Value Network Development in Industry 4.0 Environment

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Abstract. We are moving towards fourth industrial revolution through the development of digitalization. Globalization, shortage on resource, change on purchase behavior, urbanization e.g. influence on new competitive situation in every industry segment. This causes as well remarkable change pressures and opportunities for most of the industry. The development of competitiveness of the region as attractive and maintaining it continuously requires co-operation between actors and building up a Roadmap, how to do continuously and systematically small development steps towards the vision and start development activities according that. This article introduces created development process and framework for regional Roadmap-development for various industry segments in Industry 4.0 environment. It also analyses how the increase of digitalization influences on work environment. The most important is how the mindset of people and behavioral culture is possible to change. The introduced industry sectors are manufacturing industry and circular economy.

Keywords: Industry 4.0 · Value network · Digitalization · Transdisciplinary · Co-innovation · Co-evolution

1 Introduction

Many observers believe that Europe is at the beginning of a new industrial revolution, considered to be the fourth such leap forward and hence labelled Industry 4.0. The ubiquitous use of sensors, the expansion of wireless communication and networks, the deployment of increasingly intelligent robots and machines – as well as increased computing power at lower cost and the development of 'big data' analytics – has the potential to transform the way goods are manufactured in Europe. This new, digital industrial revolution holds the promise of increased flexibility in manufacturing, mass customization, increased speed, better quality and improved productivity. However to capture these benefits, enterprises will need to invest in equipment, information and communication technologies (ICTs) and data analysis as well as the integration of data flows throughout the global value chain [1].

The role of Finnish manufacturing industry is not often to be the main contractor (OEM) but biggest potential is in acting as subcontractor (SME) in supplier network for big international main contractors and be as part of their value network.

Succeeding in future in global supplier network requires that operations of main contractors and subcontractors are connected effectively and seamlessly together. Value networks function by flexible and cost efficient way and evolve continuously according the needs of main contractor and global competition.

The development of competitiveness of the region as attractive and maintaining it continuously requires co-operation between actors and building up a Roadmap, how to do continuously and systematically small development steps towards the vision. It is also important to benchmark industrial case studies and field labs on various other regions and find the most successful ones (e.g. Germany, Sweden, Austria).

Subcontracting network of manufacturing industry has significant influence on wellbeing, activity and employment of regions and areas. That is the reason, why regions/cities/countries has to develop and secure the competitiveness of industry and society. In future, the most essential task is to engage the companies and other stakeholders on regions as part of the development of Industry 4.0 and form a functioning ecosystem for the development work.

This article will demonstrate that 4.0 Industry is not only the goal but also the means. It introduces a strategic concept, responsible business leadership, for utilizing responsibility as a business and innovation driver to facilitate the transition of industrial business towards the new service economy. 4.0 Industry is creating significant impact and opportunities where business, technology and innovation intersect.

Digitalization is rapidly increasing and enterprises must find new ways to innovate for business advantage. Through digital transformation, the use of new technologies like cloud, mobile, big data, and social networks with increasing intelligence and automation enterprises can capitalize on new opportunities and optimize existing operations to achieve significant business improvement. The collection of enormous amount of scattered data, clustering it for analysis, visualizing it for decision making and using the selected data in new service development and execution is most important in the concept of responsible business leadership.

Häme University of Applied Sciences (HAMK) has a Smart Service-research center as dynamic breeding environment to create and execute, together with co-operation network, well-addressed research and development activities for regional and enterprise development needs. The research unit supports cross-sectorial utilization of digital technologies and service business development. The objective is also to offer development support for municipal, industrial and commercial organizations by creating new opportunities and responding on business transition challenges. The management of responsibility in value network and entire society is becoming an important business driver. Most of companies, which are moving towards service business, need new concepts to manage life cycle business on the responsible way.

