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Organizational Culture as an Indication of Readiness to Implement Industry 4.0

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Abstract: Industry 4.0 has managed to attract lots of attention from researchers because of the benefits it has to offer and many studies about Industry 4.0, as well as readiness and maturity models, are available from the technological point of view. Meanwhile, the organizational culture dimension of Industry 4.0 has received little to no attention. The aim of this paper is to find out whether or not the size and type of an organization influence the innovative culture and consequently the readiness of the organization for implementing industry 4.0. Results show that the innovative organizational culture according to the index of organizational culture does not depend on the size of an organization but to some degree depends on the type of the organization.

Keywords: Industry 4.0; organizational culture; size of organization; type of organization

1. Introduction

Industry 4.0 is considered the essence of the fourth Industrial revolution, and it has been utilized in manufacturing in recent times through employing cyber-physical systems (CPS) so as to reach high levels of automation [1]. The Cyber-Physical System (CPS) is the footing for smart factories and it makes interconnecting sensors, machines, and IT systems possible within the value chain all the way through enterprise boundaries [2].

From the point of view of information technology, Industry 4.0 has been very well studied and documented. In addition, there are lots of readiness and maturity models available in this regard. On the other hand, the organizational culture dimension of Industry 4.0 has received little to no attention. Nevertheless, it is important to consider the organizational culture as other studies proved that the organizational culture has some influence on knowledge sharing with regard to business systems' success, which is considered to be essential for the propose of Industry 4.0 [3].

Between the three types of organizational culture explained [4], the innovative culture stands out as the type of culture that is more suitable for the implementation of Industry 4.0. In other words, organizations that have a higher level of innovative culture are more likely to have better transition when it comes to implementing Industry 4.0 and are more ready. It is important not to confuse having innovative organizational culture and being an innovative company. Having an innovative culture in an organization creates an environment that encourages risky behavior, accepts new challenges, and supports creative work [4,5]. Whereas to be an innovative company means that the company is adapting innovative processes that cover the physical, technical, and knowledge-oriented activities of the company [6].

Bearing this assumption in mind, the main aim of this study is to find out whether or not the size and type of an organization affect the innovative culture and consequently the readiness of the organization for implementing Industry 4.0. For the purpose of this article, quantitative methods are used as the most appropriate methods in this research in order to diagnose organizational culture.

Each of these methods has some advantages and also some disadvantages, and this is exactly why a combination of these two methods is often used in practice.

The results of this research will be useful in the constructing and adjustment of strategy and methodology in favor of preparing firms for the implementation of Industry 4.0 and the efficiency of human resource utilization and consequently the economic outcomes of the firms can increase with the help and utilization of Industry 4.0.

2. Literature Review

2.1. Industry 4.0

Thanks to Industry 4.0, producing things that are unique regarding excellent quality has become possible and with a price matching the price of mass-produced goods [7]. "Industry 4.0 concept can be characterized as a transformation of production as separate automated factories into fully automated and optimized manufacturing environments. Production processes are linked vertically and horizontally within enterprise systems." [2]

Implementing Industry 4.0 and digital transformation concepts theoretically is increasingly significant for manufacturing companies that are performing in such markets that are considered as both dynamic and competitive. Yet in practice, there are some challenges for organizations when implementing such concepts in view of the fact that Industry 4.0 is more a concept than a ready-to-implement solution; additionally, the complexity of Industry 4.0 causes delays to the successful implementation of Industry 4.0 systems in such a way that they include all organizational features and levels in an accurate manner [8].

According to some researchers, Industry 4.0 requires an 'organic' organization design, which is not very official with flexible rules and policies desires decentralization, empowerment of employees, cooperative teamwork and horizontal communications. In a changing environment, the Innovation capability is more compatible with an organization that has an organic design [9].

The organization of production processes is defined by Industry 4.0, and these processes are based on interacting technologies and devices, in other words, a 'smart' factory where physical processes are controlled by computer-driven systems and make decentralized decisions which are heavily relying on the self-organization mechanisms [10]. In another research [11], the main advantage of the Smart Factory concept is mentioned as "the high level of process standardization, due to which the production process remains stable while maintaining a high level of flexibility and agility".

