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A two-step digitalization level assessment approach for manufacturing companies

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Abstract

Manufacturing companies are facing the fourth industrial revolution, which concerns itself with the real-time data-based communication and connection between cyber-physical systems and people. To initiate a successful digital transformation, many organizations turn to Industry 4.0 maturity models for orientation and advice. This paper aims to enable companies to find the model that suits them best. Therefore, several existing models are introduced and two of them, a quick-assessment model (*CCMS*) and a more extensive approach (*Industry 4.0 Maturity Index*), are described in detail. These two complementing models are combined into a new resource-efficient approach to assessing Industry 4.0 maturity.

Keywords: Industry 4.0; Maturity model; Readiness assessment; Digitalization

1. Introduction

The fourth industrial revolution is characterized by "real-time, high data volume, multilateral communication and interconnectedness between cyber-physical systems and people" [1] [2] [3]. "Industrie 4.0" as a synoptic term in German for the result of this industrial revolution was first applied in 2011 [3], [5][6]. Within this paper, it will be referred to as "Industry 4.0".

Due to the ongoing development of Industry 4.0 and its broad variety of options for digital transformation and interconnected technologies, many organizations struggle to identify their role within the field and the Industry 4.0 measures that will suit their company [5]. To support companies in assessing their current status quo within the Industry 4.0 context, many academic institutions, industrial federations, and commercial corporations have developed Industry 4.0 maturity models. These maturity models differ significantly in their approaches, structures, and complexity levels. Some characterize a company's Industry 4.0 maturity by simply filling in an online survey, while others are more sophisticated and include on-site interviews and workshops with employees. Today, the number of Industry 4.0 maturity models is so high that it is difficult for companies to choose the model that will serve them best [5].

At the outset of this study 22 existing maturity models were analyzed and weighed against each other. Subsequently, categories of maturity models and comparative criteria were derived from the collected literature (see section 2). Two

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maturity models *CCMS* (see section 3) and *acatech Industry 4.0 Maturity Index* (see section 4) were selected for further investigation, due to their detailed approaches and complementing characteristics. The CCMS model focusses on the Industry 4.0 maturity on a company level, while the acatech model also considers concrete measures within company departments. Finally, a two-step approach that combines the two models was developed (see section 5). This resource-efficient approach is aimed at companies who are starting out in Industry 4.0 and are debating whether to invest into a maturity assessment. The new concept starts off with the quick online survey of the CCMS model, before applying the more elaborate acatech model.

2. Existing models

This section will introduce today's most relevant Industry 4.0 maturity models and their defining characteristics.

In their 2015 study PUCHAN ET AL. commented that there were no maturity models related to Industry 4.0, which address the entire value chain of a company [7]. Today this is no longer the case. In fact, the variety of models has increased and broadened to such an extent that there are several scientific studies depicting and comparing them [1][9][10], [11][12][13][17]. The literature research done for this paper looked at 22 Industry 4.0 maturity models.

All these Industry 4.0 maturity models have characteristics in common, but they also differ in their approach and scope (e.g. industry focus). In addition, some models rely on a self-assessment as evaluation method, such as the *Guideline Industry 4.0*, a visual toolbox designed for small and medium-sized engineering companies by the German Engineering Federation (VDMA) [6]. Others, like the *Pathfinder i4.0* [16] base their assessment on an external audit to be conducted.

There is a certain type of low-complexity and quick-assessment model, whose only resource is an online survey (providing a less expensive, quick answer for the company), such as the *CCMS* model and the *Industry 4.0 Readiness* model by the IMPULS Foundation of the VDMA [9]. Others, on the other hand, are more time and resource-intensive due to on-site workshops, which enable more detailed results and customized suggestions. Examples for this are the *Fraunhofer Austria Industry 4.0 Maturity Model* [15] and the *acatech Industry 4.0 Maturity Index* [3], which both rely on external audits to develop customized roadmaps for their clients. Differences between them include that the *Fraunhofer Austria Industry 4.0 Maturity Model* suggests specific project proposals and the *Industry 4.0 Maturity Index* focusses on the manufacturing industry.

Models can also be distinguished regarding their aim and focus: some of them are profit-oriented, as seen in [15],[16], [3], others aim to learn about the status of the companies to enlarge a knowledge base [7], and a third group pursues both goals [3]. There are models whose aim is to obtain a single, global view on a company [7], [17] , and others that aim to get multiple views from the evaluated company's employers as many different perspectives as possible as done in [15], [16], [3]. Other models differ in their scope, like the *Industry 4.0 migration model* developed for the *ADAPTION* project, which address socio-technical aspects and personnel-related topics in more detail [5]."