Most companies do not have a strategy or analysis on aligning business to digitalization. Being green to achieve mitigation, clean to reach up to optimization and smart to manage the transformation is the integrated, evolutionary approach. 4.0 Industry is an opportunity integrator on the path. Integrating novelty with technology brings new opportunities for more responsible business models. The transformation

towards digitalization business takes a long time and that is why it is important to fully understand the strategic concept, identify the key issues and harness the associated opportunities.

2   Theoretical Background

The term "Industrie 4.0" was initially coined by the German government. It describes and encapsulates a set of technological changes in manufacturing and sets out priorities of a coherent policy framework with the aim of maintaining the global competitiveness of German industry. It is *conceptual* in that it sets out a way of understanding an observed phenomenon and *institutional* in that it provides the framework for a range of policy initiatives identified and supported by government and business representatives that drive a research and development programme [2].

Industry 4.0 describes the organization of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the 'smart' factory of the future where computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralised decisions based on self-organization mechanisms. The concept takes account of the increased digitalization of manufacturing industries where physical objects are seamlessly integrated into the information network, allowing for decentralized production and real-time adaptation in the future [2].

In the field of **social change** there is little awareness of Industry 4.0 outside the group of key stakeholders. Larger firms tend to be more positively disposed whereas unions remain cautious and have reservations. While a skills gap (as well as a gap in willingness) to adjust to the Digital Single Market exists, the skill requirements to adjust to Industry 4.0 are much greater [2].

The physical world is merging with the virtual world. We are increasingly used to the internet of things, or the internet of everything and increasingly the industrial internet. They all are in the throes of digital transformation. The widespread adoption of information and communication technology (ICT) is increasingly accelerating the blurring of boundaries between the real physical world and the virtual one. The linkage is becoming increasingly Smart [3].

New ITC based technologies make possible 4.0 Industry development and give opportunities to reengineer value chains and create new business models. Internet of Thinks (IoT) is one of the technological fundaments for 4.0 Industry. Growth of connections brings the new possibilities and solutions for business. Other hand exponential growth brings also new challenges for education, R&D&I and regional development activities. The exponential growth of IoT connections indicates the birth of new business models and new kind of business environments.

This "smartness" requires greater connection and collaborations. This is where the 'explosion' of platforms and ecosystems is occurring. To attempt to connect the internets of things, services, data, and people are needing radical redesigns within industries and the participants to connect all of this up. Presently Industry 4.0 is more industrial driven but this will change and broaden out [4].

Eppinger [5] has discovered that the link between sustainability and innovation is commonly mentioned, but not commonly made. Chesbrough [6] points out there are a new logic behind open innovation, which embraces external ideas and knowledge in conjunction with internal R&D. This offers a novel way of creating value. Miller and Langdon [7] introduce how to manage disruptive innovation by managing platform, product and process innovation in continuous cycles. Nidumolu, Prahalad and Rangaswami, [8] explain widely why sustainability is now the key driver of innovation. Salminen [9] has discovered that when new value for the customer is created in the form of a product or service offering and it results in sustainable innovation, it is essential to know whether there is also a transition into a new business model of circular economy. At the same time, the business innovation must be built on the essential business structures (operational systems, contracts, network structures, competence, etc.). Tammela and Salminen [10] introduce the interoperability concept through which common innovation of sustainable products and services can be accelerated by an open semantic infrastructure. The open innovation process requires the definition of interoperability in order to achieve a critical level of network dynamics to create new products and services. Skyttner [11] introduces new systems theory with self –organization and evolution. Jamshid [12] introduces that system thinking is the art of simplifying complexity. It is about seeing through chaos, managing interdependency, and understanding choice. Concepts are important to explain chaos. Sanchez and Heene [13] have proposed an open systems model of firms. Improving of organizational competence also requires increasing managers' own cognitive flexibilities to imagine new strategic logics for creating and realizing new kinds of value-creating product offers and new ways of managing processes for creating and realizing new and existing product offers. Markopoulos and Vanharanta [14] have created the Company Democracy Model. It can be characterized as a multidisciplinary science, as it integrates many management (strategy, leadership, etc.), engineering (process knowledge, innovation), social (human resources, ethos, etc.), financial (marketing, extroversion, etc.) and other disciplines. The uniqueness of the model is its capability to integrate them all in a transparent way, making the execution sequence these disciplines to seem absolutely normal, reasonable and effective. The co-evolutionary spiral method in the model contributes towards the identification and achievement of the capacity, capability, competence, and maturity needed to turn knowledge into innovation. The model is structured in such a way that the method reflects the Co-Evolute methodology [15] and its application in organizational democratic performance. Evolute is an intelligent web-based system for managing human competences and organizational objects and capability in the world of business. Both organizational development methodologies (Co-Evolute and the Company Democracy Spiral Method) are directed towards the creation of an organizational knowledge based culture [16].

