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FOSTERING INNOVATION IN 'LATERCOMER' ECONOMIES: NATIONAL, CLUSTER, AND ORGANIZATIONAL LEVELS

A Cross-Border Innovation Cluster Assessment Methodology

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Abstract

Cross-border innovation clusters are some of the essential concepts of reinforcing regional innovation capacities. In accordance with the concept of Industrie 4.0, introduced in 2011 in the Hannower Messe as the next industrial revolution, there appear new opportunities to build innovation clusters, combining innovation with a networked manufacturing system. Its core property will be new network technology on which they would create new products and services. This new type of cross-border innovation clusters will be the result from innovation policies carried out in regions. The main advantage of this type of clusters is that they allow the re-industrialization of regions, the end of mass production monopoly, and, thus, a successful competition with corporations, and also prosumer-based production. To achieve these objectives, the cluster has to deal with economically efficient technology. One of the key instruments of innovation policy will be the evaluation of the economic potential of the cluster before its appointment.

The aim of the article is twofold. Firstly, it is to introduce the idea of a cross border innovation cluster and a network that combines innovation with a network manufacturing system. Secondly, the goal is to provide the method for assessing the economic potential of a prospective cross border innovation cluster. The assessment of cluster's economic potential, based on the evaluation of the technology used in its development and the future products and services, developed in the prospect cluster, will be among the most important tools of innovation policy in regions. This issue is important because the methodology of such an economic potential assessment of prospect cross-border innovation clusters has never been developed.

In this study, the authors have collected representative examples of the implemented Industrie 4.0 solutions. Using a QuickLook assessment methodology, developed at the University of Texas, USA, and transferred to the University of Lodz, Poland, as a part of the offset program established in 2003, the authors have found that it could be applied to both Cyber-Physical System based Industrie 4.0 initiatives and other network manufacturing initiatives, based on the new technology. On the basis of a case study, concerning Polish cluster initiative Green Cars, the article concludes that there are many potential applications of the presented methodology to the Lithuanian-Polish prospect manufacturing system.

Keywords: **cross-border innovation cluster, cluster assessment, new industrial revolution, Industrie 4.0, RadicalLook methodology.**

Introduction

The key application domain for the Internet of Things (IoT) and Cyber-Physical Systems (CPS) technology seems to be the creation of innovation business ecosystems around smart cities in the sense of innovation clusters and networks, enabling [re-]industrialization of regions, inter-regional interconnections, and multinational enterprises through cross-border initiatives. An important part of this strategy of smart cities/countries/regions is the assessment of the cluster and network initiatives before its/their appointment. In the paper, the authors have attempted to define their own vision of the idea of a cross-border innovation cluster and network which combine innovation with a networked manufacturing system in accordance with the concept of a new industrial revolution; they have collected representative case studies of that kind through web search (review of academic papers and books, reports, current projects initiatives) to propose a new assessment methodology for cross-border innovation clusters and networks, developed as an innovative policy tool, and to suggest the presented methodology as an instrument for the development of the Lithuanian-Polish cross-border innovation cluster and network initiatives.

In the past, Lithuanian-Polish cross-border cooperation was concentrated on the common problems of the neighbouring regions and aimed at making the regions more competitive and attractive. The authorities of Polish and Lithuanian regions and also the Kaliningrad Oblast signed agreements on common cooperation. Euroregions were established: the Nemunas-Niemen-Neman in 1997 and Euroregion Baltic in 1998, with the participation of the regions of the program area (Klaipeda, Taurage, and Marijampole counties, Warmia-Mazury, Podlaskie and Pomorskie regions, Kaliningrad Oblast). Many activities and projects, both on regional and local levels, were developed within the Euroregion cooperation and provided notably the ERB with long-term development foundations. Many of them were linked to tourism development, the development of cross-border infrastructure and border security, economic and scientific/technological co-operation as well as people to people cooperation, socio-cultural integration and the labour market.

There have been some cluster initiatives and common Lithuanian-Polish programs recently. One of them was Lithuania-Poland-Russia Cross-border Cooperation Program, realized from 2007 to 2013. The units of the program are, in Lithuania, Klaipeda, Marijampole, and Taurage counties as well as Alytus, Kaunas, Telsiai, and Siauliai counties; in Russian Federation, Kaliningrad Oblast (region); in Poland, Gdańsk-Gdynia-Sopot, Gdański, Elbląski, Olsztyński, Ełcki, Białostocko-Suwalski sub-regions and Słupski, Bydgoski, Toruńsko-Włocławski, Łomżyński, Ciechanowsko-Płocki, Ostrołęcko-Siedlecki ones. The main aim of the program was to help overcome development barriers. The emphasis was put on creating transport axes and trade and tourism routes. Its cooperation should evolve into a cross-border region of working together to develop or maintain the most important developmental assets of the area, such as natural and cultural heritage and human capital. The objectives of the program were to promote economic and social development on both sides of the common border (sustainable use of environment, accessibility improvement), to address common challenges and common problems working together (including tourism development, improvement of social conditions, governance and educational opportunities, development of the labour market, joint spatial and socio-economic planning), and to promote people to people co-operation (Lithuania-Poland-Russia ENPI Cross-border Cooperation Programme 2007-2013, 2013).

