Socio-Cultural Factors of Industrial Symbiosis – Conceptualization and Research Approach

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***Abstract*—**Industrial symbiosis represents a relationship between three or more social actors, involved in exchange of waste as material, water or energy sources, whereas the resource exchange represents synergies between these actors. All actors, involved in exchange of resources, achieve their own benefits, help achieve other actor's benefits and at the same time increase the benefits of society in general – it is therefore a winning move for social and natural environment at the same time. Industrial symbiosis networks are therefore a subject of multi-disciplinary research, most in the field of waste management, ecology, industrial ecology, logistics, supply chain management, and economy. The emphasis of this article is on embeddedness and role of socio-cultural factors in industrial symbiosis networks. It identifies the key socio-cultural factors and potential obstacles in the formation of an industrial symbiosis network and provides in-depth information on the study of its social milieu. Social actors, which are involved in industrial symbiosis networks, should be familiar with different socio-cultural, ecological and economic factors of industrial symbiosis networks in order to be able to recognize them. This knowledge would benefit social actors in terms of a good foundation for adopting decisions regarding their own performance within industrial symbiosis network, as well as conceptualize policies for its realization.

***Keywords*—**Industrial Symbiosis, Industrial Symbiosis Networks, Socio-Cultural Factors, Research Approach.

I. INTRODUCTION

INDUSTRIAL symbiosis represents a multi-disciplinary research environment, the primary research field of which belongs to ecology, economy as well as sociology. Some authors [1, 2, 3] define industrial symbiosis as an approach to industrial ecology; as synonymous to industrial ecology [4]; as subset of industrial ecology [5]; as activity within industrial ecosystem [6]; as eco-industrial symbiosis representing circular economy on local and regional levels with sustainable effects and approaches to environment [7] or as one of the three levels of industrial ecology research [7]. Industrial symbiosis exists in the social milieu and is studied through its opportunities for exploration as well as ecological, economical and social synergies.

The advantages of industrial symbiosis for social actors and society alike apply to ecological, economical, and social areas. In ecological sense it is carried out through joint reuse of used material resources; in economical sense it applies to joint savings from purchasing new material resources and correct disposal of used material resources; in social sense it is visible through joint social concern in terms of established approaches in environmental management and informal networking between social actors, bringing new knowledge and best practice into all other fields of management. Socio-cultural factors have a key role in industrial symbiosis – without them, exchange as the main activity of industrial symbiosis would be hindered. Within the domain of key socio-cultural factors, which we classify as part of sociological field of expertise, we should emphasize trust, cooperation, motivation, flexibility, and creativity. Despite the crucial role of these socio-cultural factors in practical implementation of industrial symbiosis, these factors can also become obstacles, reasons for their hindering effect being diverse.

Exploration of socio-cultural factors of industrial symbiosis for us, researchers, poses many challenges and dilemmas due to the lack of explicit research methodology. One such dilemma involves preparation of an appropriate research program and plan, the purpose of which is to guide the researcher. The following dilemma poses a question of how much we should combine qualitative and quantitative research paradigms – or whether we should combine them at all. These dilemmas further open questions on appropriate sampling; selection of methods for data collection; data processing method; potential problems incurred during research, and how to solve them efficiently. It is these dilemmas and questions that represent key motivation in our research.

II. THEORETICAL BACKGROUND

A. Industrial symbiosis

Industrial symbiosis is defined as a collective approach, which includes physical exchange of materials, energy, water, and byproducts between social actors in different industries with the intention of gaining a competitive advantage [8]. On the other hand, industrial symbiosis is defined as mutually-dependent relationship between two social actors, which exchange material resources and energy for their mutual benefits, where the intention of each partner is to increase their own benefits as well as the benefits of the other partner [9]. Social or economic actors in the exchange of material resources, water or energy are represented by industrial as well as non-industrial companies. When mentioning social actors, we focus on those organizations which are simultaneously involved in for-profit and not-for-profit activities. Companies are good examples of for-profit social actors, while educational institutions can represent not-for-profit social actors. When speaking of economic actors, however, we focus on organizations, which are primarily involved in for-profit activities. Examples of economic actors are companies and

entrepreneurs. An economic actor also represents a social actor which is active in the social milieu and acts for the benefit of the society. Beside companies, social actors are also local communities, local authorities, educational institutions, research centers, ministries, and government and similar agencies on a national and international level.