3   Research Questions and Research Approach

Digitalization will bring new business opportunities, and increasing competition. Companies are forced to renew their processes and activities and same time restructure their business models. As well, regions and areas have forced to plan and redesign

again their attractiveness for new and existing business in their business environments. In order to see the development needs for attractiveness and welfare, but also to use the development recourses best possible way the key research questions are:

1. How to determine the implementation plan and roadmap for Finnish Growth Corridor to industry engagement on the approved Industry 4.0 European Growth Strategy
2. How education can updated to responds the need of new competition in exponentially growing digital environment
3. How to ensure the change and innovations in organizations.
4. How to define the roles of actors in regional development and "smart clusters"
5. How to start using the Industry 4.0 framework in continuous development

This article introduces a concept model for utilizing 4.0 Industry as a business and innovation driver to facilitate the transition towards the new Digital Single Market.

4   Multidisciplinary and Co-operative Environment

Digitalization changes everything and is a great opportunity to find out competitive advantage in business. Universities of applied science have a good opportunity and central role in supporting the growth of business on the area of circular economy.

The co-operation between government, enterprise and universities is essential to succeed in co-evolution when building up cumulative competence in creation of solutions for Regional Development by benefiting digitalization in it. It is also essential to have a common vision to direct the local operation and funding. Otherwise, the activities can splinter as small pieces and do not form parts of the whole vision.

The development of business environments is understood to be the responsibility of public sector and government. Public sector is however multilayered (e.g. legislative-national- provincial- regional- municipal- areal). There are still other committees and operations, which have the duty to develop business environment. All the layers and activities should be along the same line, support each other and sustainable to get the co- operative environment to function efficiently. In rapidly changing operational environment, it requires clear and commonly understood vision.

The vision and approach are based on the need of regional clusters and the strengths of region (e.g. logistic, university, natural recourses etc.). 4.0 Industry development will been seen as a smart utilization of digitalization, which has European level comparability to European development in all key clusters.

Development roles will be designed the way that roles are tested in region where development is ahead. That approach mean that Reginal level organization (HAME OWL) is taking responsibility about the common platform and development resource allocations for the clusters ("smarts").

Contents of education and training will be designed so that content will respond the future needs. Learning will take place in "real world" environments (field labs), which gives faster cycle time for development activities and implementation. This is the way, how to ensure the birth of new innovations and the renewing the businesses and organizations (Fig. 1).
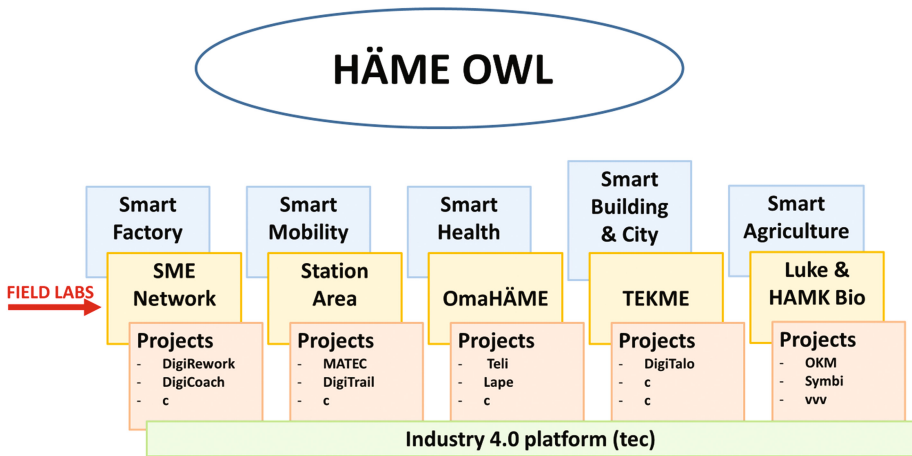
Fig. 1. Häme Region Cluster/"Smarts", field labs, future development projects and platform.

