis that a significant discriminant function differentiating quality cultures exists. The stepwise method of discriminant analysis running in three steps detected three significant variables from among the eight variables entered. The value of canonical correlation is very high and the value of percentages of explained variance is as well. These attributes mark that functions sufficiently and strongly differentiate individual quality cultures from each other. Table 16 shows significant variables that have not been removed from the function: the improvement and assurance of quality, the use of information and overall effectiveness. □

Table 15. Canonical correlation and the significance of discriminant function.

Eigenvalue	Canonical Correlation	% of Variance	Wilks' Lambda	Chi-Square	df	Significance
5.124	0.915	90.3	0.100	210.296	9	0.000

Table 16. The unstandardised coefficients and correlations.

Variable	Coefficient	Correlation	Content
Variable 1	1.439	0.784	Improvement and assurance of quality
Variable 3	1.007	0.600	Use of information
Variable 7	0.442	0.326	Overall effectiveness
Constant	−11.628	-	-

The improvement and assurance of quality has the highest value of correlation (correlation coefficient) as shown in Table 15, which means this factor has the highest classification ability from all significant variables.

The final notation of the model of the classification of the quality culture in the conditions of Slovak manufacturing enterprises is:

$$\begin{aligned} \text{Z-score} = -11.628 + 1.439 \text{ Improvement and assurance of quality} \\ +1.007 \text{ Use of information} + 0.442 \text{ Overall effectiveness} \end{aligned} \tag{4}$$

The classification of the enterprises to the individual quality culture is made based on the comparison of the achieved Z-score and the value of the centroid. The centroids symbolise the characteristic points that represent the position of each quality culture of the enterprise within the identified classification function. The representative values of centroids for individual quality culture are shown in Table 17.

Table 17. The centroids of quality cultures.

Quality Culture	Centroid
Quality Culture 1 (absence of emphasis on quality)	−2.717
Quality Culture 2 (error detection culture)	−1.965
Quality Culture 3 (error prevention culture)	0.074
Quality Culture 4 (creative quality culture)	3.932

To verify the classification ability of the model formed, we use Equation (4) to predict the classification of the test group of the enterprises (20% of the sample) compared to individual quality culture as identified from the survey. The total classification ability of the model is 80%.

IBM SPSS software has implemented the function of the validation of the original group (80% of the sample) and cross-validation. 85.4% of original grouped cases are correctly classified and 83.3% are cross-validated. All classification results are demonstrated in Table 18.

Table 18. Classification results.

Quality Culture			Predicted Group Membership				Total
			QC1	QC2	QC3	QC4	
Original group (80% of the sample)	Count	QC1	9	3	0	0	12
		QC2	1	20	2	0	23
		QC3	0	6	34	2	42
		QC4	0	0	0	19	19
	%	QC1	75.0	25.0	0.0	0.0	100.0
		QC2	4.3	87.0	8.7	0.0	100.0
		QC3	0.0	14.3	81.0	4.8	100.0
		QC4	0.0	0.0	0.0	100.0	100.0
Cross-validated	Count	QC1	9	3	0	0	12
		QC2	2	19	2	0	23
		QC3	0	7	33	2	42
		QC4	0	0	0	19	19
	%	QC1	75.0	25.0	0.0	0.0	100.0
		QC2	8.7	82.6	8.7	0.0	100.0
		QC3	0.0	16.7	78.6	4.8	100.0
		QC4	0.0	0.0	0.0	100.0	100.0
20% of the sample	Count	QC1	3	0	0	0	3
		QC2	1	4	1	0	6
		QC3	0	0	9	2	11
		QC4	0	0	1	4	5
	%	QC1	100.0	0.0	0.0	0.0	100.0
		QC2	16.7	66.7	16.7	0.0	100.0
		QC3	0.0	0.0	81.8	18.2	100.0
		QC4	0.0	0.0	20.0	80.0	100.0

In our case, the discriminant analysis generated three significant discriminators: the improvement and assurance of quality, the use of information and the overall effectiveness.