Although the cooperation has a long history, there are no common Lithuanian-Polish cluster initiatives nowadays.

Innovation clustering and networking phenomena

The relationship between university research, industry research, and government research as well as their interactions with businesses constitute a complex phenomenon; however, a widely shared opinion is that business competitiveness lies in innovative activities and, among those, in clusters and networks (Brocker, 2003; Breschi, 2007; Carayannis, 2007; Dioguardi, 2009; Belussi, 2012; Wang, 2013). There is no consensus on the definition of an innovation cluster and network, which provides the opportunity to build a new definition, applying to the requirements of the new industry revolution concept (Anderl et al., 2012; Baum et al., 2013; Scheer, 2013). The authors define a cross-border innovation cluster as a distributed organization, built on the basis of the Internet of Things paradigm, and of the two following determinants (Gontar, 2013): (i) a smart operation center equipped with tools to monitor and control, in real time, smart processes, organizational units, and value chains in the enterprise, and (ii) a smart enterprise model assuming the modularity of business processes and their dynamic structure, interconnections in the sense of vertical integration and networked business system, and horizontal integration through value networks.

A characteristic feature of the current definition is an integration of product/service and process planning, and the engagement of entities from various countries, both in operational center activities and in business modules activities. Innovation cluster/network is understood as a group of entities involved in a new product/service planning process and process planning, together with a group of entities involved in product/service production, established as the result of a smart strategy developed by a smart city/region.

The frame of a new industrial revolution

Industrie 4.0 is a forward-looking vision of manufacturing, based on the concepts of the ICT industry – the Internet of Things and Services (IoT)[1] (Ashton, 2009) and Cyber-Physical Systems (CPS)[2] (Lee and Seshia, 2011) where which physical equipment of the manufacturing environment is treated as smart objects with unique IP[v6] addresses, located physically anywhere with broadband internet access, autonomously exchanging information, triggering actions, controlling each other, and visible for the enterprise as objects in the internet cloud (Kagermann, 2013). There are other terms coined for this new concept of manufacturing, e.g., industrial internet (Evans, 2012), smart production (Vrba et al., 2011), smart factory (Zuehlke, 2010), smart manufacturing (Heilala, 2008), cloud manufacturing (Xu, 2012), and advanced manufacturing (Shipp, 2012). All these concepts indicate a new industrial revolution in the sense of the end of mass manufacturing monopoly[3] (production in small quantities in real time), the end of fixed and predefined manufacturing structures[4], the triumph of a modular production strategy and, as a consequence of modularity of

[1] Internet of things is a term coined in 1999 by an entrepreneur Kevin Ashton, and is referring to the system of physical objects interconnected via internet and equipped with sensors connected to applications enabling to control these objects.

[2] Cyber-physical systems is a term coined in 2006 by Helen Gill at the National Science Foundation in the USA, and they are physical, biological, and engineered systems whose operations are integrated, monitored, and/or controlled by a computational core. Components are networked at every scale. Computing is deeply embedded into every physical component, possibly even into materials. The computational core is an embedded system, usually demands real-time response, and is most often distributed

[3] Even one-off item can be manufactured profitably (Kagermann et al., 2013).

[4] Instead, a set of configuration rules will be defined to automatically build a specific structure [ibid.].

manufacturing, the triumph of distributed innovation[5] (business ecosystem) across the whole value chain.

It could be noted that these principles very much resemble those, which allowed Toyota to build high quality automobiles, known as lean production (networks, dynamic, and self-coordinating work teams). The difference is that in Industrie 4.0, a manufacturing structure is defined automatically, 'work teams' are ready to use, but their choice depends on the results of the assessment analysis, conducted in real time by smart factory, and 'work teams' are grouped in business ecosystems.

A platform is both a business model and organizational design dedicated to business ecosystems. Baldwin indicates the emergence of new organizational designs, i.e. open-(source) communities and standard-setting organizations (Baldwin, 2012). The article proposes a different organization design principle, based on distributed computing on the Internet, such as the Folding@home[6] project organized by Stanford University, which reached 8.8 PFLOPS and a design of Berkeley Open Infrastructure for Network Computing[7] conducted by Berkeley University, which reached 5.5 PFLOPS. The grids achieved reached computing power, comparable to IBM and Cray supercomputers. The same principle applied to industrial grids, allowing them to achieve production capacity, capable of competing with the big production companies. The authors call it a Cross-Border Innovation Cluster. A Cross-Border Innovation Cluster is characterized by the dominance of an innovation unit (product and process planning), modularity of manufacturing process, dynamic structure of manufacturing processes, interconnections in the sense of vertical integration and networked manufacturing system, and horizontal integration through value networks, efficient manufacturing of any scale, prosumer manufacturing, cross-border connections.

The core of a Cross-Border Innovation Cluster is a Cyber-Physical Systems platform, supporting collaborative industrial business processes and the associated business networks for all the aspects of smart factories and smart product life cycles, analysis and forecasting processes in business networks (Kagermann et al., 2013). It is a competency center for business processes in business networks.

This new concept is not limited to smart manufacturing. Typical applications of this idea include: town, company, mobility, energy, industry, buildings (Kagermann, 2013). The following discussion will focus on smart manufacturing and smart tourism.

