Competencies as a Criterion for Assessing the Readiness of Organizations for Industry 4.0 - A Missing Dimension

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Abstract: The main purpose of this paper is to present a conceptual model for the integration of employees' competencies into the models for assessing the readiness of organizations for Industry 4.0. Transformative changes of the business environment and subsequently of the organizations caused by the adoption of Industry 4.0 principles, demand from employees to have new, better, and upgraded personal and professional competencies. A growing amount of literature indicates that increasingly multicultural and multidisciplinary business environment, which is also technologically advanced, will impact the aspects of personal and professional sides of employees' competencies the most. However, with regards to the current models for assessing the readiness of organizations, their focus largely on the technological side of the transformation and subsequently the softer people-related aspects are understated. One of those understated aspects are competencies that are not considered as an independent criterion, which can help to more comprehensively determine organizations' readiness for Industry 4.0.

Keywords: Industry 4.0, Industry 4.0 readiness models, competencies.

1. Introduction

The impact of Industry 4.0 on the current business environment is a strong one and consequently organizations, especially manufacturing ones, are experiencing rapid dynamic and transitional changes that are based on the integration of technologies connected to digitalization, automation, and artificial intelligence into the business processes [1][2][3][4][5].

This means, that the impact of these technologies will be such, that it will lead the way for the next industrial revolution [6][7]. Within the economic system, these

changes are especially evident in organizations [8][5], that can be considered as core entities of the economic system [9] and thus of paramount importance to study. This opens up a question of determining the readiness of organizations for Industry 4.0, and how to comprehensively assess it. Current comprehensive models for assessing the readiness and maturity of organizations for Industry 4.0, one devised at the Fraunhofer Institute [10] and the other at the University of Warwick [11] focus largely on the side of "hard" technology related aspects and criterions and not enough on the "soft" people and philosophy related ones.

One of such soft aspects are employee competencies, as it is clear that in this manner the changes will not be focused only on technological processes within the organizations, but rather the employees will also be significantly impacted [1][12][13]. Employee competencies represent a fundamental resource that enables the success and competitiveness of an organization [14] and thus they should not be overlooked in the models for assessing the readiness for Industry 4.0.

There is a lot of fear that automation will replace the need for human labor [15][12] and this opens up a significant question of whether current employees have the right competencies to perform work in the Industry 4.0 environment. Industry 4.0 will not only replace repetitive work, but it will also change the working environment. It is estimated that the new business environment under Industry 4.0 will become more multicultural, interdisciplinary, multidisciplinary, collaborative, teamwork oriented, etc. [16][17][18][19], which by itself calls for new or improved personal and professional competencies, so that employees will still be able to add value to organizational efforts.

Since the competencies represent a major area of change, we propose that the focus on the usage and development of key competencies should be measured dimensions of assessing an organization's readiness for Industry 4.0. Additionally, based on the recognized importance of competencies for successful implementation of Industry 4.0 principles and exclusion of competencies in current models for assessing readiness, we propose the conceptual model, which outlines the relationship between organizations' readiness for industry 4.0 and key competencies under Industry 4.0 working environment. First, this paper offers a theoretical overlook of the phenomenon of digitalization and the concept of competencies, Secon, the paper offers a list of the most crucial personal and professional employees competencies required in Industry 4.0. Lastly, the paper presents a theoretical model, where employee's competencies are considered as one of the key criterions in assessing organizational readiness for Industry 4.0.

2. How Digitalization Made Industry 4.0

2.1Digitalization

Digitalization has transformed the society in recent years to the point, where it would be unrecognizable to humans only 30 years ago. This impact is such, that authors claim its importance in human development is equal to the discovery of fire, development of agriculture or the development of language. Digitalization is now guiding socio-economic development of humans, but these effects are now more than ever before spilling over to the economy [20][5]. The idea in the economy is that digitalization can enable favorable economic outcomes if properly utilized [21].

Digitalization refers to a plethora of singular phenomena, but collectively it represents the process of the representation of real-world data or objects through digital symbols and then reflecting this information back to the world with digital technologies [5]. This has significant implications in the way we spend our time working, as the majority of energy is spent on the cognitive work, where is the most added value because the machines are taking over manual workloads.