4. Discussion

Firstly, we compare our results to previous research undertaken by Cameron and Sine (1999) and Jancikova (2008) because the same questions were used in the survey. The levels of the quality culture are differentiated by the approach to the use of the information about the expectations and the satisfaction of the customer, the quality of the product and the production quality, the cost items, the reasons for success or its shortcomings. This content is captured as the use of information and proved to be significant in both Slovak and American research (Table 19). More developed quality cultures focus on quality as a strategic advantage, engaging employees and giving them greater powers. Quality teams are founded, and enterprises focus on improvement and the assurance of quality. They come with quality-improving reports, and stories of the improvement are shared within the enterprise. Quality has its own plans, management and goals. This description of these activities is involved in a variable called improvement and the assurance of quality. It is a statistically significant factor in all analysed research. The last significant factor in our discriminant function is the overall effectiveness of the enterprise, which is identical to the content of the excellence used in Czech research (Table 19). This factor is characterised by its orientation to high quality, which gains a new definition. Organisational culture and the strategy of the enterprise are no longer separate. The preferences of the customers are created through the provision of the services beyond their expectations. New loyalty of the employees is thereby created. The work of the employees is consistent, production is characterised by minimal repairs and reworking of the products, and work absenteeism is also minimal. There is a high degree of teamwork within the department as well as in cooperation between the departments. As indicated by the label and the content of the variable in Czech research, this factor is aimed at achieving excellence and world-class quality. Comparing the significant discriminant variables, we have two common variables in the case of the identified American function as well as in the case of the determined Czech function. Slovak enterprises should pay attention to the significant factors detected to ease their effort to absorb and adopt the principles of Industry 4.0.

Table 19. Comparison of significant variables.

American Research	Czech Research	Slovak Research
Information use	Improvement of quality	Improvement and assurance of quality
Information and analysis	Excellence	Use of information
Customer satisfaction	Training of employees and quality management objectives	Overall effectiveness
Quality assurance	Attitudes and work morale	-
Quality tools	-	-

All three functions have the same position of the centroids for the individual quality culture. Comparing our research and that of Cameron and Sine (1999) and Jancikova (2008), there is a clear intersection in Table 20. The centroid positions of the two less developed quality cultures are found in the negative part, while the opposite position of the centroids of the two more advanced cultures are oriented in the positive part.

Table 20. Comparison of centroids.

Quality Culture	American Research	Czech Research	Slovak Research
Quality Culture 1 (absence of emphasis on quality)	−4.97	−2.706	−2.717
Quality Culture 2 (error detection culture)	−0.45	−0.595	−1.965
Quality Culture 3 (error prevention culture)	0.23	0.608	0.074
Quality Culture 4 (creative quality culture)	1.31	1.355	3.932

Srinivasan and Kurey (2014) support the connection between quality culture and Industry 4.0 and their study confirms that an excellent quality environment can be created through a true culture where every employee has a passion to imbue rather than simply follow mundane rule-based techniques, such as quality control tools or imitation of best procedures and practices.

Mohelska and Sokolova (2018) also do not focus on technical aspects, but rather managerial approaches for Industry 4.0. According to their findings, Czech respondents perceive the organisational culture in the organisations under review as more bureaucratic and supportive than innovative. In their view, the signs of innovative culture are not so striking. It is necessary to change managerial approaches to support innovative solutions. Quality culture is one of the possible innovative solutions.

A limitation of our research is that we focus on only creating positive quality culture, but other authors discuss further possible solutions for manufacturing enterprises to prepare for Industry 4.0.

Ghobakhloo (2018) discusses the fact that manufacturers who are transitioning into Industry 4.0 need to devise new marketing strategies, and the assessment of their level of digital market maturity is the first step for this purpose, and describes modern marketing strategies such as market sensing and learning strategy as well as data-driven marketing, which is coupled with blockchain-based platforms and smart contracts. Wu (2015) emphasis that an IT governance team should perform a detailed analysis of existing IT infrastructure (e.g., networks, computer hardware and software, sensors, controllers and actuators) and identify the most meaningful approach for using them in support of Industry 4.0 transition. Hamid et al. (2018) highlight the effective application of a reinvestment allowance that was designed to support Industry 4.0. Tolstykh et al. (2018) suggest the creation of a laboratory which will allow manufacturing enterprises to carry out analysis, assessment and engineering of existing processes from the perspective of digitalisation, performance, project orientation and efficiency. Telukdarie et al. (2018) propose global standardisation and inter-functional integration. They deal with a global system approach, as defined by Industry 4.0 (vertical, horizontal and total business integration).