Industrie 4.0 is sometimes described as the advent of forth industrial revolution. The first industrial revolution is characterized by the invention of the steam engine and the mechanization of manual work in the 18th century. The second industrial revolution is noted for the implementation of mass production techniques in the early 20th century. The third industrial revolution is known for electronic systems and computer technologies for automating manufacturing processes in the last few decades. The forth industrial revolution could be described as a smart era because of the production facilities which will be much smarter by using miniaturized processors, storage units, sensors, and transmitters, embedded in machines, unfinished products, and materials, and smart tools and software for structuring data flows. As a consequence, products and machines will communicate with each other and control manufacturing processes largely by themselves. Broadband networks, data standardization, transmission protocol systems will be available (Kagermann, 2013).

The term Industrie 4.0 is hardly used outside Germany. The same goal in other industrialized countries is determined by other ideas, i.e. 'Smart Factory 1.0' in China.

A road map to a Cross-Border Innovation Cluster is a process that proceeds through the following stages: imagining, strateging, platforming, networking, promoting, and sustaining. A successful a Cross-Border Innovation Cluster implementation is based on identifying the key functions, value outcomes, and stakeholders on each stage of the a Cross-Border Innovation Cluster evolution, and focusing on the resources required to progress from one stage to the next. The proposed method of assessing an innovation cluster is to be used for this purpose.

Innovation clusters assessment

In the contemporary world, certain elements of Industrie 4,0 technologies already exist. Those are the Internet, PROFInet – an international standard developed by PROFIBUS International for network systems in industrial automation, simulation software, and Siemens TIA portal for rapid engineering. The fundamental barriers that prevent the development of initiatives of this type are as follows: a lack of information concerning opportunities, cost and benefits of innovation clusters and networks built on the base of this technology, a lack of human resources and institutional capacities to evaluate innovation clusters projects. As a result of these barriers, innovation cluster projects are not routinely considered by industrial companies, research institutions, and governments.

The method of Innovation Clusters Assessment, described in the paper and called RadicalLook, is an extension of the QuickLook method, used originally at the NASA Mid-Continent Technology Transfer Center to provide preliminary assessment of the commercial potential of a new technology. The method was refined at the University of Texas at Austin, USA, as a result of studies carried out by the Institute of Innovation, Creativity, and Comunity (IC2) on the commercialization of technology from government and corporate laboratories. In 2003, the University of Texas at Austin transferred the QuickLook method to the University of Łódź, Poland, and to the F.I.R.E Foundation located in Warsaw as a part of an offset obligation arising from a contract with Lockheed Martin Corporation (LMC) of 18 April 2003 (Gontar, 2005). This was in connection with a LMC contract for the

[5] The term distributed innovation was introduced by Eric von Hippel in 1988 (Baldwin, 2012).
[6] folding.stanford.edu
[7] boinc.berkeley.edu

delivery of an F-16 multirole fighter aircraft for the Polish Armed Forces.

The QuickLook method is based on the model of the process of technology commercialization, developed by Vijay K. Jolly (Jolly, 1997). Jolly treats the commercialization of technology as a dynamic process that is carried out in the five following stages: conception, incubation, demonstration, promotion and maintenance, and development. Jolly uses a two-tier approach for technology assessment, which takes into account two significant risks: technological risk and market risk. From this perspective, Jolly develops a framework for achieving successful commercialization of technologies by identifying key features, performance, and stakeholder value at every stage of technological development, focusing on the resources required to move from one stage to another. On the basis of numerous examples from different industries, taking into account both successful and unsuccessful attempts to commercialize technology, Jolly defines a new approach to managing the process of research and development aimed at supporting the commercialization stage, referring to the management of investments in new technologies in short and long term horizons.

The analysis of the innovation cluster presented below has been determined by the schedule of the report, which was taken from the QuickLook method. It includes the following elements:

1. The description of the innovation cluster should be free of industry and scientific jargon, and should have a clear structure. Representatives of various fields of science and industry use different jargon. In innovation clusters, there are varieties of interdisciplinary teams composed of specialists from science and industry. The description must therefore be easy to understand both for scientists from different scientific fields, for professionals from various industries as well as non-professionals; it should highlight what and how will be produced by the innovation cluster, rather than how a radical innovation should be brought about. The entire description of the innovation cluster should consist of a few short paragraphs. It must include the analysis of potential scenarios for value creation in the network of the innovation cluster (analysis of the commercial potential of the technology, technology purchasing and deployment decisions, design of production and control structures, design of recycling structures), manufacturing specifications, and the design of integrated production (in terms of product and processes).
2. Economic benefits of the innovation cluster. Potential markets for products manufactured within the innovative cluster. It requires the staging of interviews with coordinators of the innovation cluster and independent market research. The results of these studies encompass the following items: the main market for the product in terms of composition, structure, size, analysis of the supply and demand balance, the market research of buyers and end users, and potential benefits of the new products,
3. The rate of interest in the market, paying particular attention to the following points: preferred pricing models, key purchase factors, the usual number of orders with a common order frequency, predicted properties of the product, delivery expectations, certification expectations, and expectations for after-sales support.
4. The state of development of the innovation cluster, i.e. scenario planning, in terms of value adding and the definition of integrated product development.
5. The legal status of the innovation cluster (for network connections in the cluster) in the context of cross-border initiative, assessing protecting corporate data, issues of liability and responsibility, data protection standards, and practical solutions for handling personal data, trade restrictions in each participant country (Kagermann, 2013).
6. Competitive clusters and their market competitors. Also, the barriers to entry and potential opportunities.
7. Recommendations for quantification of the innovation cluster (a decision on the yes/no) and an outline of the steps needed to start production and carry out legal procedures.