Digitalization is enabled with digital technologies that represent a plethora of devices, gadgets, protocols, etc., which are in term able to gather, interpret, use, and represent information. It should be stated however, that artificial intelligence is one step further and it is able to learn from gathered data to improve the processes [5][4][22].

Currently, in the economy and subsequently in organizations [9] the most potential for making a profit and better the situation form the standpoint of economic activities is in the adoption of principles of Industry 4.0 [4][21].

2.2Industry 4.0

Under the influence of Industry 4.0, practices of digital transformation seem to be beneficial to the degree, where they can cause the next industrial revolution [7][17][4]. Industry 4.0 is the European agenda to digitalize organizations with the implementation of high-technology in manufacturing processes and broader organizational workings [6][2][24]. So far, every industrial revolution has contributed to society and economy with its innovative solutions to improve manufacturing processes and philosophies of organizational workings [25]. With each new invention, the entropic complexities were also increasing in the organizations, where nowadays the role of human labor becomes less a factor than it was in the past [20][12]. This is nicely reflected through the evolution of industrial revolutions, as first two were driven by human labor and fossil fuels, the

third and prospective fourth are however based on cognitive work and mental power, and computational and digital technologies [5].

2.2.1 Technological drivers and enablers of industry 4.0

Basic technological concepts that are at the root of the phenomenon of Industry 4.0, have up till now been defined on the bases of three major technological groups [24][26]. Namely:

Internet of Things and Services (IoT), represents the integration of processes and machines with information and communication technologies, cloud computing, smart objects, etc. to make way for cyber-physical systems [27][28][29].

Cyber-Physical Systems (CPS) use IoT and information and communication technologies to gather data and ultimately control the production, other physical systems, and business processes in real time, presenting building blocks for smart factories [30][29][24].

Smart factories and Smart Manufacturing, are at this time considered small digitalized and entirely decentralized autonomous production units. They utilize all of aforementioned technologies (IoT and CPS) that are integrated in symbiosis with artificial intelligence, meaning that connected smart factories can self-organize and self-optimize [6][17][24].

2.3 The Current State of Models for Assessing the Readiness and Maturity of Organizations for Industry 4.0

Currently developed models for determining and assessing readiness and maturity of organizations for Industry 4.0 [31][10][11] are empirically still untested and are focusing far to greatly on the so-called “hard aspects” of organizational workings, such as information technology and infrastructure, production technology and infrastructure, sensors, smart supply chain, etc. So-called “soft aspects” are in large part understated. Although these models do encompass individual softer aspects, such as business models, human resources, organizational culture, etc. these however do not have equal precedence to hard aspects. In the literature there is a growing amount of studies indicating the importance of employees’ competencies see, [16][17][18][19] in securing the relevant knowledge, skills, and abilities for employees to perform their work efficiently, effectively, and generally successfully. Yet employees’ competencies are in the current models not considered as a vital soft criterion to determine the readiness of organizations for Industry 4.0. Basic traditional organizational theories [32][33] outline that in order for organizations to be successful in the marketplace or in their environment, they should have a cohesion and symbiosis between hard and soft aspects of organizational workings and behavior. Thus, to more comprehensively consider

the readiness of organizations for Industry 4.0, we should, among other soft criterions also integrate the focus on the usage and development of key employee competencies.

3. The Concept and Implications of Competencies in Industry 4.0

Competencies are conceptually a very broad field of study, which is considered important in various scientific fields dealing with human labor, e.g. business, economy, to psychology, education, etc. [18]. Because they have a different meaning in the sense of the level of consideration, different definitions have emerged.

The role of competencies was first focused on the employees' abilities to achieve desired work results. Thus, competencies were defined as a set of personal and subsequently general characteristics or even as a plethora of habits that can the individual with its application to achieve the desired work result [34][35].

Later on, competencies were more specifically defined as individual's knowledge and subsequent abilities, which are gathered with experiences, training, practice or learning that generally show what a person is capable of (Spencer & Spencer, 1993). It is curious however that up till now, competencies still do not have an excepted universal definition [18].