In the following, the quick-assessment model *CCMS* and the in-depth approach of the *Industry 4.0 Maturity Index* will be introduced in more detail.

3. CCMS Model

The aim of the CCMS model [19] developed by EPIC InnoLabs is to reflect and report on the responses of an increasingly widespread selection of industry representatives, both in terms of exploring internal contradictions and in terms of a proposed target system based on science aspects. The purpose of the representative survey is to assess the entire Industry 4.0 ecosystem of a company interested in being digitally transformed. Weighting each sub-area provides a basis for the formulation of a strategy that incorporates the organization's industrial digitization efforts. Using a hierarchical, top-down approach the model is also suitable for simultaneously displaying the inputs of key players representing the horizontal approach of company management, i.e., technological and business aspects.

The model is based on pillars built on dimensions [19]. These pillars represent different aspects of industrial digitization. On the subordinated level, intervention points were marked and identified. Their level of maturity is mapped using pre-defined questions. Ultimately, the response(s) to each question determines the digital readiness of the organization for that particular intervention point. Respondents are representing different background knowledge and experiences, therefore, they have fundamentally two different approaches to the organization and its operation. Thus, technological and business-oriented questions are also included in case of an intervention point.

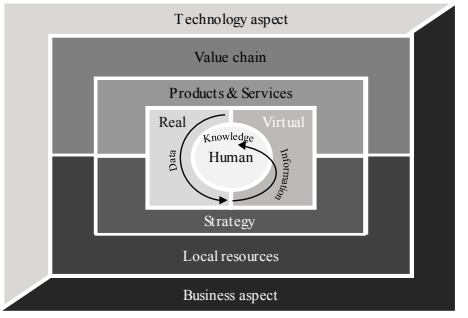

Fig.1. Structure of the CCMS model

The model is built upon three pillars: *Ecosystem*, *Value Creation* and *Value*. By our definition, the essence of industrial digitization is the close intertwining of the *Real* and *Virtual World*, with a focus on the *Human*. These three dimensions characterize the Value Creation pillar which takes the given inputs to creates the desired output. The Data flowing between the three dimensions creates an inseparable connection, from which *Information* and, at the very end, *Knowledge* emerges. Input resources provided by the Ecosystem pillar include the organization's *Strategy* and all *Local Resources* (e.g., infrastructure elements, legal environment etc.). On the output side, the *Value* (third pillar) the companies produce appears in

the form of smart *Products and Services*. The *Value Chain* dimension implements horizontal integration that in turn deals with suppliers, business partners and customers. The connection between the different dimensions and aspects are depicted in Fig.1. In the following subsections, the pillars of the model and the dimensions are introduced in detail. An overview can be found in Table 1.

Table 1. Pillars and dimensions of the CCMS model

Pillar	Topic	Dimension	Questions
Ecosystem	Financial and statistical data Local environment	Local resources Strategy	27 (29%)
Value Creation	Individual Industry 4.0 capabilities Physical resources Processes of the virtual world The human who is able to interpret the data and control the system	Real world Virtual world Human	35 (38%)
Value	Smart products and services Customers, suppliers, and business partners	Products and Services Value chain	30 (33%)

3.1. Ecosystem

This pillar contains a group of management and statistical data questions characterizing the digitalization strategy of the company. Questions aimed at a comprehensive knowledge of the local environment are also included here.

In the *Local Resources* dimension the direct operating environment of the company and the peculiarities of the local market are examined. The issues addressed concern relevant obstacles, available Research, Development and Innovation (R&D&I) services, existing appropriate infrastructure, and up-to-date info-communication technologies.

The companies are asked about how satisfied they are with the conditions of the business environment, the legal environment, institutional provision, and infrastructural developments. Other important aspects involve the financial resources used to support the R&D&I activities and the extent, to which these are applied. The model includes questions about the range of services available in the local market in terms of quantity, quality, and price. The feasibility of environmental awareness and sustainable development raise the question of the company's attitude towards conscious use of energy and materials, as well as their manufacturing methods.

In the *Strategy* dimension, the primary question is whether the company whether the company can align its competitiveness with its advancement towards a higher Industry 4.0 maturity state. It is essential to identify the key areas and measures for which the greatest value will be generated. If such an accepted strategy document exists, it is worth measuring the implementation of it with indicators. Organizational issues, such as the availability of the necessary expert base, the evaluation of parallel infrastructural developments, competitiveness preferences, R&D&I efforts are also relevant. The results of strategic decisions, which address development target areas and the commissioning of tools and technologies that support sustainability, are also investigated.