4.0 Industry and industrial internet can then be used when increasing the efficiency of processes. Industrial internet enables functional optimization of entire value network and increasing of use of material side flows (material and energy efficiency). It is possible to anticipate beforehand the disturbance situation of value network and their repair operations. Collected data from whole the value network can be used for its functional development or forecasting purposes. New entrepreneurship and new digital services can be created through digitalization activities. Industry 4.0 standard architecture can be applied for common framework, when starting business on circular economy.

In Fig. 2, there is an example of technology oriented competence and solution creation on the smart clusters. It is essential to gather data from various sources and different processes. Automation system or sensor network (IoT) is creating data, which is gathered, clustered, analyzed and compare it with the data gathered earlier and then make decisions on how the optimize activities. To support this value network process it is important to have all type of experts in virtual network optimizing material, logistic and reuse of material. There can also be final customer experts in the same network.

The substance in the network is knowledge and capability, which is activated when the customer requirements are decomposed. In order to manage economical and technical risks the new innovation should be evaluated as a value for customer and network partners. Effective method of decomposing the requirements reveals precisely. Content management competence, organizational capability and human mental capability are in strong interrelationship. It is planned to parametrize each of the entities and turn as a questionnaire's. Evolute- system is thought to gather and analyze the knowledge needed.

New ITC based technologies make possible 4.0 Industry development and give opportunities to reengineer value chains and create new business models (Fig. 3).
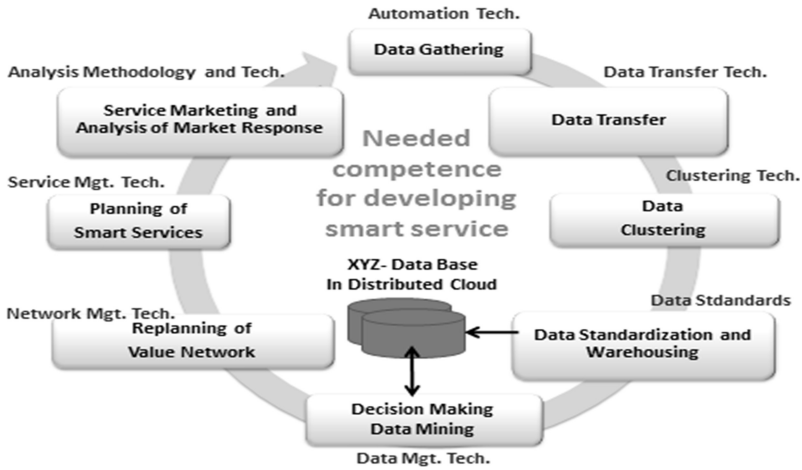
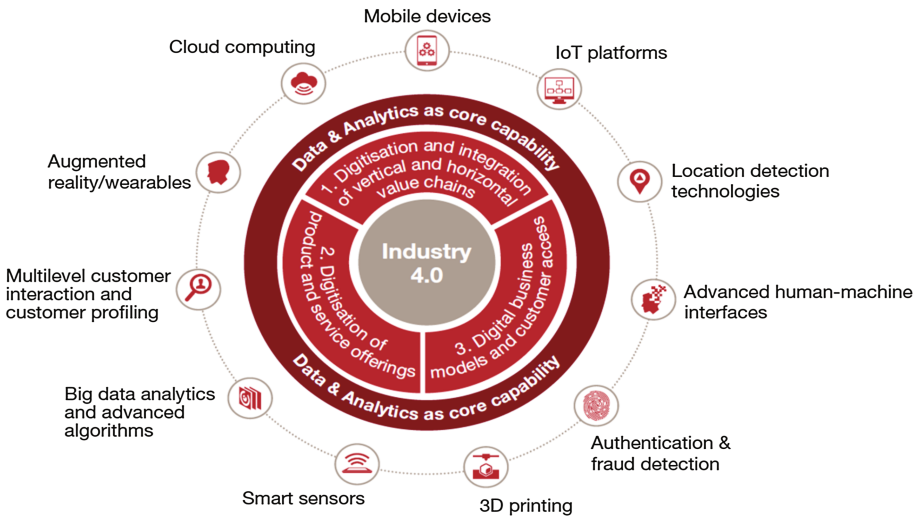**Fig. 2.** Relationship of technology and competence using the data effectively

