INDUSTRY 4.0 IN CLUSTERS

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Abstract

The paper aims to explore the consequences of applying industry 4.0 in a specific cluster. Current literature and discussions focus on different aspects of the industry 4.0, often on its application in companies and subsequent changes in the society. However, the discussion lacks emphasis on industry conglomerates such as clusters. The research reviews different aspects of the cluster towards the application of industry 4.0 and its possible consequences, limitations and relations typical for clusters. It applies Porter's cluster mapping to determine the current cluster competitive advantages. Semistructured interviews with cluster management and survey among active cluster members determine relevant dimensions to measure the cluster preparedness for industry 4.0. The identified industry 4.0 aspects enhance the current cluster mapping with insights for the application of industry 4.0 in an industrial cluster. The research reacts to the need to study the relation between clusters and industry 4.0 - the requirements and consequent benefits.

Key words: Industry 4.0, Cluster, Maturity model, Cluster mapping

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Introduction

The current discussion about industry 4.0 (i4.0) comprises different technological aspects such as additive manufacturing, collaborative robots or cyber physical systems. The discussion also includes some management, social and economic aspects. However, the main subject of the discussion is firms. So far, the literature fails to include Industrial conglomerates, such as clusters, in the discussion. Therefore, the aim of this paper is to explore i4.0 within a cluster.

The today´s society is typical for turbulent changes that arise along with new technologies and disruptive innovations. As the time is really dynamic, industry and institutions must be flexible

and fast enough to reflect the changes and appropriately respond in order to be able to survive on the market.

This condition does not apply only to companies that are always at the center of attention, but also to the relevant business networks, such as clusters. Clusters are often the basis of a regional competitiveness. Their task is usually to identify the problems faced by businesses and all its other participants and then develop their program statement and action plan to increase the competitiveness of the cluster.

This paper aims to explore the consequences of applying industry 4.0 in a specific cluster. It reacts right on the current lack of discussions on relation between i4.0 and interorganizational networks such as clusters. Research and studies have been often focused only on i4.0 in companies and institutions by now.

1 Theoretical background

Clusters are geographically close groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills (Porter, 2008). The usual members of a cluster include firms, financial institutions, specialized infrastructure providers, government and other institutions providing specialized training education, information, research, or technical support. The cluster members obtain benefits from access to technology that might have been unaffordable on their own. They also have the opportunity to contribute with the development of the human resources required for generating new innovative ideas and products in the new industry of the Internet of Things (Mihailescu, Svasta, & Marghescu, 2015). Porter wrote in 2003 in the foreword of a Cluster Greenbook (Sölvell, Ketels, & Lindqvist, 2003): "As more and more resources are devoted to efforts to foster cluster development, the need to understand best practice has become urgent".

As the Landau and Rosenberg's (1986) model describes, knowledge creation and innovation can be viewed as collective processes. Although clusters are often at the forefront of technical progress and they are important linkages and spillovers of technology, skills and information, there are currently no discussions about i4.0 and its impact on interorganizational networks such as clusters. This paper reacts on this lack, maps the current state and sets the appropriate maturity levels of clusters in i4.0.

The term industry 4.0 marks the start of the fourth industrial revolution. Its characteristics are mass expansion of the Internet and its impact on human activity. The Internet itself is not new, but what is typical for today, is the interconnection of Internet of things, services and people and the associated large volume of generated data. Production is characterized by the advent of new technologies such as autonomous robots, large data analysis, computer simulation and virtualization, cloud, 3D printing, and expanded reality. The key concept becomes digitization.

As J. A. Simpson and E. S. C. Weiner (1989) claim, the term maturity refers to a state of being complete, perfect, or ready. It implies some system evolution and final, desirable future state. Maturity models are used for measuring maturity of an institution or a process regarding some specific target state (Schumacher, Erol, & Sihn, 2016). The maturity evolution is limited by the number of maturity levels (often by 4-6 levels). The individual levels are arranged from the primary to the final target one. The development should proceed from one level to the next, no level should be omitted or overlooked (Khatibian, Hasan, & Jafari , 2010).