3.2. Value Creation

Further aspects considered, when assessing a company's capabilities at the micro-level, are the physical resources required to create value in the *Virtual World*. These resources are closely linked to the *Human* dimension, which describes the people who are able to interpret the data and control the systems.

The dimension *Real World* is not just suited to qualify the organization in terms of their Industry 4.0 readiness, but also, in a broader sense, to highlight the strengths and weaknesses of their current market position. The existing equipment and future development directions, challenges, and possibilities of cyber-physical production systems must also be evaluated. New and trending Industry 4.0 technologies are examined in order to identify digital tools that could be applied in the company. It is important to determine where the main challenge regarding the implementation of these technologies lies: Is it in the research, development, realization, or deployment phase? Robot density is an exact and internationally studied indicator that is also included in the model. The qualitative and quantitative criteria of the tools available in logistics and manufacturing, as well as the relevant development ideas of the company are also addressed.

The questions in dimension *Virtual World* take the internal production and logistics processes and their characteristics into account. The addressed issues are the following: the areas of data collection, data processing methods, opinion about robotization and safety of cloud-based platforms, implementation phase of virtual environment.

In the *Human* dimension, impact of robots on the labor market, changing human conditions, type of existing training programs, and the assessment method of employee competences are examined.

3.3. Value

The characteristics of smart products and services and the customers, suppliers, and business partners closely associated are assessed in this third pillar. The hallmark of smart products is the collection and transmission of data about themselves during their product use phase. The question is whether these are utilized by the manufacturer and, if so, where exactly? How well are services built into the company's knowledge base? These questions are investigated in the *Products and Services* dimension.

The *Value Chain* dimension provides an answer to where a company can position itself in the global market. From the analysis of the number of partnerships, the learnings about the organization of the company and the operational philosophy in general, decisive conclusions about horizontal and vertical integration as the basic characteristics of Industry 4.0 can be drawn.

The extent to which a company supports open innovation and whether active innovations management is pursued are relevant to this approach. The territorial embeddedness of the company in the innovation system, the willingness of R&D&I to cooperate, the existence of cooperation with the actors of both the university and research institutes, as well as the

economic sphere are examined. In terms of horizontal integration, the local market players who can be used as suppliers, the level of trust networks that emerge, and the extent and direction of information sharing are important aspects. Organizational philosophy, such as where the company sees its own role in the supply chain and how dominant its added value is, are also addressed.

3.4. Evaluation method

The CCMS model is operated as an online survey, whose results are generated promptly and automatically after finishing the survey. They are presented in an interactive dashboard including statistical results in connection with the responses. The questionnaire has to be filled out by the selected staff of the hierarchy, based on the current state of the company, and the answers in connection with intervention points (which are important fields of improvement included in the survey) are compared to a sector-dependent baseline determined by the model creators. The intervention points are also weighted in a pre-defined manner. The output of the model is an intervention point list determined by the weights and the difference between the current company status and the baseline, which indicates the most relevant fields of action.

4. Industry 4.0 Maturity Index

The Industry 4.0 Maturity Index [13] is a maturity model published in 2017 by the German Academy of Science and Engineering "acatech". In the following, it will also be referred to as acatech model. It was developed by an interdisciplinary consortium of research institutions in different fields with the help of several partners from industry [3]. The model's aim is to determine the Industry 4.0 maturity stage of any manufacturing company and support it in the next steps towards its digital transformation. This is done by identifying areas where further action is required. These results and recommendations are given to the company in a customized roadmap.

To design such a roadmap, an in-depth understanding of the organization is required [3]. This is achieved by regarding the entire value chain of a company as four structural areas of Industry 4.0 with two guiding principles each. The company is externally assessed with the help of several tools such as a digital survey and an on-site workshop. Once assessed, the organization is ranked into one of six maturity stages, which are detailed below. The results of this analysis are given as graphical representations of the business' strengths and weaknesses, which amount to a digital roadmap with recommendations for further action.

The following subsections will introduce the general structure and practical application as well as the structural areas and capabilities of the maturity model.