The RadicalLook report may contain a few dozen pages. For the needs of this article, the authors have referred to the investigations concerning innovation cluster called Green Cars[8]. The following paragraphs summarize the results of the analysis. It is not a cross-border innovation cluster but such clusters, as defined in the article, are not present yet. The cluster was created in Warsaw in 2007 for the emerging market of electric cars, as an attempt to overcome the primary barriers facing the dissemination of the electric car, namely, the lack of public interest in these types of cars because of their high cost, short range, and lack of charging stations. The introduction of this market is intended to transform the way in which the management of electricity is performed in enterprises. In Poland, the main obstacle to the development of this industry is the lack of a native automotive industry. This has resulted in the production of electric cars as a niche activity, carried out by manufacturers in other industries, i.e., Melex, separated from the holding company WSK/PZL Mielec, producing electric golf carts, and similar vehicles including passenger, baggage, and special, and ELIPSA Electric Vehicle Plant, separated from ZNTK Radom, producing electric passenger cars Elipsa Verstyle and trucks Elipsa.

The electric car industry is dominated by major automotive companies (Renault-Nissan/Renault Zoe and Nissan Leaf, Mitusbishi/i-MiEV, and Chevrolet/Volt). In the absence of Polish automotive companies which would be able to create an electric car project, a potential existed to build networks between the cities, interested in creating clusters of new industries. The model can be derived from the idea of distributed computing on the Internet. The cluster (i) allows for the use of market mechanisms to build a socially responsible innovation, trying to solve the following world's biggest social problems: non-renewable resources depletion, CO2 emissions from motor vehicles,

[8] www.gc.greenpl.org

noise and vibration caused by the development of motorization, (ii) defines business rules enabling the cooperation of enterprises and institutions operating in different areas, (iii) supports the innovation cluster by the operations of public institutions: electrification of transport (electric cars, electric buses).

The main recipient of this technology would be large Polish companies from the energy sector, interested in building the domestic production of electric cars as part of a national smart grid. The electric car will be an integral part of the smart grid and the dominant energy storage receiver. It can be used at any time, without changing the level of power generation in power plants. Energy companies may be interested in both building and testing electric cars in order to collect the data necessary to estimate the future demand for electricity when there comes a wide use of electric cars. Due to a small driving range and a long charging process, electric cars are promoted as city cars. Another stakeholder, interested in this technology, could be Polish smart cities interested in the development of electric transport in tourist areas (electric vehicles for municipalities, electric bus lines, electric vehicles for tourists).

The Embronic electric car industry includes the production of Melex and Elipsa vehicles, and Romet which manufactures electric cars for the Chinese company Yogomo. It should be noted that the electric car market has two principle operational aspects. Firstly, there exists the possibility of building a large network of charging points. Secondly, in the smart grid, every enterprise and every institution will be a micro-energy producer and a "domestic fuel station." It will be necessary therefore to build electric cars for micro-energy producers.

The cluster Green Cars differs from the existing automotive cluster in Poland in several important points. Those are: an innovative cluster where the main operational entity conducts R & D, an area of corporate social responsibility, and, as such, involving a number of public institutions, interested in achieving tangible social benefits, arising from sustainable development and public investment (Gontar et al., 2013). The strategy of the Green Stream Project links to social responsibility primarily in terms of the implementation of the smart grid. The smart grid can be seen as a way to achieve energy independence, a remedy for global warming and a guarantee for securing the power system as well as the model of society drastically restricting the use of coal (low carbon society). The smart grid creates an appropriate infrastructure to accomplish this type of benefit. Energy savings, reduced costs, increased reliability, and transparency (equitableness) is the result of the use of ICT systems in the power system.

Industrie 4.0 and IoT best practices

The absence of the initiatives of cross-border innovation clusters and networks, as defined in the paper, was an incentive to look for examples that could become the basis for the establishment of such Lithuanian-Polish initiatives in the future. The list is presented below. It includes case studies of two areas, namely, smart manufacturing and smart tourism.

SmartFactory^{KL} in Kaiserslautern[9]*, Germany*. SmartFactory^{KL} is a manufacturer-independent model, demonstration and a research platform. The vision of the intelligent factory of the future was developed in 2004. In 2005, a non-profit association ‘Technology Initiative SmartFactory KL’ was established and built, in 2007, in Kaiserslautern, Germany by the German Research Center for Artificial Intelligence (DFKI) with 20 industrial and research partners. The production system produces and bottles colored liquid soap. The product is manufactured, filled into dispenser bottles, labeled, and delivered by consumer order. The plant has been designed as modular and consists of a process manufacturing part and a piece goods handling part (Zuehlke, 2009). Physical components, utilizing Bluetooth, ZigBee, and RFID, automatically recognize their functions and position in the process chain; they have been integrated for plant management. The SmartFactort^{KL} has applied SOA architecture, using Business to Manufacturing Markup Language (B2MML) model according to ISA-95, a WSDL model, and BPEL for administration. The platform has served as a research and development basis in numerous projects.