Recently some maturity models have been proposed, for example knowledge sharing maturity model (Arif, et al., 2017) or a maturity model in SME's towards Industry 4.0 (Ganzarain & Errasti, 2016).

2 Methodology

The aim of the paper is to explore the consequences of applying i4.0 in a specific cluster. The proposed model identifies relevant dimensions of i4.0 in clusters. These dimensions cover the typical aspects for strategic alliances which characterize the preliminary maturity model. This model enables the assessment of the current stage of cluster maturity towards i4.0. This assessment determines the required areas for further improvement, and on the contrary, the strengths in which the cluster become a best practice.

The research implements comparative analysis of the current maturity models and case study research design for the specification of the model and the assessment of the cluster.

The research explores different approaches and maturity models of i4.0 application in companies. The comparison of these models identifies possible relevant aspects for clusters and the development of a theoretical maturity model.

The information from the identification of the theoretical maturity model allows the development of a semi structured interview. This is conducted with the current cluster management. The interview aims to confirm, reject, add or modify the theoretical dimensions of the model. The compiled information from the interview determines the maturity model. Furthermore, active cluster members review the maturity model developed with the cluster management. Surveys facilitate the collection of the data. The data from the surveys enhances the proposed maturity model.

The final stage is the application of the model in the cluster. Data from the surveys and additional semi structured interview determine the assessment of this specific cluster towards i4.0. The model levels describe different stages of maturity towards i4.0 aspects. The last, fourth level, represents the last stage, in which the cluster has already implemented i4.0 policy in the appropriate dimension.

The chosen cluster and subject of this research is cluster OMNIPACK. The semi-structured interview is conducted with the cluster manager who has been working for the cluster since its foundation and it represents more than 10 years by now. Furthermore, 17 out of the 20 active members complete the survey for the enhancement of the model and the assessment of the cluster.

The cluster focuses on design and production of industrial packaging and packaging technology. The clusters activities also include logistics firms, service organizations and educational institutions.

The arguments to select of this cluster emphasise its openness to innovations. The cluster's mission states: to increase the competitiveness and economic growth of packaged and logistics services by supporting its innovative activities. The cluster management aims to coordinate functional cooperation between members. They also procure the expansion of existing infrastructure and the creation of tools that allow more efficient use of internal resources and capacities. All these activities aim for an environment favourable for the development of innovative activities, economic growth and increased competitiveness. Besides its strategic focus on innovation, this cluster represents one of the most stable and mature clusters in the Czech Republic.

3 Findings

The research deploys an i4.0 maturity model for clusters and the assessment of one cluster with this model. The model includes five dimensions: strategy, cyber security, processes, data and collaboration. Each dimension presents four maturity levels. The first represents the initial level of cluster preparedness for i4.0 while the fourth level describes already mature cluster which has fully developed the relevant aspects of i4.0.

Tab. 1: Cluster i4.0 maturity model

Levels	Level 1	Level 2	Level 3	Level 4
1. Strategy				
1.1. Defined strategy i4.0	Cluster is not familiar with the i4.0 concept. Strategy i4.0 is not defined.	Cluster is familiar with the i4.0 concept. Strategy i4.0 is not defined, but cluster is considering its creation.	Cluster is preparing strategy i4.0.	Strategy i4.0 is defined and implemented.
1.2. Investments	There is no investment in i4.0, cluster does not consider investments in future.	There is no investment in i4.0, but it is planned in future.	Cluster already invested in i4.0, but does not plan any further investment.	Cluster already invested in i4.0 and is open to further investments.
1.3. Benefit analysis	Benefit analysis of i4.0 in the cluster is not prepared and it is not being considered in future.	Benefit analysis of i4.0 in the cluster is not ready yet, but its preparation is being considered.	Benefit analysis of i4.0 in the cluster is prepared.	Benefit analysis of i4.0 in the cluster is prepared and being actively used.
1.4. Institutional readiness analysis	The readiness analysis is not prepared and it is not being considered in future.	The analysis is not prepared, but its preparation is being considered in future.	The analysis is prepared.	The analysis is prepared and being actively used.
2. Cyber security				
2.1. Data storage	Data is not stored.	Data is stored internally only.	Data is stored in a shared repository.	Data is stored in the cloud.
2.2. Backup power source	No spare power supply is provided and it is not being planned.	Backup power source is not provided, but it is being planned in future.	Backup power source is provided for critical activities only.	A backup power source is provided for all activities.