4.1. Model structure and application

The Industry 4.0 Maturity Index is a tool for manufacturing businesses to assess their current situation and goals concerning their digital transformation from a technological, organizational, and cultural perspective [3]. This is achieved with the aid of a survey whose questions help to evaluate the relevant Industry 4.0 capabilities. The four key dimensions of the model are referred to as "structural areas of resources, information systems, culture and organizational structure" [3]. For each of them, two guiding principles and their respective necessary capabilities are defined (see subsection 4.2).

Before developing the customized roadmap that helps in planning the future of the business, the company is asked to decide on its own target maturity stage, by considering which of the six "represents the best balance between costs, capabilities and benefits for its own individual circumstances" [3]. According to the Industry 4.0 Maturity Index, the six maturity stages that companies go through in their "transformation into learning, agile organizations" [3] are: (1) Computerization, (2) Connectivity, (3) Visibility, (4) Transparency, (5) Predictive capacity, (6) Adaptability. The first two stages, computerization and connectivity, describe the digitalization phase, which is the basic requirement for the implementation of Industry 4.0, as achieved in the following four stages. The third stage focusses on the question "What is happening?" and the fourth on "Why is it happening". Stage 5 deals with being prepared for what may come and stage 6 concerns itself with the creation of autonomous responses.

The Industry 4.0 Maturity Index is divided into the four above mentioned structural areas and another five functional areas: development, production, logistics, services, and marketing & sales. These functional areas, which are based on corporate processes, are each investigated separately regarding the key capabilities derived from the guiding principles of all four structural areas. In practice, these capability evaluations per functional area all give an individual maturity score (from 1 to 6) based on the company's multiple-choice answers to the survey questions, which are each linked to one of the six maturity stages. Together, all these individual maturity stages result in the overall maturity score of the organization.

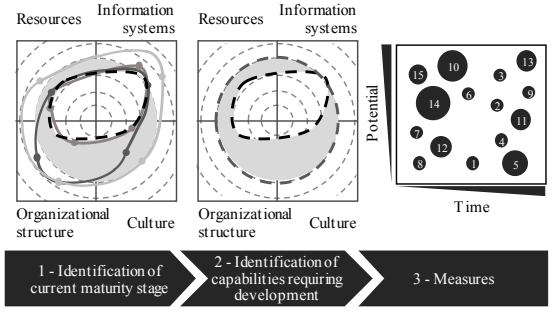

Fig. 2. Application of the Maturity Index [3]

Having applied the above procedure, which includes an on-site tour of the company, and a workshop on existing management processes, the current maturity stage of the organization can be determined. Once a score for the company as a whole is obtained, it is used to identify the desired target maturity stage. This is followed by a gap analysis to determine the missing capabilities that are required to reach such a stage and the areas that still require action. In the final phase of the analysis, recommendations for action are given, and the digital roadmap is built-up, based on various diagrams such as cost-

benefit matrices, visual representations of the required fields of action and their time-potential ratings. These three phases of the model's application are depicted in Fig. 2.

4.2. Structural areas and capabilities

The structure of an organization consists of the four structural areas mentioned above. (see Fig. 3). Each of these structural areas has two guiding principles with several required capabilities assigned to it, which indicate the direction of continued development [3]. The extent to which the capabilities are in place provides a maturity assessment for the guiding principles, which contribute to the overall maturity stage of the structural area.

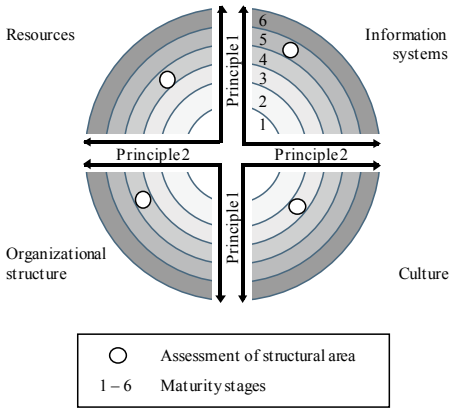

Fig. 3. Overview of structural areas [3]

The *Resources* of an organization include its employees, as well as its machines, tools, materials, and products. To process information purposefully and in a timely manner, the workforce, as well as machines, require "an interface between the physical and digital worlds"[3]. The two principles derived from this comprise digital capability and structural communication, i.e., the necessity of "automated data acquisition through sensors and actuators", and the need for efficient and task-based communication.

The structural area of *Information Systems* addresses the question of how "captured data [can] be prepared and delivered to employees in a way that allows them to make data-based decisions". Therefore, the first principle of this structural area focusses on how information is processed, with capabilities such as "data analysis" and "contextualized data delivery". The other guiding principle refers to information systems integration with the aim to increase agility, which includes "data governance" and "IT security" as capabilities.