Sufficient resources, skilled and capable employees, and well-organized processes—that are suitably flexible and innovative—are believed to be necessities while implementing the Smart concept [11]. Industry 4.0 defines the organization of production processes which are based on interacting technologies and devices, also referred to as a 'smart' factory, where physical processes are controlled by computer-driven systems and decentralized decisions that are relying on the self-organization mechanisms are made [10]. "Maturity models can be considered as a structured collection of elements in which certain aspects of the capability maturity in an organization are described" [12]. Typically, maturity models are in use as a tool to conceptualize and measure maturity of an organization or a process regarding certain target state [13].

"The transformation of the manufacturing sector towards Industry 4.0 is setting the scene for a major industrial change. Currently, the need for assisting companies in this transformation is covered by a number of maturity models that assess their digital maturity and provide indications accordingly" [14].

To accomplish success in a vague environment such as Industry 4.0, training, learning, and innovation capability have significant roles. Organizational training, learning, and innovations are sturdily dependent on the role of employees in the organization, and because of that organizations have to prepare their strategies conferring to what they expect from their employees [9]. On the other

hand, transparency is important to be considered as it plays an important role in rationality, decent governance, and better progress [15].

The intention of designing the 'Capability Maturity Model' was to assess and evaluate the development of software systems and some other areas associated with this development such as project management, human resources management and IT governance. The most important assumption of this model is that the performance of the organization would be correspondent to its maturity level [8]. Maturity models are typically used as a tool to conceptualize and measure maturity of an organization or a process with reference to some precise target state. In order to facilitate different analyses of Industry 4.0 maturity, the proposed model includes a total of 62 maturity items, which are grouped into nine company dimensions [13].

According to some studies [12] the main features of Industry 4.0 are as follows:

- Interoperability: cyber-physical systems (work-piece carriers, assembly stations, and products) allow humans and smart factories to connect and communicate with each other.
- Virtualization: linking sensor data with virtual plant models and simulation models creates a virtual copy of the Smart Factory.
- Decentralization: ability of cyber-physical systems to make decisions of their own and to produce locally thanks to technologies such as 3D printing.
- Real-Time Capability: the capability to collect and analyze data and provide the derived insights immediately.
- Service Orientation.
- Modularity: flexible adaptation of smart factories to changing requirements by replacing or expanding individual modules.

2.2. Organizational Culture

"Organizational or corporate culture is the pattern of values, norms, beliefs, attitudes and assumptions that may not have been articulated but that shape the ways in which people in organizations behave and things get done. It can be expressed through the medium of a prevailing management style in the organization" [16].

Organizational culture is defined and used largely as a correctly steady set of values, beliefs, assumptions, and symbols distributed in the organization and according to this formation, researchers have developed studies regarding the relationship among several types of cultures and innovation results [17]. Organizational culture is the common beliefs, principles, standards, and assumptions that form behavior by building commitment, giving direction, generating a combined identity, and building a community. An organizational culture is thought to be effective when it is in alignment with the organization's environment, resources, values, and goals [18].

Supplementary studies about organizational culture concluded that as a leading enabler in building a positive knowledge transfer environment, organizational cultural elements such as trust, communication, reward system, and organizational structure are able to have a positive influence on knowledge sharing in organizations [19].

Innovations are considered to be the processes of 'economy-wide learning' and 'self-discovery' that help companies to provide analytical linkages connecting macroeconomic financial stability and microeconomic firm behavior. Companies will seek to innovate if they are confident about their technological and market opportunities in future, otherwise, they will not innovate [20].

It has been proven that innovation is essential to the success of an organization and also individual creativity and innovativeness has been proven to be as a key to organizational level innovation. Organizational climate can have a significant effect on creativity and innovation within organizations. Employees with the potential to be innovative and creative are most likely to do innovation if they get strong organizational support [21].

The innovation process covers the physical, technical, and knowledge-oriented activities that are essential in developing and preparing routines for production of goods [6].