We consider the following areas as potential directions for further progress on this topic:

1. An extension of the areas of interest to the service enterprises and public organisations.
2. An extension of the areas of interest to businesses that have not implemented a certain quality management system.
3. Characterisation of a comprehensive framework of the quality culture in the era of Industry 4.0 through active cooperation with the business sphere.

5. Conclusions

Industry 4.0 is no longer a "future trend" and many leading enterprises have placed it at the centre of their strategic agenda; those manufacturers who are able to catch up will benefit from the competitive advantages that are available to the early adopters (Ghobakhloo 2018). Developed quality cultures enable enterprises to adapt to Industry 4.0. The current knowledge of the level of quality culture in Slovak conditions is highly insufficient. For this reason, the identified gap can be filled at least in part with the results of the article. We have confirmed the existence of a medium dependency between the quality concepts and the quality cultures. We emphasise the creation of a methodology for identifying a characteristic quality culture for each quality concept. Based on the methodology, we have indicated the fact that error detection culture is typical for manufacturing companies that follow at least one sectoral standard. For manufacturing companies that have at least one ISO standard implemented, a typical quality approach is defined by an error prevention culture. Manufacturing companies tending towards the TQM philosophy prefer a creative quality culture. Part of the article concerning the formation of a model quality culture in the era of Industry 4.0 detects significant factors that differentiate individual quality culture in the Slovak Republic. Manufacturing enterprises should focus their attention on the improvement and assurance of quality, the use of the information and its overall effectiveness.

The future research is focused on the adaptation of Industry 4.0 to all enterprises on the national market, not only to manufacturing enterprises implementing at least one quality concept, which is considered to be the limitation of the study. A comprehensive view of the topic will be necessary to extent the scope to the service enterprises, public organisations and, lastly, to enterprises that have not implemented any quality concept. The final aim related to this topic will be creating a detailed description of the model of the status of the quality culture in the era of Industry 4.0 with proactive and flexible cooperation with successful Slovak adopters to Industry 4.0.

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Appendix A

Table A1. Cross-tabulation of quality culture and quality concept (expected counts).

Quality Concept	Quality Culture				Total
	Quality Culture 1 (Absence of Emphasis on Quality)	Quality Culture 2 (Error Detection Culture)	Quality Culture 3 (Error Prevention Culture)	Quality Culture 4 (Creative Quality Culture)	
Sectoral Standards	**2.6**	5.1	9.3	5.1	22
ISO standards	9.6	18.6	34.1	18.6	81
Total Quality Management	**2.7**	5.3	9.7	5.3	23
Total	15	29	53	29	126

Table A2. Rotated component matrix.