The area *Organizational Structure* comprises a company's interior structure and is defined by the guiding principles of "organic internal organization and dynamic collaboration within the value network". The former aims at giving employees more individual responsibilities and fewer constraints. The capabilities required include building flexible communities and implementing decision rights management and motivational goal systems. The principle of dynamic collaboration aims at enhancing the organization's focus on customer benefits, as well as cooperation.

The structural area of *Culture* is closely linked to the above. It refers to the company's willingness to change (first principle) and the implementation of social collaboration (second principle).

5. A combined, two-step assessment with CCMS and the acatech model

The acatech Industry 4.0 Maturity Index's extensive approach provides detailed hands-on results and is beneficial for most companies. However, the high investment in terms of personnel resources for carrying out the analyses deters those who are still unfamiliar with Industry 4.0. This section suggests a two-step assessment that combines the CCMS and acatech models into a more accessible, low-risk approach.

This approach slowly introduces hesitant companies to the concept of maturity models by first implementing the CCMS model as a quick maturity assessment. The results of the CCMS model, which include a priority list of relevant intervention points, allow for a high-level overview of the company and its as-is status. This new perspective enables the company to select meaningful targets for their digital transformation and Industry 4.0 developments. These targets are essential for the success of the acatech model, which is now applied as a second step of the combined approach (see Fig. 4). The outcome of the overall process is a customized roadmap detailing how to close the gap between the target state (determined by the CCMS model) and the present state (determined by the acatech model).

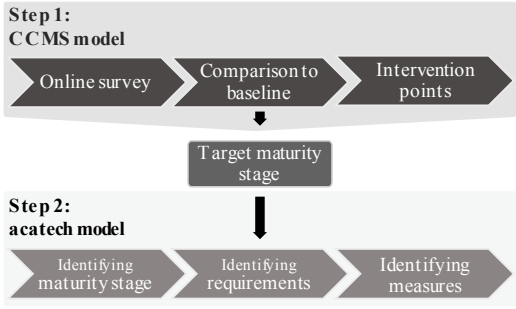

Fig. 4. Two-step assessment approach with the two models

As EROL ET AL. mention in [18], one of the main problems regarding Industry 4.0 is the lack of understanding of the concrete relevance and benefits of the concept. According to this, companies require guidance and suggestions from experts. Without them, isolated solutions may come to life – the most common being an isolated focus on technological aspects and the assumption that Industry 4.0 is achieved by just introducing smart machines and more AI into one's business. These issues are addressed by the suggested approach, which guides companies throughout the decision-making process:

The CCMS model creates a global view of the company and a first understanding for its potential areas of improvement. This not only helps the company in determining their digitalization targets, but also justifies the investment into the more involved acatech model by hinting at its upcoming financial returns.

This new approach may seem redundant, as it combines two existing assessments without introducing any substantial

changes. However, the aim of this two-step assessment is not to change the CCMS model nor the Industry 4.0 Maturity Index, as both of them work well for their separate purposes. Instead this new method is meant as guidance for small and medium-sized enterprises (SME). It is ideal for those SME that are still in the early stages of their Industry 4.0 development and who do not wish to make any precipitated decisions. The actual application of this approach may therefore vary depending on the context and the experience of the company. By taking the time to follow this two-step assessment the company will secure itself the advantages of both sides: a detailed assessment of their current situation and a customized roadmap on how to achieve their carefully chosen target.

6. Conclusion

In this paper, two maturity models were selected from an extensive literature research for a detailed analysis and their combination into a new low-risk approach to Industry 4.0. The CCMS model focusses on providing a quick overview of the company via an online survey. Its results enable decision-makers to define clear digital transformation targets for their company. These serves as investment purpose and input for the acatech Industry 4.0 Maturity Index, the second step in the combined approach. The acatech model provides detailed results and defines customized improvement measures based on a deep, micro-level investigation of the company, including on-site visits, workshops, and a survey.

This recommended approach is not a new maturity model in and of itself, but a combination of the advantages of each of the two models into a low-risk procedure offering more guidance and understanding. This is particularly useful to companies, who are new to Industry 4.0, as they are slowly introduced to the concept and enabled to set meaningful targets before any high investments are made."

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References

[1] Lasi H., Kemper H., Fettke P., Feld T., Hoffmann M. Industry 4.0. Springer Fachmedien; 2014.