The general rule for defining industrial symbiosis says that at least 3 economic or social actors must be involved in exchange of at least 2 material resources [1]. There are four flows connecting the actors: material, information, financial and knowledge flow. Material flow begins with the partner selling the material resources and ends with the partner buying them; financial flow usually runs in the opposite direction. In practice, financial flow can be excluded when only material exchange occurs between the partners. Knowledge flow is a very important and multi-directional aspect, enabling social actors to exchange know-how and experience. Chertow also states geographical proximity of partners as one of the conditions for industrial symbiosis [8].

Industrial symbiosis networks can be seen as virtual networks, which are present and active on regional, national or international level, where industrial symbiosis can be carried out in accordance with the geographical proximity criterion.

In cases, where several companies or social actors, involved in industrial symbiosis, are located in the same geographical area, they can be connected through clusters and industrial districts. Clusters are defined as geographical concentration of inter-connected companies and institutions from different or related industries in a certain geographical area [10]. We are speaking of cooperation between companies, which are not connected formally, but which use clusters to increase their own competitiveness and that of all involved companies in order to achieve significantly better results than competitive companies – those, which are not connected into clusters [10].

Industrial district, on the other hand, represents the concept of clusters. It is often seen as a synonym for agglomeration, localization and connection, and often represents the concentrated location/area of companies, which – according to Marshall – operates outside its local level [11]. Characteristics of industrial districts are strong territorial identity, collective entrepreneurship, flexible specialization, and simultaneous existence of competition and cooperation with the development of competitive and cooperative advantages, proactive spread of information and innovation, economic and social cohesion, and collective identity [12].

Since industrial symbiosis brings about positive effects in terms of ecology as well as economy and can help solve challenges related to environmental protection, energy, sustainable development and resource efficiency, countries can incorporate it into their strategy of smart specialization, which is part of the country's industrial policy. In Slovenia the strategy of smart specialization represents a strategic document to be used as foundation for investing development resources into research, development of and innovation in those areas, which could have the largest impact on Slovenia's economy [13]. Smart specialization was based on global social challenges – sustainable energy, mobility and construction, health, food and environment, safe and inclusive society, and resource efficiency [13]. In relation to smart specialization, industrial symbiosis is linked to green growth of the economy and effective use of resources [13].

Industrial policy falls under government policies and represents a combination of government activities, which impact the growth, productivity and competitiveness of a certain industry. Industrial policy is defined as state-regulated measures, which use different instruments to interfere with macro- and micro-economic factors and increase the efficiency of dynamic, internal allocation in the national economy [14]. Another option is to view industrial policy in its wider perspective, where it not only deals in industry, but primarily serves as a means of improving the standard of living for its citizens [15].

Uzzi in Domenech [16] focuses on 3 typical characteristics of industrial symbiosis networks: trust; exchange of information and knowledge; and joint resolution of problems. Therefore, industrial symbiosis networks connect social actors, which cooperate in carrying out industrial symbiosis in order to fulfil their own economic, ecologic and social goals. Like other networks, they consist of nodes and connections. Social or economic actors will represent the nodes of industrial symbiosis networks and cooperation between these actors will represent the connections between the nodes. The connections are represented by four flows: information, material, financial, and knowledge flow. Material flows are carried out on local and regional levels; whereas industrial symbiosis networks exist on a national or international level.

III. SOCIO-CULTURAL FACTORS OF INDUSTRIAL SYMBIOSIS

Socio-cultural factors represent a very important precondition of industrial symbiosis in terms of its existence as well as its performance. In relation to social dimensions of industrial symbiosis, Kurup [17] states that social benefits of industrial symbiosis materialize through trust and cooperation between organizations or social actors. Domenech [18] states that – next to material factors – cooperation in transfer and exchange of knowledge and technologies between social actors is crucial for industrial symbiosis. Trust between social actors in industrial symbiosis diminishes the risks and insecurity of this exchange and is of vital importance in creating cooperation [18]. Lack of trust in industrial symbiosis impedes communication and motivation for cooperation between social actors [18]. Based on this statement, we can search for different causal and consequential relations in socio-cultural factors, taking into account that we currently lack generalized and valid causal and consequential relations and that these relations are not all-inclusive, i.e. do not apply to industrial symbiosis as well as networking between any organizations. If we assume that both, communication and motivation, exist between social actors in industrial symbiosis, trust can be one of the most important socio-cultural factors for materialization of ecologic, economic and social goals of industrial symbiosis. According to its area of

implementation, communication and motivation within industrial symbiosis can be considered either as preconditions for existence of socio-cultural factors or as two of the socio-cultural factors itself. In terms of trust, we focus on inter-organizational trust, mainly because industrial symbiosis involves not only trust within one organization (organizational trust), but also trust between several organizations or social actors.