Speaking in practical terms, competencies can be defined as a capability of an individual to practically apply his or her knowledge, skills, and abilities to situations, where it is possible to achieve desired work result or goals [36]. To further define what comprehensively determines a competence IPMA [36, p. 15] propose three dimensions:

1. **Skills**, that are connected more to technical aspects of performing a given task.
2. **Knowledge,** that is an individual's private and personal accumulated collection of information and experiences.
3. **Abilities,** that reference an efficient and effective application of knowledge and skills in a given practical context.

With regards to the level of consideration, many types of competencies are often outlined, i.e. generic competencies [37], managerial competencies [38], etc. For this research problem it is feasible to consider competencies as professional and personal [36] due to the different goals they reference [39]:

- **Personal competencies** refer to the fundamental abilities and knowledge that a person can apply to the task.
- **Professional competencies** refer to more specific skills of technical and technological nature, which can be applied to tackle a specific problem.

3.1 Conceptual Meaning of Competencies Considered with Connection to Industry 4.0?

Nowadays, competencies could be considered more as a means to resolve specific work-related situations. Some authors emphasize professional aspects of competencies, such as customer communication, nonformal brainstorming, goal setting, debates, presentation of ideas, etc. [40]. Other authors emphasize general and generic ones, those connected to the imminent changes of the environment, changes of work, changes of society, and interpersonal relationships [17].

Specific to the current situation, important dimensions of competencies are more clearly defined. Important areas that are impacted are therefore connected to purely mental abilities e.g. leadership and decision making, cooperation and support, personal interactions, etc. and to mental and technical skills, e.g. technical presentation abilities, analytics and interpretation, creativity and conceptualization, organization and performance, self-management, and lastly to the focus on organization and work performance [18][37] .

Still other model focus on the management positions as the most important. Those emphasize that managers and leaders should be creative, entrepreneurially minded, good problem and conflict solvers, good decision-makers, etc. Professional they should be good and proficient with analytics and research projects, and all the while focused on productivity and efficiency of organizational workings [38].

4. The Conceptual Model for Integration of Employees' Competencies in Industry 4.0 Readiness Models

As we have identified, there are two main categories of competencies applicable to differentiate between when examining the concept of Industry 4.0. Namely, those are connected to personal and professional dimesons. Various authors present competencies that are overlapping, but there are also some that are unique. Next, we will outline some of the most important ones, which are also represented below.

Personal competencies for Industry 4.0

- Holistic professional profile of the employee integrating self-reflection and self-management [36].
- Openness for multidisciplinary [10].
- A comprehensive approach to leadership and the openness to change management style [17][18].
- The ability to work in multicultural and multidisciplinary teams [17][10].

Professional competencies for Industry 4.0

- Technical and technological abilities [16][19].
- Digital and analytical abilities and skills [10].
- Creativity and proclivity for innovation [18].
- Professional holism of an individual (research abilities, statistical skills, communication and presentation skills, teamwork abilities, big data analytics skills, the ability to use CRM and ERP solutions, etc.) [41][30][17][18].

4.1 A more comprehensive model for assessing the readiness of organizations for Industry 4.0

To integrate employee competencies into the current models for assessing the readiness of organizations for Industry 4.0 [10][11] we propose, that two main dimensions of competencies should be measured. Namely, the focus on the usage and the development of personal and professional competencies. First, focus on the usage of these key competencies should indicate the frequency with which they are applied in the practice and should point to the level of organizations' integration and awareness of practices that Industry 4.0 is bringing. Second, the focus on the development of key competencies should reflect the Industry 4.0 strategy that organizations have set and whether they are committed to carrying through the integration of Industry 4.0 and are preparing their employees accordingly. The measurement instrument is presented in table 1.

Table 1 The proposed measurement model for determining the level of focus on the usage and the development of key competencies

Rank grade	**Focus on the usage of key competencies**	**Focus on the development of key competencies**
1	I do not have or use this competence	I do not recognize the importance of this competence
2	I have but do not use this competence	I recognize the importance of this competence, but do not plan to develop it
3	I have and occasionally use this competence	I recognize the importance of this competence and plan to develop it
4	I have and frequently use this competence	I am fully aware of the importance of this competence and am already developing it
5	I have and always use this competence	I am fully aware of the importance of this competence and have already developed it

Source: (Own research)

The proposed measurement instrument reflects the instruments used in the existing models for assessing the readiness of organizations to Industry 4.0 [10][11][42]. This means that with the measurement of the focus on the usage and development of key competencies we measure one more dimension of readiness. The conceptual model for the integration of competencies in the existing models of readiness is presented in Figure 1.