Question	Component							
	1	2	3	4	5	6	7	8
Question 66	**0.654**	0.138	0.065	0.09	0.353	0.222	0.188	0.168
Question 57	**0.651**	0.180	0.286	0.098	0.236	0.154	−0.042	0.065
Question 64	**0.648**	0.196	0.235	0.087	0.407	0.187	0.094	0.137
Question 56	**0.639**	0.307	0.237	0.064	0.267	0.289	0.092	0.065
Question 76	**0.631**	0.228	0.256	0.292	0.057	0.103	0.113	0.141
Question 80	**0.630**	0.108	0.078	0.335	0.202	0.338	0.143	0.182
Question 78	**0.619**	0.132	0.121	0.484	0.124	0.145	0.029	0.122
Question 62	**0.619**	0.431	0.377	0.139	0.076	0.001	0.115	0.137
Question 60	**0.610**	0.234	0.396	0.221	0.233	0.156	0.102	0.01
Question 77	**0.591**	0.262	0.216	0.449	0.005	0.185	0.156	0.064
Question 72	**0.578**	0.386	0.307	0.273	0.165	0.226	0.093	0.091
Question 67	**0.575**	0.342	0.106	0.039	0.126	0.175	0.190	0.070
Question 75	**0.564**	0.297	0.281	0.240	−0.123	0.136	0.391	0.066
Question 79	**0.548**	0.236	0.288	0.324	0.159	0.235	0.097	0.017
Question 58	**0.531**	0.018	0.339	0.235	0.486	0.066	0.052	0.131
Question 73	**0.516**	0.324	0.309	0.389	0.025	0.139	0.091	0.267
Question 112	**0.491**	0.485	0.111	0.166	−0.009	0.155	0.203	0.111
Question 29	**0.489**	0.235	0.475	0.254	0.097	0.192	−0.001	0.060
Question 26	**0.488**	−0.127	0.414	0.151	0.129	0.232	0.217	−0.004
Question 63	**0.433**	0.330	0.199	0.357	0.09	0.175	0.300	0.213
Question 65	**0.432**	0.347	0.077	0.343	0.098	0.243	0.037	0.247
Question 30	**0.419**	0.317	0.250	0.294	0.303	0.076	0.224	0.061
Question 85	0.043	**0.764**	0.219	0.176	0.127	0.137	0.136	0.152
Question 70	0.360	**0.734**	0.097	0.090	0.097	0.186	0.061	0.105
Question 86	0.164	**0.715**	0.269	0.096	0.008	0.128	0.161	0.105
Question 88	0.269	**0.712**	0.208	0.170	0.149	0.093	0.181	0.182
Question 69	0.280	**0.679**	0.120	0.281	0.200	0.208	0.147	0.132
Question 71	0.516	**0.578**	0.254	0.067	0.120	0.194	−0.010	0.123
Question 87	0.110	**0.541**	0.357	0.34	0.115	0.245	0.126	0.042
Question 68	0.534	**0.536**	0.109	0.097	0.122	0.068	−0.063	0.234
Question 36	0.159	**0.520**	0.304	0.325	0.371	0.115	0.201	−0.079
Question 101	0.270	**0.519**	0.106	0.292	0.221	0.181	0.394	0.060
Question 91	0.141	**0.519**	0.373	0.272	0.184	0.035	0.084	0.324
Question 92	0.225	**0.513**	0.328	0.346	0.224	0.035	0.111	0.377