A. Inter-Organizational Trust

Trust represents one of the most important indicators of social capital [19]. Trust is important in all areas of social life [20] and is of key importance for successful cooperation and effectiveness of organizations [21]. In modern society with its increasing complex and uncertain business sphere, an undisturbed business operation would be much harder without personal and inter-organizational trust [21]. Trust is linked to cooperation and can lead to cooperation, whereas Adam [22] says that trust is not (always) a precondition for cooperation – instead, successful cooperation leads to trust.

In sociological theory, trust is closely linked to social capital, which Putnam in Kešljević [23] defines as networks, trust and norms for improving coordination and cooperation for the purpose of mutual benefits. In a wider sense of connection between social capital and trust, Adam, Makarovič, Rončević and Tomšič in Kešljević [23] define social capital as an intangible resource, which solves the problem of trust and coordination in and outside of organization. In general, theory states that social capital represents the intensity of networks between people and common values based on these networks – it is the increased interaction between people which increases the feeling of belonging [24]. Adam [22] also highlights that trust and social capital are contextually very sensitive concepts, which require a careful application in generalization and passing between the levels.

Trust between social actors in industrial symbiosis networks decreases transaction costs, risks, and exchange insecurity and is crucial for creating cooperation structures or cooperation [25, 1, 26, 27 in 21]. We will focus on inter-organizational trust, which applies to trust between several social actors. In modern-day business, known for its high level of complexity and insecurity, operations would be much harder to maintain without inter-personal and inter-organizational trust [21]. Cummings and Bromiley [28] believe that inter-organizational trust is mainly about individual's expectations – expecting that another individual or group will act with good intentions and in accordance with their obligations. In industrial symbiosis, inter-organizational trust is connected to inter-organizational cooperation and can also result in inter-organizational cooperation (or vice versa), which is the foundation for the exchange of material or other resources.

B. Inter-Organizational Cooperation

Cooperation can be defined as any adjustment, which has developed even partially for the purpose of reproductive success between social actors [29]. In light of cooperation we focus on inter-organizational cooperation, i.e. cooperation between several social actors. Young and Wilkinson [30] say that industries, organizations and chains are not able to develop and become competitive on the market without inter-organizational cooperation. The inter-organizational cooperation can be defined as joint, harmonized actions of several organizations, the purpose of which is achieving common goals [31]. Fhionnlaoich [32] thinks wider: he says it is a process in which organizations take part simply because it would take them longer to achieve the benefits of inter-organizational cooperation on their own. Industrial symbiosis demands cooperation between organizations, i.e. inter-organizational cooperation [33] as the basis for all primary activities of industrial symbiosis.

C. Inter-Organizational Motivation

Motivation is a desire to achieve a goal or specific level of competence, which lead to targeted behavior [34]. Here, we focus on inter-organizational motivation, where motivation between social actors must exist to enable primary industrial symbiosis activities to take place. Motivation between social actors can be defined as joint interest in collective ventures and inter-organizational cooperation between social actors [35]. Inter-organizational motivation must therefore exist to incite industrial symbiosis in the sense of material exchange, i.e. for inter-organizational cooperation. It is almost a pre-condition for material cooperation. Inter-organizational motivation is therefore needed to stimulate the idea of industrial symbiosis and inter-organizational cooperation (as well as inter-organizational trust).

D. Inter-Organizational Flexibility

Regev and Wegmann [36] define flexibility as capability to adjust to changes. Inter-organizational flexibility is thus the capability of organizations, i.e. social actors, to respond to stimuli coming from business networks, which they belong to, or their own organization [37]. In industrial symbiosis networks, inter-organizational flexibility means that social actors are able to efficiently respond to external and internal influences, which (could) have an effect on implementation of industrial symbiosis. External influences, which require inter-organizational flexibility, can be influences from other social actors, which are part of industrial symbiosis networks, or external responses from other social actors. In case of external influences, which concern several social actors and their operations, inter-organizational trust is required to help with inter-organizational flexibility, whereas inter-organizational cooperation must be self-evident.