The implementation of the Industry 4.0 concept needs contribution from top management encouraging comprehensive change management activities and processes for assembling organizational and production structures in harmony with the needs of the connected value creation. Another factor for success is a cooperative, explorative, and entrepreneurial mind-set that is necessary to set up among a company's employees, which are considered as the most important resource. Managers must have inclination to persuade employees of the beneficial nature of Industry 4.0 and to address their worries actively. With the apprehension to this fact, employees' training and development should be focused concerning Industry 4.0's specific competencies and skills like data analytics, IT, software, and human–machine interaction know-how [22].

The key to success in an uncertain environment such as Industry 4.0 is training, learning, and innovation capability. Organizational training, learning, and innovations are profoundly dependent on the role of employees in the organization and for this reason organizations must formulate their strategies according to what they want and expect from their employees [9].

The adaptation and application of innovation has to align perfectly with corporate culture in order to reach success. Innovation is considered to be a multi-dimensional process that includes firm culture, internal processes, and external environment and the firm culture together with internal processes and external environment define the innovation capability of the firms [18].

Organizations always need to increase their flexibility, responsiveness, and efficiency due to the nature of global business environment that is very unpredictable, and because it is necessary to be able to respond to challenges faced by both local and international competition. This means that there is a bigger need for constant innovation of internal processes and behaviors and not only innovation of products and services.

Another thing that is vital for organizations and their success in the employee knowledge in the case they want to innovate and develop a competitive advantage. As a result, it is crucial to know how to create an organizational climate that nurtures innovation among employees [21].

2.3. Wallach's Model

Organizational culture can be categorized into three groups (dimensions): bureaucratic, supportive, and innovative. Bureaucratic culture is thought to be a prominent hierarchical organization that is greatly organized on the foundation of a clear definition of authority. A supportive culture is generally focused on interpersonal relationships and it is founded on mutual trust, encouragement, and co-operation. Innovative culture on the other hand is considered to be dynamic and it supports and encourages creative work, and it is considered to faces new challenges and inspires risky behavior [4].

Wallach's questionnaire (1983), otherwise known as the Organizational Culture Index (OCI), is more often than not recognized and the questionnaire is prearranged in a way to analyze the organizational culture level and due to the fact that the individual parameters of the questionnaire are fairly simple; it is not influenced by the social and technological development and advancement in a significant way. Due to the simplicity of Wallach's questionnaire and since it allows the comparison of the results internationally; scholars tend to be in favor of using this method even to this day. Revising of scientific sources, for instance Scopus and Web of Science, proves the validation of this model, as it is obvious in the impact factor journals that researchers are still using this method.

2.4. Hypotheses

The following hypotheses were formulated for this paper:

Hypothesis 1. *The innovative organizational culture according to the index of organizational culture depends on the size of the organization.*

Hypothesis 2. *The innovative organizational culture according to the index of organizational culture depends on the type of an organization (domestic (Czech in this case), international, state).*

3. Materials and Methods

The most important goal of this paper is to find out if the innovative culture, which is a very essential pre-condition for implementing Industry 4.0, varies in organizations of different sizes and different types. The following steps were chosen to be taken in order to achieve the before mentioned objectives:

- To analyze the existing state of implementing Industry 4.0—accessible research and review of literature as well as business case studies.
- To identify benchmarks and the main factors within individual pillars of implementing Industry 4.0—search of foreign specialized literature and description based on a questionnaire survey.
- To identify the level of organizational culture in organizations in the Czech Republic—search of foreign specialized literature and description based on a questionnaire survey.
- To answer the identified research questions, based on primary research.

Quantitative methods are used in this research in order to diagnose organizational culture. Each of these methods has some advantages and also some disadvantages, and this is exactly why a combination of these two methods is often used in practice. The Organizational Culture Index (OCI) questionnaire was used as the major method for the purpose of this study on top of other methods of data analysis and synthesis, induction and deduction, abstraction, and concretization were used.

Data was collected from 1500 copies of the Wallach's questionnaire (translated to Czech language) that were printed and distributed among part-time students of university of Hradec Kralove, studying at the faculty of Informatics and Management in the years 2013, 2015, and 2017.