Fig. 3. Industry 4.0 framework and contributing digital technologies [4]

5   Pilot (Case: BioEngineering (ICT))

In order to develop its own knowledge and flexibility to response the demand of exponentially growing digitalization and transdisciplinary problems. Based on that development, HAMK has designed new program (BioEconomy Engineering ICT), with the idea, that it will be first pilot step to start implement 4.0 Industry concept in "Smart" BioEconomy Cluster and start learning process to make change toward 4.0 Industry also in other "Smart" Clusters and whole Häme Region.

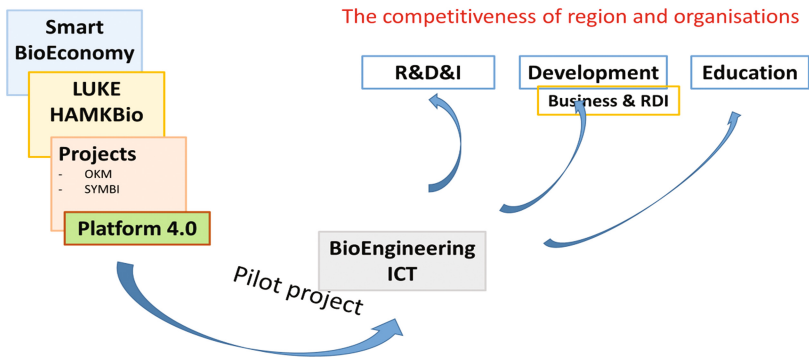## Pilot Case: BioEconomy engineer (ICT)

Fig. 4. The content of BioEngineering DP is planned so that it support the development of industry and region.

Content of studies and learning method with the cooperation of industry are designed 4.0 Industry compatible. (BioEngineering DP is ICT programme for BioEconomy environment.) (Fig. 4).

Education will take place in close cooperation with industry by doing projects by "resolving real life" problems. By this approach is possible to educate students to response to transdisciplinary problems, but also to speed the development in industry and region.

The every study module of degree programme is planned so that it will support regional development and R&D&I activities. This is considered to be very important to be able to find new innovations in company surface. In order to create unik organization culture many other degree programmes are involve and their cultures, not only because of their knowhow.

Partly "R&D-teams" will take care of a few study modules, in order to strengthen the content of new technologies in HAMK. R&D-teams will operate over the study programme and faculty boarders and will participate actively human resource activities.

The study modules which are ran by "R&D-teams" are like "Data Collection & Visualization", "Data analytics and Clouds", "Service Design" etc.

Usability of this kind of "R&D-teams are piloted in BioEngineering education" (Fig. 5).