Siemens, Germany. Siemens electronic factory in Amberg[10], Germany, is used for planning and manufacturing of new Siemens Programmable Logic Controllers (PLC). It is an example of digital planning of new products, and, simultaneously, design manufacturing processes. The factory is equipped with fully automated production line, enabling to collect, analyze, and assess the manufacturing data (on throughput, cost, and other parameters), and, in consequence, to determine different manufacturing routes for new products. The factory uses the Siemens Simatic system, based on PLCs which dates back to the 1950s. This breakthrough technology appeared in 1979, as S5 series enabled replacing large computers in machinery and production lines managing and controlling.

There are sister factories of Siemens in Amberg, Germany, and in Nanjing, China. Hareon Solar Corporation[11], China, is manufacturing solar photovoltaic (PV) cells is also equipped with Siemens equipment.

StreetScooter GmbH. StreetScooter GmbH is a company which develops and produces electric cars and delivers mobility services (car-leasing, car-sharing, car workshop). StreetScooter GmbH[12], founded at the University of Aachen in order to develop an electric car, could be regarded as an example, that the ideas of Industrie 4.0 can be used even with no Cyber-Physical Systems platform, mentioned above. StreetScooter was developed in a dynamic, broad partner and supplier network of different companies, and its role has been to coordinate and synchronize the entire network. The approach of StreetScooter manufacturing is described as Disruptive Network Approach (DNA). It is an attempt to create a

[9] www.smartfactory-kl.de
[10] siemens.com
[11] hareonsolar.com
[12] www.streetscooter.eu

network production system, based on the existing methods of integrated product and process development, while accelerating the planning of production and the reduction of production costs. This approach requires the assessment of the commercial potential of the technological and production structure of the initial configuration before the product is designed. The planning process begins with the production of various planning options to create value in order to determine the relationship between the specification and design of the product.

The idea of a Disruptive Network Approach has been based on the assumption of the use of a modular process design and development of products and processes in which many network partners operate in parallel and use the assessment of the commercial potential of technologies and assess the feasibility of the network structure of production design/production at the planning stage before the start of the product design stage and planning processes. The evaluation of the product and the network production structure is made qualitatively (for ‘yes’ or ‘no’). After confirming the validity of the product development, one can proceed to the specification and integrated product design and manufacturing processes for integrated planning. The implementation and development of production are carried out iteratively and require agreement within the production network.

A key element in the implementation of the Disruptive Network Approach in the cluster is to establish a center of radical innovation, modeled on the Business Process Competency Center (BPCC). The BPCC concept refers to the idea of a center of excellence with a model of Corporate Information Factory (CIF), designed in 1998 by Bill Inmon, a creator of the concept of a data warehouse. In the extended version of the CIF, there is a center of excellence (CoE), defined as a group of people, processes and technology, established to promote cooperation and the application of the best practices.

Bosh, Germany. Bosh Rexroth Cyber-Physical Production System independently controls the required maintenance and repair services of 8 machines in the Bosh Feuerbach plant from Berlin. The Remote Condition Monitoring (RCM) triggers all the processes automatically: ordering spare parts or informing technicians about further actions that have to taken.

The Bosh Plant Homburg connects multiple partners in the logistic value chain with a RFID-based Automotive Network.

Museums. The Australian Museum[13] is going to use Near Field Communication (NFC) and Quick Response (QR) technologies to digitally tag artifacts in the museum and to develop ‘operational center’ enabling visitors, equipped with smart mobile devices, to access the ‘exclusive content’. NFC tags are embedded in a panel (it can be a separate panel or just a sticker on the existing text panel), enabling visitors to access videos and image galleries and to share impressions on social media, or to connect with the Museum via the website. The "Internet of Things" gives the ability, through smart objects, NFC and geolocation, to provide visitors with more personalized experience, to take home the content and then interact with the museum after the visit.

The Royal BC Museum in Canada[14] introduced the Wifarer in 2012, a free application as a museum guide. Through QR codes and the Wi-Fi positioning technology, a visitor can find a direction, information about the exhibits near him/her and access additional content, such as video, audio, text, images and web links, or follow the web link, see the archival images or listen to an audio file. The application uses the Wi-Fi positioning technology to connect the user to the nearest place and then enjoy interactive experience. The application is run over Wi-Fi (there is a free hotspot at the museum) and the positioning is determined via Wi-Fi positioning techniques. A visitor can easily start a tour and access information. Choosing ‘My location’ option takes visitors to a floor plan and point users' current position on the map as a colorful dot, moving in real time along with user. When the visitor walks around the museum there will be icons, signaling cyclically, meaning that extra information (e.g. a story, audio, video) is accessible there.

The Museum of Modern Art (MoMA)[15], New York, is one of the first American museums using IoT. Sensors and microprocessors have been placed in gallery furniture and connected to 17 computers, hidden to the visitors.