To test and analyze the obtained data, ANOVA, Kruskal–Wallis, Brown–Forsythe, and Cronbach's alpha were used.

Differential single factor analysis was used to verify differences between groups. Where the dispersion homogeneity was not confirmed, a Brown-Forsythe test was used as an alternative. Different post-hoc tests were used to learn differences between groups (Bonferroni or Dunnett). As a substitute, the nonparametric analogy of the ANOVA–Kruskal–Wallis test was added.

4. Results

Results of the demographic part of the survey show that the number of female participants was somewhat over the number of male participants. In the last year of 2017, the number of male participants increased but did not exceed the number of female participants. Most of the respondents fall into age categories of 21–30 years and 31–40 years in all years of investigation. There were far fewer respondents in the first (below 20 years old) and final (61 years old and more) age categories, but they do not have a significant impact on the interpretation of results.

Organizations were categorized into three groups according to their size: organizations with up to 50 employees, organizations with employees between 51 to 250, and organizations with more than 251 employees. Results demonstrate that there is a statistically significant difference in bureaucratic culture between first and second groups, first and third groups, and second and third groups as shown below in Table 1. In supportive culture, a statistically significant difference amongst the first with the other two groups is present.

Table 1. Results of statistical analyses of dependence of the culture indexes on the size of company

	Bureaucratic	Innovative	Supportive
ANOVA	<0.001 *	0.358 *	<0.001 *
Kruskal–Wallis	<0.001	0.137	<0.001
Differences	1-2,1-3,2-3		1-2,1-3

* Brown–Forsythe test used for non-homogeneity of scattering.

In innovative culture on the other hand, there is no significant difference between organizations of different sizes. Generally large organizations have higher bureaucratic culture, and small organizations have a significantly higher supportive culture than the other organizations.

As we can see in Figure 1, bureaucratic culture gets noticeably stronger as organizations get larger. Instead, the larger organizations get the less supportive culture they have. Innovative culture though, does not change much.

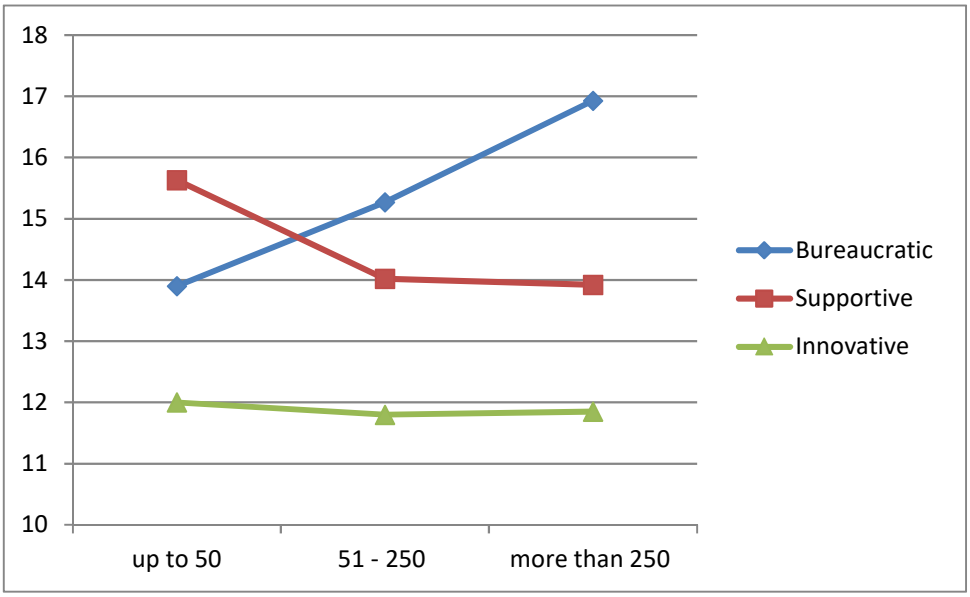

Figure 1. Dependence on the size of the organization. Source: author.

As for the type of organizations, results of statistical analysis (Table 2) show that for the whole period 2013–2017, there are visible differences between different types of companies in all different types of cultures. The least differences are present in the supportive culture, where the difference is significant only between Czech and state organizations.