2.3. Data backup	Data is not backed up.	Data is backed up, but not at regular intervals.	Critical data is backed up at regular intervals.	All data is backed up at regular intervals.
2.4. Access to data	Members of the cluster have access to data without any restrictions.	All members of the cluster have access to the data with some restrictions (password).	Chosen members (management) of the cluster have access to the data with some restrictions (password).	Cluster members have access to data according to their assigned roles. Authorization process.
3. Processes				
3.1. Digitization of communication	Communication is not digitized and it is not planned in the future.	Communication is not digitized, but it is planned in the future.	Communication is partly digitized.	Communication is fully digitized.
3.2. Joint investment decision making	There is no set process for joint investment decision making and it is not planned.	There is no set process for joint investment decision making, but it is planned in future.	There is a process for joint investment decision making.	There is a process for joint investment decision making investment, which uses a common digital platform.
3.3. Knowledge sharing	Knowledge is not shared among institutions and it is not planned in the future.	Knowledge is not shared among institutions, but it is planned in the future.	Knowledge is shared, but there is no common platform.	There is a common platform for knowledge sharing and knowledge is being shared.
3.4. Joint purchase	There is no process of joint purchase.	There is a process of joint purchase, but it is not digitized.	The process of joint purchase is partly digitized.	The process of joint purchase is digitized.
4. Data				
4.1. Data collection	The cluster does not collect data and does not consider it in future.	The cluster does not collect data, but it is planned in future	The cluster collects data ad hoc. There is no common platform.	The cluster collects data regularly through common platform.
4.2. Level of automation of data processing	Data is not collected.	Data is collected manuály.	Data collection is partially automated.	Data collection is fully automated.
4.3. Ability to process data in real time	Data is not being processed.	Data is processed with a delay.	Some data is being processed in a real time.	Data is being processed in a real time.

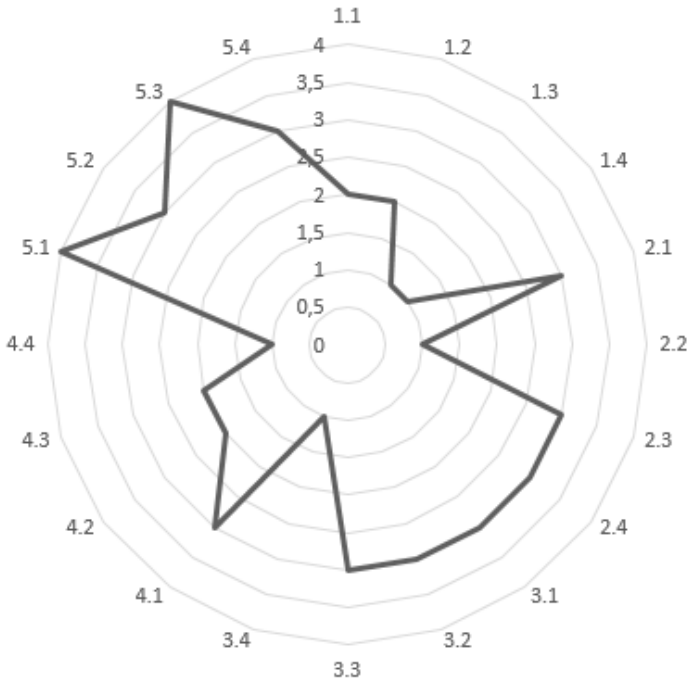
4.4. Ability to use data	Cluster does not use data and does not consider it in future.	Cluster does not use data, but it is planned in future.	Cluster can only use part of collected data.	Cluster is able to use its data.
5. Collaboration				
5.1. Research and development	Cluster does not have joint research and development and it is not planned in future.	Cluster does not have joint research and development but it is planned in future.	Ad hoc projects, mostly inconsistent with the cluster´s vision.	Research projects correspond to the vision of the cluster and are responsive to current market trends.
5.2. Sharing experience with suppliers	Institutions do not share their experience with suppliers and they do not plan to do that.	Institutions do not share their experience with suppliers, but it is planned in future.	Institutions share their experience with suppliers, but there is no set proces.	Institutions share their experience with suppliers and the cluster offers platform and processes for sharing.
5.3 Sharing outcomes from joint research and projects	There are no outcomes of joint research and projects.	Outcomes of joint research and projects are not available to all members.	Outcomes of joint research and projects are available to all members, but most of them does not benefit from them.	Outcomes of joint research and projects are available to all members and they often benefit from them.
5.4 Services	Institutions deal with services independently and cluster does not consider offering a joint demand for services.	Institutions deal with services independently, but cluster considers offering a joint demand for services.	Institutions are asking for selected services through cluster, but there is no set proces.	Institutions are asking for selected services through cluster, there is a set proces.