When the "R&D- teams" have been develop and tested, the experience of teems will be utilized in other programs under redesign and other activities over the faculty boarders

Smart services research unit at Häme University of Applied Sciences supports industry, commerce and the society in digitalization and service development needs. The task of the research unit is to create and execute, together with co-operation network, well-addressed R&D activities for the region and its' enterprises. The Smart Services research unit supports the utilization of digital technologies and service business development across sectors: similar solutions can be adapted in various lines of business.
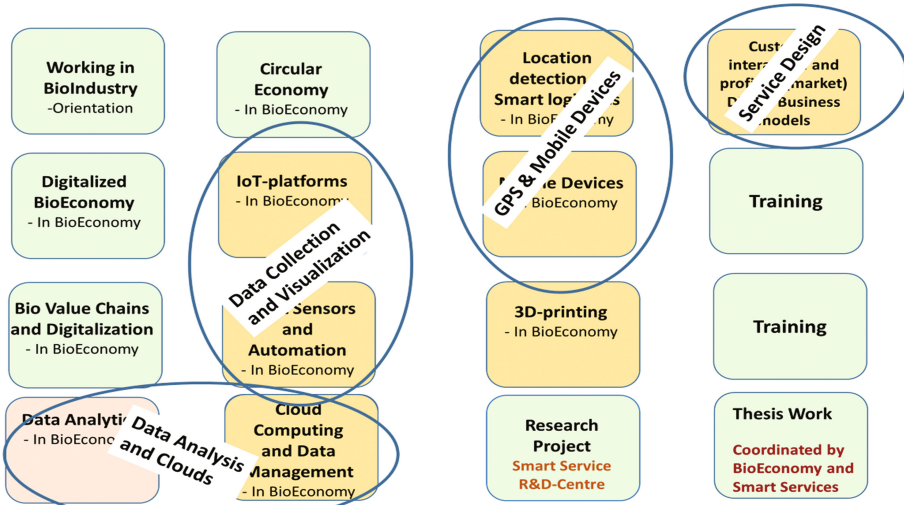
Fig. 5. The responsibility of "R&D-teams"

6 Benefiting Digitalization and Big Data Supporting Business Co-evolution

The amount of scattered and structured data around us is increasing dramatically. It is a great business opportunity to benefit that data in business purposes. Circular economy with interrelated bio and mechanical cycle consists of huge amount of data. The data of
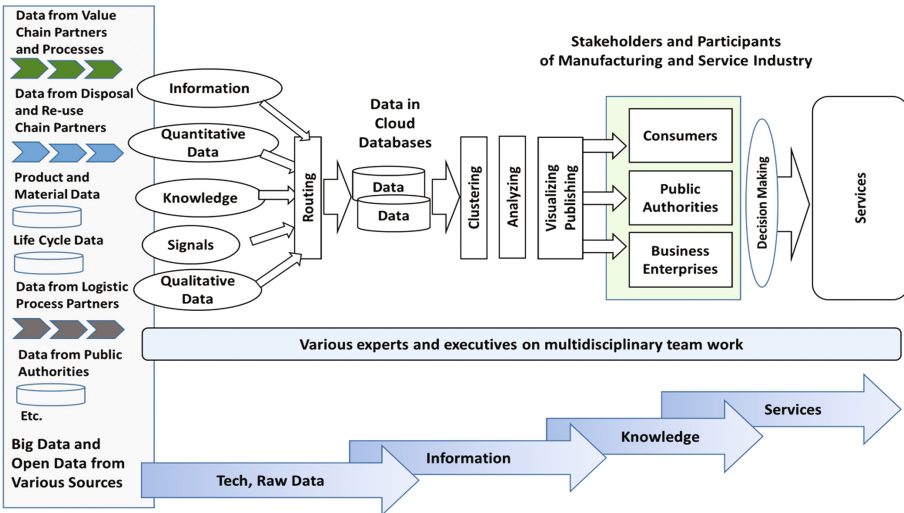

Fig. 6. From data to services process in business co-evolution

waste from one partner means material for the other partner. Understanding the value proposition in growing value networks is essential. Management and analysis of data coming from various sources is routed through data- to- service process in business co-evolution of circular economy, Fig. 6. Creation and optimization of new operational functions and responsible business co-evolution requires democratic innovation and decision culture.