QRator project[16]. The QRator project was established at the University College London (UCL) as an extension of the Tales of Things project[17], which allows adding data to physical objects and sharing them with others. The Grant Museum of Zoology[18] in London, a university zoological museum of the University College London, and the Museum of Brands[19] have applied the QRator project, which allows visitors to send their impressions of museum artefacts; therefore, they become a part of object’s history, presented via the interactive label system (which allow the display of comments and information directly next to the artefacts). Visitors’ thoughts become a part of museum objects history along with the display itself, creating digital ‘living’ labels that the following visitors can read and respond to comments in real time. There are ten iPads attached to displays across the Grant Museum of Zoology and six iPads at the Museum of Brands, encouraging visitors to answer questions. Each iPad holds a current question which visitors can respond to on an iPad itself, via Twitter, or using the Tales of Things applications on their own smart phones.

Santander, Spain; Genoa, Italy; Fujisawa, Japan; Mitaka, Japan. Sensing and vitalizing the city has enabled startups to develop applications like SmartSantanderRA. It is a free application for smartphones, enabling displaying information about 2700 places in the augmented reality technology in the following categories: beaches, parks and gardens, monuments, Points of Interest (PoI), tourism offices, shops, art galleries, museums, libraries, culture events agendas, shops, public buses, taxis, bikes, parking

[13] australianmuseum.net.au

[14] royalbcmuseum.bc.ca
[15] www.moma.org
[16] www.qrator.org
[17] talesofthings.com
[18] www.ucl.ac.uk/museums/zoology
[19] www.museumofbrands.com

places, etc. It is available because Santander, participating in the smart city project, deployed QR codes and NFC tags within the city.

Media House, Barcelona. Media House is a joint project of MIT Media Lab[20], the architect Metápolis Group, Barcelona, and the Fundacio Politecnica de Catalunya, Spain. Objects of the house with the internet access and operational centre enable to create a Cyber-Physical System in the sense of micro-city, multifunctional environment encompassing work, shopping, leisure, and rest facilities (Guallart, 2005).

The RadicalLook methodology, presented in the article, could be used to assess this type of ventures, presented above as case studies, before their appointments. The example of the Green Stream Project evaluation indicates that such assessment would be a valuable tool in the development of interregional policy.

Conclusions

The authors have presented a model for describing and assessing cross-border innovation clusters from the perspective of a new industrial revolution. Industrie 4.0, and the related approaches offer a new perspective on global economic governance, as a result of the emergence of new smart technologies. Although appropriate time period of Industrie 4.0 implementation is estimated to be 20 years or so (Nikolaus, 2013), there will be a surge of interest in development strategies for cross-border innovation clusters, driven by the internationalization of value chain functions, reindustrialization as a reaction for deindustrialization occurred rapidly in recent years, as a chance for increase economic development and growth of smart cities.

There is plenty of assessment methods which could be used in cross-border innovation cluster assessment, i.e. Michael Porter's National Diamond, the Tim Padmore and Hervey Gibson's Groundings-Enterprises-Markets (GEM), the Orjan Solvell, Goran Lindqvist, and Christian Ketels's Cluster Initiative Performance Model (CIPM), the Gary Gereffi's et.al Global Commodity Chain (GCC). The approach presented in this article differs from previous assessment methods in several ways:

1. It considers a cross-border innovation cluster as a network production system;
2. It concentrates on disruptive innovation as a basis of integration of this network system;
3. It takes into account a technical risk for the production system and a market risk for the economical potential of disruptive innovation as well as the creation of new markets for innovation;
4. It could be used to evaluate projects before a cross-border innovation cluster arises.

The assessment of Polish cluster initiative Green Cars indicates that there could be a trend called business process outsourcing (cloud manufacturing), which allows the emergence of fabless companies[21], focused on the production of intellectual property.

[20] www.media.mit.edu
[21] a fabless company is a company without own manufacturing facilities