Source (Adapted from interviews with cluster members)

Interviews and survey also revealed the state of preparedness of the OMNIPACK cluster. The dimensions are described in the radar chart (Fig. 1), which also describes the strengths and weaknesses towards the i4.0 in the cluster. The strongest part in the analyzed cluster is collaboration – especially research and development and sharing outcomes from joint research and projects, in which cluster got the maximum points (5.1, 5.3). On the other hand, the weak dimensions in the observed cluster are represented by the absence of benefit and institutional readiness analysis (1.3, 1.4), absence of backup power source (2.2), no process of joint purchase (3.4) and its inability to use data (4.4). There is neither defined strategy of i4.0

nor properly secured data.

Fig. 1: Maturity levels of cluster dimensions



4 Discussion

The dimensions of the maturity model for cluster are similar than the dimensions for a company. The main difference is the maturity levels. Each dimension presents the four stages of maturity within the cluster but avoid the assessment of the maturity of the organisations in the cluster. The premise of the model is that the simple addition of the maturity level of the cluster's members fails to indicate the maturity level of the whole cluster. This means that the cluster as single entity possesses it own i4.0 level. Moreover, it is important to consider the maturity level of the members. Cluster as a service provider collects members' requirements. Therefore, it is expected that the increase of the members' maturity level positive influence the i4.0 maturity level of the cluster. This is an important aspect to explore in future researches.

The last dimension which describes cluster´s collaboration is specific right for clusters as they are consisted of institutions from different fields operating within. It is one of the primary objectives of the cluster. Simultaneously, securing high level of collaboration maturity

is important for the member firms so they can really benefit from being part of the network. Without good level of collaboration cluster cannot develop other dimensions of the maturity model.

Among the main limitations of the study can be considered application of the maturity model in clusters without previous analysis of members' readiness for i4.0. The model expects a certain stage of maturity of companies and other member institutions on which can then the cluster build. Cluster cannot foster the i4.0 concept when the members are not ready for it.

In general, the term maturity refers to a state of being complete, perfect, or ready (Simpsons et al., 1989) and implies some progress in the development. The analysis of readiness happens before engaging in the maturing process whereas maturity assessment aims for capturing the as-it-is state whilst the maturing process (Schumacher, Erol, & Sihn, A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises, 2016).

The future research would focus on the relation of institutional and cluster readiness and the practical implication of the maturity model. The results described by this paper should be confirmed by their application in other clusters and adjusting found differences.

Conclusion

Although there are maturity models towards industry 4.0, which were being recently published, they are not considering the industrial networks at all. The purpose of designing the cluster i4.0 maturity model as was described above is to capture all the relevant areas the cluster should pay attention to, and so help increase its competitiveness. Matured cluster can provide such an environment for its members that enables besides secured data sharing in a real time, digital communications, joint research and development and joint investments. The proposed model suggests desirable levels of maturity towards these i4.0 aspects.

The output of the model is cluster analysis in the form of radar chart and its current stages of readiness towards i4.0. The analysis also highlights the strengths and weaknesses that the cluster should pay more attention to. The cluster should not forget, that it must firstly help increase the maturity of its members so the cluster infrastructure can connect to the already existing one and build on it.

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