[2] Rüßmann M., Lorenz M., Gerbet P., Waldner M., Justus J., Engel P., Harnisch M. Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries. Boston Consulting Group 9.1; 2015; 54-89.

[3] Schuh G, Anderl R, Gausemeier J, ten Hompel M.. Industrie 4.0 Maturity Index. Managing the Digital Transformation of Companies – UPDATE 2020 - (acatech STUDY). Munich; 2020.

[4] Kagermann, H.; Lukas, W. D.; Wahlster, W.: Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution. VDI Nachrichten; (13); 2011.

[5] Leineweber S., Wienbruch T., Lins D., Kreimeier D., Kuhlenkötter B. Concept for an evolutionary maturity based Industrie 4.0 migration model. Procedia CIRP; 2018; 72; 404-409.

[6] VDMA and Partners. Guideline Industrie 4.0 Guiding principles for the implementation of Industrie 4.0 in small and medium sized businesses. Frankfurt am Main: VDMA Verlag; 2016.

[7] Puchan J., Seif H., Mayer D., Bestimmung des Stands deutscher produzierender Unternehmen auf dem Weg zu Industrie 4.0 und Verwendung der Ergebnisse für ein Industrie-4.0-Reifegradmodell. Lucerne: mana-Buch; 2015; 60-68.

[8] Nick G, Szaller Á, Bergmann J, Várgedő T. Industry 4.0 readiness in Hungary: model, and the first results in connection to data application. IFAC PapersOnline; 2019; 52 (13) : 289-294.

[9] Nick G, Gallina V, Szaller Á, Várgedő T, Schumacher A. Industry 4.0 in Germany, Austria and Hungary: interpretation, strategies and readiness models. Proceedings of the16th IMEKO TC10 Conference; 2019; 71-76.

[10] Jodlbauer H., Schagerl M. Reifegradmodell Industrie 4.0 - Ein Vorgehensmodell zur Identifikation von Industrie 4.0 Potentialen. Bonn: Gesellschaft für Informatik; 2016; 1473-1487.

[11] Leyh C., Schäffer T., Forstenhäusler S. SIMMI 4.0 – Vorschlag eines Reifegradmodells zur Klassifikation der unternehmensweiten Anwendungssystemlandschaft mit Fokus Industrie 4.0. Dresden: 2016.

[12] Marheine C., Gruber L., Back A. Innovation durch den Einsatz von Enterprise IoT-Lösungen: Ein Modell zur Bestimmung des Innovationspotenzials. HDM 56; 2019; 1126-1143.

[13] Mittal, S., Khan, M., Romero, D., Wuest, T. A Critical Review of Smart Manufacturing & Industry 4.0 Maturity Models: Implications for Small and Medium-sized Enterprises (SMEs). Journal of Manufacturing Systems; 2018; 49. 194-214.

[14] Goericke D, Lichtblau K, Stich V. Industry 4.0 Readiness Online Self-Check for Businesses. Cologne/Aachen: Cologne Institut for Economic Research Consult GmbH (IW Consult) & Institute for Industrial Management (FIR) at RWTH Aachen; 2020. https://www.industrie40-readiness.de/?lang=en.

[15] Schuhmacher A. Fraunhofer Industrie 4.0 Reifegradmodell – Digitalisierung im Unternehmen systematisch umsetzen. Vienna: Fraunhofer Austria Research GmbH; 2016.

[16] Innovationszentrum für Industrie 4.0 GmbH & Co. KG. Strategic Consulting. Regensburg; 2020. https://www.i40.de/consulting/.

[17] Kidschun, F.; Hecklau, F.; Orth, R.; Singer, K. (2019): Development of an organisational structure model as a basis for the assessment of the digital transformation of organisations. In: Proceedings of the 15th European Conference on Management, Leadership and Governance, pp. 217-226, 14.-15.11.2019, Polytechnic Institute of Porto, Portugal.

[18] S. Erol, A. Schumacher, and W. Sihn, "Strategic guidance towards Industry 4.0 – a three-stage process model," in Proc. of International Conference on Competitive Manufacturing 2016 (COMA16), Stellenbosch, South Africa.

[19] Nick G., Szaller Á., Várgedő T. CCMS Model – a Novel Approach to Digitalization Level Assessment for Manufacturing Companies Proceedings of the 16th European Conference on Management, Leadership and Governance, ECMLG 2020 Reading, United Kingdom, Academic Conferences and Publishing International Limited (accepted)