Table 2. Results of statistical analyses of dependence of the culture indexes on the type of company (C—Czech; I—international; S—state organization). Source: author.

	Bureaucratic	Innovative	Supporting
ANOVA	<0.001	<0.001 *	0.029 *
Kruskal–Wallis	<0.001	<0.001	0.003
Differences	C-I, C-S	C-I, C-S, I-S	C-S

* Brown–Forsythe test used for non-homogeneity of scattering.

The level of innovative culture is the highest in international organizations, and then Czech organizations are slightly lagging behind. At last the state organizations have the least amount of innovative culture with a large distance from the other two types, which entirely makes sense.

Figure 2 visibly shows the differences mentioned above among the different types of organizations, it is obvious that the state organizations have the least innovative culture and the international organizations have the most bureaucratic culture.

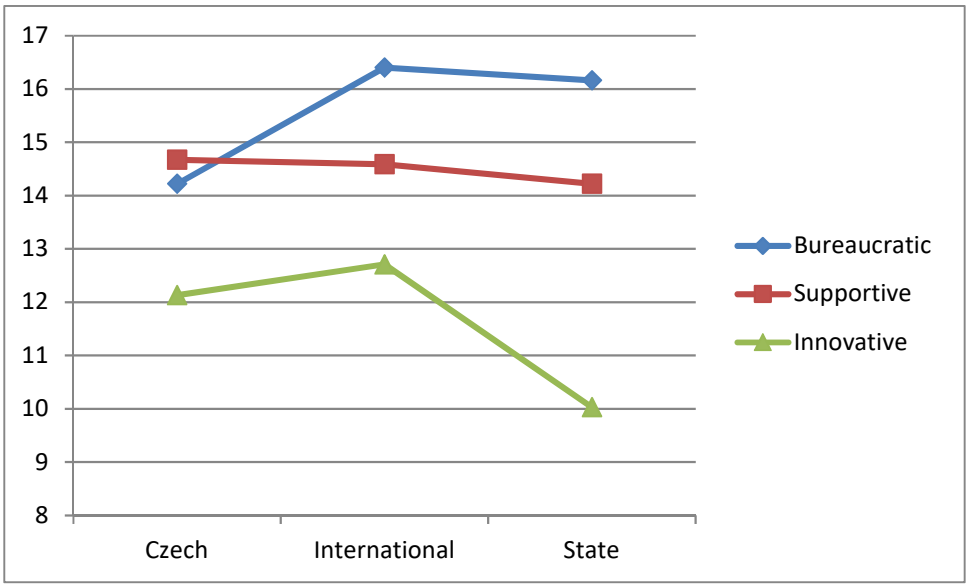

Figure 2. Dependence on the type of the organization. Source: author.

Based on the data, the frequency of responses in relation to culture was calculated to get a better understanding of the data and to choose the statistical methods accordingly.

As we can see that the distribution of the data showed in Figure 3, more or less resembles the one of normal distribution and the breakdown of the score in all of the three culture dimensions is approximately symmetric, and fairly close to normal distribution without significant anomalies. However, tests did not confirm that this is a normal distribution.