References

1. Anderl, R., Eigner, M., Sendler, U., & Stark, R. (2012). *Smart Engineering. Interdisziplinäre Produktentstehung*. Springer-Verlag Berlin Heidelberg. http://dx.doi.org/10.1007/978-3-642-29372-6
2. Ashton, K. (2009). *That 'Internet of things' Thing. RFID Journal*, June 22, 2009.
3. Baldwin, C.Y. (2012). Organization Design for Distributed Innovation. *Working paper,* 12-100, Harvard Business School, May 4.
4. Baum, G., Borcherding, H., Broy, M., Eigner, M., Huber, A.S., Kohler, H.K., Russwurm, S., Stümpfle, M., & Sendler, U. (2013). *Industrie 4.0: Beherrschung der industriellen Komplexität mit SysLM*. Springer Vieweg.
5. Belussi, F., & Sammarra, A. (eds.). (2012). *Business Networks in Clusters and Industrial Districts*. London: Routledge.
6. Breschi, S., & Malerba, F. (eds.). (2007). *Clusters, Networks, and Innovation*. Oxford University Press.
7. Brocker, J. (2003). *Innovation Clusters (Advances in Spatial Science).* Berlin: Springer.
8. Carayannis, E.G., Assimakopoulos, D., & Kondo, M. (2007). *Innovation Networks and Knowledge Clusters, Finding and Insights from the US, EU and Japan*. Palgrave Macmillan.
9. Dioguardi, G. (2009). *Network Enterprises, the Evolution of Organizational Models from Guilds to Assembly Lines to Innovation Clusters.* Springer.
10. Evans, P.C., & Annunziata, M. (2012). *Industrial Internet: Pushing the Boundaries of Minds and Machines*. General Electric White Paper.
11. Gontar, B., & Gontar, Z. (2013). Potencjał ekonomiczny społecznej odpowiedzialności klastrów innowacyjnych. *Proceedings of the conference 'Społeczna odpowiedzialność w procesach zarządzania obszarami miejskimi',* April 18-19, 2013, Łódź.
12. Gontar, Z. (2005). *Developing and implementing educational programs in technology commercialization, some preliminary findings of the American-Polish Offset Program*. Technology Policy and Innovation Value Add Partnering in a Changing World. Centrum Innowacji Uniwersytetu Łódzkiego.
13. Gontar, Z. (2013). Enterprises in the Third Industrial Revolution. *11th Eurasia Business and Economics Society (EBES) Conference,* September 12-14, Ekaterinburg, Russia.
14. Guallart, V., & Cantarella, L. (2005). *Media House Project, the House is the Computer, the Structure is the Network.* Barcelona: Actar/AAC.
15. Heilala, J., Helaakoski, H., & Peltomaa, I. (2008). Smart Assembly – Data and Model Driven. Micro-Assembly Technologies and Applications. *IFIP – International Federation for Information Processing*, 260, Springer. http://dx.doi.org/10.1007/978-0-387-77405-3_37
16. Jolly, V. (1997). *Commercializing New Technologies: Getting From Mind to Market*. Boston Massachusetts: Harvard Business School Press.
17. Kagermann, H., Wahlster, W., & Helbig, J. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Securing the future of German manufacturing industry. *Final report of the Industrie 4.0 Working Group*.
18. Kagermann, H., Wahlster, W., & Helbig, J. (2013). Securing the future of German manufacturing industry, Recommendations for implementing the strategic initiative INDUSTRIE 4.0. *Final report of the Industrie 4.0 Working Group.*
19. Kampker, A., Franzkoch, B., & Nowacki, C. (2012). Networked product and production development for lithium-ion batteries. *Enabling Manufacturing Cooperativeness and Economic Sustainability*. Springer. http://dx.doi.org/10.1007/978-3-642-23860-4_35
20. Lee, E.A., & Seshia, S.A. (2011). *Introduction to Embedded Systems, a Cyber-Physical Systems Approach*.
21. Lithuania-Poland-Russia ENPI Cross-border Cooperation Programme 2007-2013 (2013).
22. Nikolaus, K. (2013). Building the Nuts and Bolts of Self-Organizing Factories. *Manufacturing and Innovation*, Spring.
23. Scheer, A.W. (2013). *Industrie 4.0*. IMC AG.

24. Shipp, S.S., et al. (2012). Emerging Global Trends in Advanced Manufacturing. *Institute for Defense Analysis*, March, IDA Paper P-4603.
25. Vrba, P., Kadera, P., Jirkovsky, V., Obitko, M., & Marik, V. (2011). New Trends of Visualization in Smart Production Control Systems. Holonic and Multi-Agent Systems for Manufacturing. *Lecture Notes in Computer Science*, 6867, Springer. http://dx.doi.org/10.1007/978-3-642-23181-0_7
26. Wang, J. (2013). *Institutional Change and the Development of Industrial Clusters in China*. World Scientific Publisher. http://dx.doi.org/10.1142/7488
27. Xu, X. (2012). From cloud computing to cloud manufacturing. *Robotics and Computer-Integrated Manufacturing*, 28, 1. http://dx.doi.org/10.1016/j.rcim.2011.07.002
28. Zuehlke, D. (2008). SmartFactory – from Vision to Reality in Factory Technologies. *Proceedings of the 17th World Congress. The International Federation of Automatic Control*, July 6-11.
29. Zuehlke, D. (2009). Smart Factory – A vision becomes reality. *Information Control Problems in Manufacturing*, 13.
30. Zuehlke, D. (2010). Smart Factory – Towards a factory-of-things. *Annual Reviews in Control*, 34, 1. http://dx.doi.org/10.1016/j.arcontrol.2010.02.008

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Tarpvalstybinio inovacijų klasterio vertinimo metodologija

Santrauka

Tarpvalstybiniai inovacijų klasteriai yra viena svarbiausių koncepcijų, plėtojant regionų inovacinį potencialą. Naujoji industrijos revoliucija, paskelbta Vokietijoje 2011 metais bei vadinama Industrijos 4.0 iniciatyva, atvėrė naujas inovacijų klasterių kūrimo galimybes, sujungdama inovacijas ir išmaniąsias gamybos sistemas. Tokie naujo tipo inovacijų klasteriai atsiranda išmaniuosiuose regionuose diegiant inovacijų politiką. Pagrindinis tokio tipo klasterių turtas yra tinklų technologija, įgalinanti jos pagrindu kurti naujus produktus ir paslaugas. Sienas kertančių tarpvalstybinių inovacijų klasterių privalumas yra tas, kad jie įgalina regionų reindustrializaciją, griauna masinės produkcijos monopolį, skatina glaudesnį vartotojo ir gamintojo (*prosumer-based*) santykį gamyboje ir taip sėkmingai prisideda prie konkurencijos su korporacijomis. Šiame kontekste vienu svarbiausių inovacijų politikos instrumentų tampa klasterio ekonominio potencialo vertinimas, įmanomas dar iki tokio klasterio identifikavimo.