7   Industry 4.0 - Conceptual Model for Adaptive Development

4.0 Industry and industrial internet are rather new topics and there are few experiences on driving of benefit out of them both in enterprises and universities. That is why co-operation serves developing on collaborative way. Most of the innovations are created at customer interface and co-operative development on common platform, research and learning environment, is essential basis in succeeding on business co-evolution. Good co-operation requires management engagement, trust building, information, and experience delivering. It happens on various levels of operation; e.g. forecasting and roadmap-projects, applied research and development projects, on bachelor and masters' thesis works or creation of research and learning environment for experimentation and piloting. It is ought to be continuous on various organization levels. Co-operation and learning together on research and learning environment supplied by university is basis for new innovations and continuous development. Developing of superior competitive power through principals of circular economy is built by lean and digitalized value networks. It is important to succeed in benefiting multidisciplinary competence and open information sharing.

Häme region is designing its new strategy "Smart Häme" to responds to the challenges of digitalization and to be the part of Digital Single Market (DSM). Based on that, the focus is to increase the knowhow to digitalization on Häme region.

Since 4.0 Industry is European concept and part of European platform, it is wise that best practices will be benchmarked into European approach and experiences.

The key elements to design the "roadmap" for 4.0 Industry, are:

- to recognize the potential "smart" clusters on the region/area
- create the goal and vision for region based on "Smart" clusters
- make companies and universities to work together and create "real life learning" environment (field labs) in clusters.
- renew education content so that it response the new ICT based technologies that are needed in 4.0 Industry
- create approach that knowhow will increase and it will be distributed on region
- the role of "Hämeenliitto" as coordinator and allocating assets
- make benchmarking for the regions which are like "Häme" and have already taken the steps to adapt 4.0 Industry

Succeeding on 4.0 Industry co-innovation requires data-to-service management process and creation of adaptive multidisciplinary co-operation model for solution development. For research center to be capable to collaborate with industrial companies, it is important to know the overall capability of research and development unit.

The experts making applied research with customers have to have content and process knowledge of customer site, they have to be capable to work in teams on distributed way with other experts in value network and have to certain collaborative skills to work together. In our article, we categorize the competence and capability on three layers: content management capability, organization capability and human competence and capability [17].

8   Discussion and Conclusions

Combining the principles of 4.0 Industry to value network thinking and digitalization of functionality of whole the network give opportunity for remarkable competitive advantage in business.

That requires combining of various theories but the main challenge is in utilization of transdisciplinary knowledge and implementation work. The use of new technologies; digitalization, big data, and social networks with increasing intelligence and automation enterprises can capitalize on new opportunities on and optimize existing operations to achieve significant business improvement on circular economy.

According the experiences of conceptual development work successful activity in 4.0 Industry is dependent on systematic long-term development on public sector. Essential topic is preparing of up to date platforms, which enables and controls and support the operation and creates business environment to apply new offering.

The important role for universities is to support enterprises by applied research and creation of research and learning environments for continuous piloting of new technologies and preparation of new business models on 4.0 Industry.

To be successful on new challenges of 4.0 Industry development, enterprise-university partnership has to be tight and main objective is common learning. Long-term co-operation creates background for new co-innovation and business co-evolution.

European community is preparing new legislation and directives, which are speeding up the development of Digital Single Market. Industry 4.0 as an industrial standard architecture has a remarkable role in preparing new functionalities on distributed value networks. The standard offers technical background and rules for implementation for digitalized circular economy.

Responsibility business leadership needs democratic innovation culture and co-innovation and co-evolution processes. This article introduces a concept of responsible business leadership. It also gives a concept on how to analyze co-evolution over the life cycle of business transition on "smart clusters" by using Evolute for managing human opinions and experiences and organizational objects on public- private- relationship and capability in executing responsible business leadership.

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