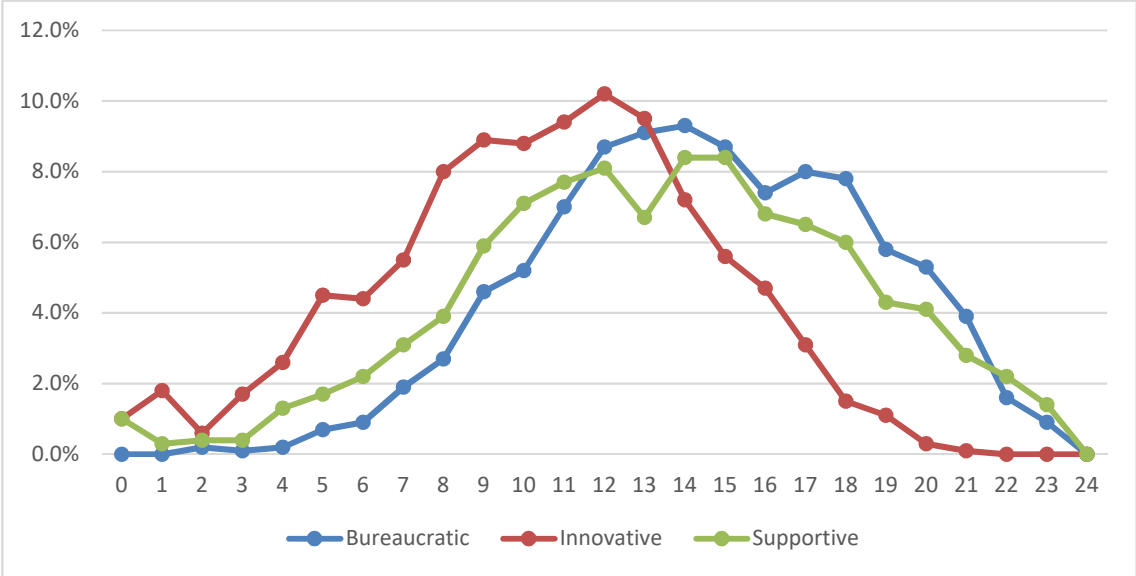

Figure 3. Frequency of responses in relation to culture. Source: author.

Cronbach's alpha was calculated for the 24 individual questions of the Wallach's questionnaire to confirm the internal consistency in order to authenticate the validity and reliability of the questionnaire based on the dimensions they were associated with, questions 3, 4, 10, 12, 14, 20, 21, and 24 are mostly

associated with the bureaucratic culture; questions 1, 6, 7, 11, 13, 18, 19, and 23 are associated more with the innovative culture; and finally, questions 2, 5, 8, 9, 15, 16, 17, and 22 are considered to be more often than not associated with the supportive culture. The results of Cronbach's alpha are demonstrated below in Table 3.

Table 3. Cronbach's alpha reliability analysis. Source: author.

	2013	2015	2017	Total
Bureaucratic	0.717	0.713	0.700	0.710
Innovative	0.705	0.688	0.705	0.699
Supportive	0.823	0.810	0.782	0.808

Generally, Cronbach's alpha test results clearly show that the bureaucratic culture's internal consistency is considered to be acceptable ($0.8 > \alpha \geq 0.7$).

Similarly, it could be said that the internal consistency of the supportive culture is considered to be Good ($0.9 > \alpha \geq 0.8$) in the years 2013 and 2015, and it could be considered as acceptable in the 2017.

For the internal consistency of the innovative culture the results are acceptable for the years 2013 and 2017 but in the year 2015 Cronbach's alpha is a bit shy (0.688) from being acceptable and it could be is considered to be questionable ($0.7 > \alpha \geq 0.6$). On the other hand, because this value is only slightly less than 0.7 and the total internal consistency of innovative culture are 0.699, we can consider it as acceptable as well.

In the overall assessment of the research form the years 2013 to 2017, there are noticeable differences between different types of companies in all areas. The smallest differences are in the supportive culture, where there is a significant difference only between Czech companies and state organizations.

In the field of innovative culture, the evaluation is markedly the highest among international companies, behind them are Czech companies somewhat lagging behind, and with large distance they are state organizations, which makes sense entirely.

Some limitations were present at this study. The selection of respondents was the major limitation. However, this deficiency is not so crucial, due to the fact that the Czech Republic presently has a relatively homogeneous socio-economic composition. However, it is recommended to have a better and wider range of respondents' selection for the future researches.

An additional limitation is that the category of employees with lower levels of education was underrepresented in our sample. Also, the method of data collection through part-time students can also be a considered limitation and it is advisable to use better means of data collection in the future research. However, this disadvantage was in part offset by the diversification of the jobs that these students have, because they worked in different areas of both the public and the private/government sectors.

Regardless of these limitations, authors believe that the data provides results that expand our understanding of the dimensions of organizational culture at organizations.

The outcomes of this research could be applied for the needs of different organizations taking into consideration also various legal forms of these organizations. Explicitly, local, national or transnational contexts of those organization and their details must be regarded.