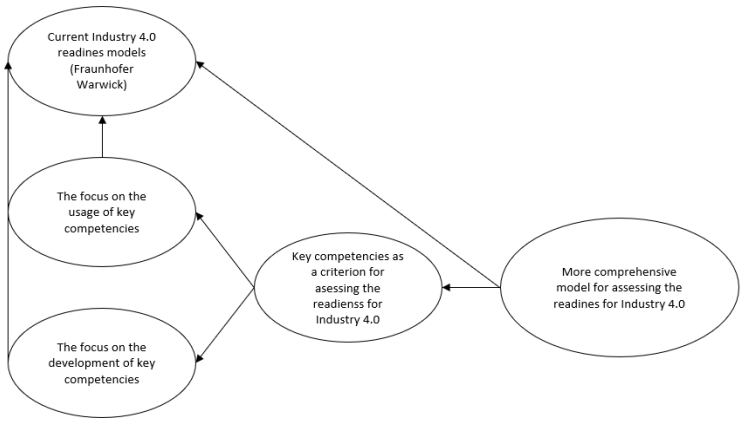

Figure 1
The conceptual model for the integration of competencies into current models for assessing the readiness of organizations for Industry 4.0 Source (Own research)

The model in figure 1 shows a conceptual process of how to integrate employees' competencies in the measurement models for assessing the readiness of organizations for Industry 4.0 as a single dimension. Current criterions in the assessment models, for example [10][11] are represented as a set of dimensions of the key workings of organizations. Therefore, we add a dimension of competencies to enhance the overlooked soft gap. We present it in figure one as a single construct, which encompasses professional and personal competencies and by extension enriches the current models.

5. Discussion

It is evident that the next industrial revolution will be a consequence of the next wave of digital technologies, encompassing, automation, cybernetics, and artificial intelligence [2][22][7][5][4]. Therefore, it is understandable why in the current models for assessing the readiness of organizations for Industry 4.0, such a large focus is given to the hard aspects of organizational workings. Although to be fair these models often reference competencies as an important aspect of change, but however not as an assessment dimension or criterion. But none the less, it is also evident that for the proper workings and behavior of organizations soft aspects are equally important [32][33]. Thus, they should be in equal measure represented in the current models and more importantly correctly measured.

Employee competencies, among others, represent the organizations' competitive advantage and thus they are a key element for the successfulness and competitiveness of organizations [14]. New technologies, which are taking over the workplace and changing the organizations, demand that employee competencies are changed and upgraded [16][17][18][19]. However, not only new technologies call for better competencies, but rather the whole philosophies of organizational workings and behavior are shifting more towards multidisciplinary, cooperation, multinationalism, teamwork, etc. [5]. This adds an additional layer of complexity to the needs for competencies because in order for employees to function well in this environment, they will also have to develop competencies that will enable their entire personality to function.

The proposed conceptual models for assessing the readiness of organizations for Industry 4.0 are still in its initial stages and largely empirically untested. In order to make them more comprehensive, we will have to upgrade them continually with new dimensions, which will encompass both hard and soft aspects of organizational workings and behavior. This is so because there are still unforeseen consequences, impacts, and effects that are a consequence of digital transformation [5], and thus we do not comprehensively understand, which aspects

and dimensions will play a key role in determining the readiness of organizations for Industry 4.0.

Conclusion

In this paper, we presented a conceptual model for the integration of key employees' competencies into the currently developed models for assessing the readiness of organizations for Industry 4.0. There is a need to integrate more soft aspects of organizational workings and behavior into these models, due to their large focus on the hard, technology-related aspects. Employee competencies are one of the most discussed topics, regarding the digital transition, but however, they are not considered as a dimension for assessing the readiness. Changes to the working environment under the influence of Industry 4.0, will change the job profiles, and consequently, new competencies will be needed. To comprehensively determine the readiness of organizations for Industry 4.0, we propose that employee competencies should be added as a separate dimension.

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