Table A2. *Cont.*

	Component							
Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Question 113	0.293	**0.505**	0.209	0.288	0.096	−0.072	0.360	−0.021
Question 47	0.267	**0.484**	0.341	0.300	0.291	0.217	0.195	0.037
Question 74	0.339	**0.460**	0.189	0.274	0.112	0.330	0.269	−0.061
Question 44	0.342	**0.445**	0.083	0.178	0.374	0.240	0.174	0.180
Question 98	0.297	**0.426**	0.170	0.251	0.296	0.231	0.187	−0.200
Question 55	0.326	**0.418**	0.060	0.238	0.240	0.384	0.131	0.212
Question 38	0.227	0.133	**0.827**	0.168	0.002	0.054	0.003	0.140
Question 49	0.296	0.128	**0.809**	0.145	0.039	0.12	−0.013	0.104
Question 48	0.153	0.211	**0.719**	0.072	0.24	0.151	0.065	−0.066
Question 37	0.210	0.137	**0.711**	0.133	0.241	0.025	−0.013	−0.196
Question 24	0.251	0.301	**0.707**	0.064	−0.006	0.246	0.055	0.161
Question 25	0.244	0.286	**0.704**	0.121	−0.017	0.277	0.064	0.072
Question 31	0.199	0.274	**0.669**	0.138	0.067	−0.037	0.059	0.050
Question 59	0.519	0.258	**0.582**	0.064	0.196	0.132	0.052	−0.060
Question 33	0.335	0.167	**0.524**	−0.015	0.046	−0.087	0.049	0.003
Question 89	−0.098	−0.154	**0.510**	−0.308	0.052	0.120	0.186	0.123
Question 99	−0.237	0.000	**0.495**	−0.114	−0.324	−0.025	0.136	0.030
Question 23	0.211	0.337	**0.371**	0.027	0.354	0.332	0.013	−0.079
Question 28	0.139	0.253	**0.347**	0.182	0.244	0.313	0.218	−0.007
Question 94	0.265	−0.022	0.013	**0.649**	0.231	−0.011	0.280	0.304
Question 110	0.102	0.295	0.183	**0.637**	0.074	0.164	0.085	0.247
Question 114	0.271	0.258	−0.009	**0.610**	0.169	0.151	0.241	0.027
Question 32	0.213	0.231	0.036	**0.593**	0.355	0.292	0.151	0.077
Question 95	0.410	0.215	0.130	**0.562**	0.233	0.175	0.216	0.256
Question 82	0.171	0.283	−0.048	**0.560**	0.307	0.365	0.167	0.264
Question 81	0.127	0.119	−0.045	**0.552**	0.229	0.306	0.197	0.162
Question 83	0.256	0.293	−0.016	**0.527**	0.314	0.322	0.232	0.150
Question 102	0.146	0.436	0.110	**0.516**	0.203	0.000	0.449	0.047
Question 93	0.052	0.295	0.350	**0.505**	−0.012	0.071	0.158	0.359
Question 103	0.226	0.455	0.113	**0.498**	0.170	0.147	0.272	−0.018
Question 111	0.338	0.357	0.111	**0.470**	0.112	0.172	0.425	0.200
Question 35	0.295	0.076	0.281	**0.467**	0.336	0.259	0.221	0.201
Question 90	0.225	0.250	0.358	**0.465**	0.107	0.064	−0.033	0.305
Question 96	0.103	0.090	0.242	**0.403**	0.058	−0.103	0.278	−0.046
Question 34	0.297	0.268	0.310	**0.386**	0.246	0.360	0.198	0.100
Question 100	0.366	0.234	0.213	**0.372**	0.33	0.032	0.227	0.209
Question 42	−0.035	0.184	−0.016	0.254	**0.666**	0.174	0.100	0.294
Question 41	0.333	0.106	0.227	0.222	**0.629**	0.168	0.115	0.195
Question 40	0.363	0.127	0.251	0.129	**0.623**	0.199	0.144	0.084
Question 61	0.270	0.323	0.135	0.288	**0.587**	0.117	0.172	0.236
Question 39	0.265	0.058	0.444	0.070	**0.513**	0.291	0.096	0.087
Question 43	0.207	0.202	−0.061	0.289	**0.502**	0.195	0.289	0.352
Question 53	0.094	0.247	0.058	0.191	**0.496**	0.411	0.064	0.239
Question 84	0.251	0.241	−0.063	0.333	**0.401**	0.340	0.136	0.306
Question 51	0.313	0.152	0.197	0.022	0.254	**0.703**	0.182	0.158
Question 52	0.281	0.185	0.152	0.152	0.194	**0.613**	0.168	0.145
Question 46	0.278	0.301	0.242	0.330	0.166	**0.602**	0.122	0.042
Question 22	0.352	0.139	0.203	0.271	0.111	**0.535**	0.144	0.308
Question 45	0.279	0.284	0.355	0.333	0.111	**0.512**	0.130	0.122
Question 50	0.235	0.060	0.417	0.014	0.232	**0.505**	0.111	0.134
Question 54	0.214	0.302	−0.067	0.279	0.350	**0.463**	0.166	0.347
Question 27	0.380	0.252	0.129	0.208	0.315	**0.393**	0.272	0.263
Question 97	0.300	0.247	0.286	0.162	0.276	**0.301**	0.273	0.006
Question 107	0.028	0.116	0.028	0.271	−0.011	0.046	**0.759**	0.059
Question 105	−0.003	0.195	0.130	0.178	0.061	0.275	**0.732**	0.013

Table A2. *Cont.*

Question	Component 1	2	3	4	5	6	7	8
Question 109	0.128	0.142	−0.011	0.117	0.354	0.089	**0.691**	0.268
Question 108	0.158	0.093	0.104	0.103	0.112	0.006	**0.666**	0.362
Question 106	0.173	0.148	0.087	0.123	0.142	0.268	**0.607**	0.192
Question 104	0.173	0.347	0.051	0.273	0.072	0.390	**0.494**	0.056
Question 19	0.105	0.179	0.033	0.194	0.210	0.220	0.235	**0.729**
Question 18	0.146	0.081	−0.09	0.238	0.216	0.194	0.311	**0.717**
Question 21	0.239	0.129	0.252	0.177	0.241	0.128	0.157	**0.616**
Question 20	0.244	0.337	0.098	0.296	0.31	0.136	0.089	**0.500**

Bolt values indicate the highest saturation of questions with the component.

Table A3. Stratified dividing of the sample.

Quality Culture	80%	20%	100%
Quality Culture 1 (absence of emphasis on quality)	12	3	15
Quality Culture 2 (error detection culture)	23	6	29
Quality Culture 3 (error prevention culture)	42	11	53
Quality Culture 4 (creative quality culture)	19	5	24
Total	96	25	121

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