Additionally, the research outputs possibly will be dealt with from quite a few points of view. Above all, the standpoint of partial subjects defines how they are applicable or functional. This includes, for example, an individual's perspective, an organizational perspective, or a national or transnational perspective.

The partial subjective insight of the relevance of the research outputs for individual groups could of course overlap and cross with the perception of others and the outputs might be considered when appropriate as usable in the public or private sector.

From an individual's viewpoint, results of this research can be used to increase employees' satisfaction. Furthermore, it could impact the company's prestige that might be supported by an index of supporting and innovative organizational culture from the point of view of the existing employees,

resulting in the satisfaction of the employees with their job position, or the fact that they work for a company whose prestige is upgraded in this way.

From an organization's perspective, the results and outputs of this research may be considered in terms of identifying strengths and weaknesses, or opportunities and threats. The research outputs can also supply the purposes of comparison involving individual competitors, or as a good starting point for benchmarking methods to determine organizations' general quality or prosperity. Using the research outputs may normally help to improve the quality and could be beneficial in increase the efficiency of business processes.

5. Discussion and Conclusions

According to the results of this study, there is a statistically significant variation in bureaucratic culture concerning all group sizes. This is because of the fact that larger organizations rely greatly on strict rules and a chain of command to facilitate a better management for larger groups of people. It turns out that strategic corporate governance is a very important determinant for organizational culture. For example, one study suggests how small enterprises within the Industry 4.0 domain can speed up their growth targets and grow to be more innovative, innovation being the move towards sustainable competitiveness and smart growth [23].

In supportive culture, a statistically significant difference between the first group with all the other groups is present as shown in Figure 1, meaning the larger the organization gets the less supportive its culture becomes. This is considered to be compelling since the supportive culture normally relying on the interpersonal relationships and it is profoundly dependent on mutual trust, encouragement and co-operation (Wallach 1983), which is harder to have as the organizations get larger.

Nevertheless, there was no significant difference found in the innovative culture between the different size groups. This could be because of the fact that smaller organizations are in general relaying on being innovative, but the larger organizations are seeking after innovative solutions rather than being innovative.

The 24 parameters of the Organizational Culture Index are organized in front of the type of culture they are generally associated with:

- Bureaucratic culture: hierarchical, procedural, hierarchical structured, the order rules here, activities are managed and regulated here, established/solid, careful, aimed at holding power.
- Innovative culture: risking, results-oriented, creative, overpressure/ explosive, stimulating, posing challenges, entrepreneurial, full of new ideas.
- Supportive culture: based on cooperation, relationship-oriented, supporting, friendly, and allowing for personal freedom, fair, safe, trusting their employees.

Based on these 24 parameters, we can explain why international organizations had the highest innovative culture in the evaluation, then Czech organizations, and with large distance from them the state organizations. In general state organizations have a hierarchical structure and people who control the power manage others with a set of rules and procedures. These kinds of people desire to stay in power so they do not endorse creative work, they do not let anybody pose any threats or challenges to them and so on. Similarly, the supportive culture tends to get weaker the larger the organization get; supportive culture is established based on cooperation and it is relationship-oriented with larger levels of trust, clearly it is more challenging to establish such values with others in an environment where there are more people.

Statistical analyses grant sufficient evidence to conclude that the innovative organizational culture according to the index of organizational culture does NOT depend on the size of an organization. Therefore, the null hypothesis H1 is rejected. On the other hand, we can conclude that the innovative organizational culture according to the index of organizational culture depends on the type of an organization and for this reason, the null hypothesis H2 is NOT rejected.

The outcomes of this research will be useful in the constructing and adjustment of strategy and methodology in favor of preparing firms for the implementation of Industry 4.0 the efficiency of human resource utilization and consequently the economic outcomes of the firms can increase with the help and utilization of Industry 4.0.

Wallach's model may perhaps provide us an excellent idea of the existing organizational climate of the firms and the appropriate approaches and strategies could be selected based on this knowledge in order to make some adjustments and prepare the firms in a way that they will meet the preconditions for implementing Industry 4.0 for an easier and smoother transition.

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