Straipsnyje fokusuojamasi į du probleminius aspektus. Pirmiausiai siekiama pagrįsti tarpvalstybinio inovacijų klasterio idėją bei tinklą, sujungiantį inovacijas ir tinklinės gamybos sistemas. Antra, šiame straipsnyje pateikiama potencialaus tarpvalstybinio inovacijų klasterio ekonominio vertinimo metodologija. Vienu svarbiausių inovacijų politikos regionuose įrankiu taps klasterio ekonominio potencialo vertinimas, grindžiamas technologijos, įgalinančios klasterio vystymą(si) ir būsimų produktų bei paslaugų kūrimą, įvertinimu. Svarbu paminėti, jog iki šiol nebuvo sukurta tokia metodologija, kuri įvertintų potencialių pasienio regionuose atsirandančių tarpvalstybinių inovacijų klasterių ekonominį potencialą.

Straipsnyje pristatoma inovacijų klasterių vertinimo sistema – RadicalLook (radikalaus žvilgsnio) metodas. Kurdami šį vertinimo instrumentą, autoriai remiasi QuickLook (greitojo žvilgsnio) vertinimo metodologija, sukurta Teksaso universitete Ostine (JAV) ir perduota Lodzės universitetui (Lenkija), remiantis 2003 metų mainų programos susitarimu. Kūrėjai pritaikė QuickLook tiek kibernetinėmis-fizinėmis sistemomis grįstoms Industrie 4.0 iniciatyvoms, tiek ir kitoms naująja technologija grįstoms tinklo gamybos iniciatyvoms vystyti.

Straipsnio autoriai išskiria tokius pristatomos naujosios metodologijos elementus : reikalavimai inovacijų klasterio rašytiniam pristatymui, inovacijų klasterio ekonominės naudos pagrindimas, atliekant interviu su koordinatoriais bei rinkos tyrimą, palūkanų normų rinkoje nustatymas, inovacijų klasterio scenarijus, jo teisinis pagrindimas bei teisinės procedūros, konkurencinė rinkos analizė ir barjerų bei galimybių ištyrimas, taip pat rekomendacijos inovacijų klasterio vystymui.

Straipsnis remiasi atvejo analizės strategija. Siūloma metodologija pagrindžiama analizuojant konkretų atvejį – Lenkijos Green Cars inovacijų klasterį, įkurtą 2007 - aisiais metais Varšuvoje (Lenkija). Deja, tai nėra tarpvalstybinis inovacijų klasteris, tačiau, autorių teigimu, kertančių valstybines sienas inovacijų klasterių šiuo metu dar nėra susiformavusių. Analizuojamas Green Cars klasteris pateikiamas kaip energetinės nepriklausomybės skatinimo, kaštų mažinimo, patikimumo ir skaidrumo didinimo, novatoriško IKT naudojimo pavyzdys, todėl gali būti įdomus bei naudingas ne tik Lenkijai, bet ir kaimyninėms šalims. Be to, analizuojamo atvejo vertinimo pagrindu autoriai daro prielaidą, jog naujoji metodologija turi didžiulę perspektyvą kaip verslo procesų užsakomųjų paslaugų (*outsourcing*) kryptis.

Be to, straipsnio autoriai surinko ir pateikė įgyvendintų Industrija 4.0 sprendimų pavyzdžių, labiausiai iliustruojančių dvi sritis: išmaniąją gamybą ir išmanųjį turizmą. SmartFactory KL (Vokietija) pavyzdžiu apibūdinama išmanioji gamykla; Siemens, Bosh atvejai pateikiami kaip skaitmeninio naujų produktų planavimo ar aprūpinimo atvejai. Išmaniųjų aplikacijų taikymas grindžiamas Kanados ir Australijos muziejų atvejais, o išmaniojo miesto koncepcija iliustruojama Santander (Ispanija) pavyzdžiu.

Autoriai teigia, jog nors Industrija 4.0 iniciatyvų diegimo laikas ir skaičiuojamas dviem dešimtmečiais, tačiau jų poreikis, taip pat ir vertinimo poreikis, neabejotinai didės. Vertės grandinės funkcijų internacionalizacija, reindustrializacija, išmaniųjų miestų kūrimasis atveria naujas galimybes inovatyvių klasterių kūrimuisi, o tokios naujos kryptys kaip „*debesų gamyba*“ (*cloud manufacturing*) inicijuoja naujų kompanijų, neturinčių savų gamybos linijų, tačiau kuriančių intelektinį turtą, atsiradimą.

Reikšminiai žodžiai: tarpvalstybinis inovacijų klasteris, klasterio vertinimas, naujoji pramoninė revoliucija, Industrie (Industrija) 4.0, RadicalLook (radikalaus žvilgsnio) metodologija.

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