E. Inter-Organizational Creativity

Inter-organizational creativity is defined as common use of new ideas and approaches for business operations, the purpose of which is inter-organizational cooperation [38], while creativity in general is developed within a single organization or social actor. In industrial symbiosis, inter-organizational creativity is closely linked to inter-organizational cooperation, since cooperation is required for improvement of industrial symbiosis by taking into consideration and implementing novelties and new approaches in this area. Inter-organizational

creativity can also have an important role in promoting industrial symbiosis in general – to potential social actors, which might become involved in industrial symbiosis networks – and in presenting industrial symbiosis to individual/interested groups.

F. Socio-cultural Factors as Barriers of Industrial Symbiosis

On the one hand, the aforementioned social factors have a key role in practical implementation of industrial symbiosis; on the other hand, they can complicate it. Reasons for it becoming obstacles are diverse. We are aware that other social factors are also important beside those we have already mentioned; however this review article will focus on these five factors. Because these socio-cultural factors can also represent barriers in industrial symbiosis networks, it is important for us, researchers, to be aware of this fact. We have observed that these barriers can be momentary, temporary or constant.

Another important point is that socio-cultural factors depend on and are impacted by other factors. Inter-organizational trust is very important, but it is also very hard to create and maintain [39]. If inter-organizational cooperation in an industrial symbiosis network depends on inter-organizational trust, this represents a barrier, as inter-organizational cooperation will only take place in the essential form of industrial symbiosis – material exchange. This will result in a poorly (or not at all) developed inter-organizational creativity, which can present itself as another barrier, as it can impede the development of industrial symbiosis. Also, the level of inter-organizational motivation will be under-developed.

Another potential barrier is the belief of individuals from social actors that inter-organizational cooperation is a pre-condition for inter-organizational trust, and the belief that an established inter-organizational creativity automatically implies an established inter-organizational flexibility. Limited and unlimited barriers can have a dramatic impact on the practical implementation of industrial symbiosis and even hinder it, which is why this field is an interesting choice of research. Relevant research results could help those interested social actors, who wish to become or are already part of industrial symbiosis networks.

IV. FUTURE RESEARCH PERSPECTIVES – RESEARCH APPROACH

Further research on industrial symbiosis is going to be focused on the latter's embeddedness in the social milieu of pertinent industrial symbiosis networks. The corresponding goal is to conceptualize a framework of regional, national and international industrial symbiosis networks that could be studied on three levels: micro-, meso- and macro-level. Micro-level denotes the basic structural layer of industrial symbiosis networks, which can be represented in the form of interlinked nodes, where nodes designate specific social actors (i.e. companies, local communities, educational and R&D institutions etc.) and series of connections between them outline the observed cooperation. Resultant relationships that form industrial symbiosis networks as a whole constitute the meso-level, while on the macro-level also the layer of outermost societal interrelationships is included.

Overall research objective is to gain insight into current state of industrial symbiosis on an international scale, including as many countries as possible, in addition to our native country, where industrial symbiosis is at present still in its infancy. Initial evidence in the case of Slovenia, based on secondary company-specific data available online, suggests there are three prototypical groups of companies engaged in industrial symbiosis, which can be identified on the micro-level. The first group is made up of companies that actively participate in industrial symbiosis and also explicitly designate such activities as eco-symbiosis, industrial eco-symbiosis and alike. Companies, which are a part of industrial symbiosis networks and maintain, use or provide some kind of industrial symbiosis activities that are on their part not directly associated with industrial symbiosis, form the second group. The third group contains companies that are still deliberating entering industrial symbiosis relationships, but see it as inevitable social practice in the future.

Analysis of the current state of industrial symbiosis within and across observed countries will be based on identification and mapping of industrial symbiosis networks, construed from relevant data on connections and cooperations between social actors. Four major stages form the backbone of the proposed research methodology:

1. conceptualization of a general industrial symbiosis network framework;
2. identification of socio-cultural factors, relevant for industrial symbiosis networks;
3. analysis of socio-cultural factors and their strucutural impact on industrial symbiosis networks;
4. classification of socio-cultural factors according to their importance and how they are perceived by social actors in industrial symbiosis networks.

Research programe under development will be designed as an international research study with a strong interdisciplinary orientation, including natural and social sciences as well as practical applications. The object of our research are complex dynamic networks and pertaining social, technical, computer and natural susbsystems, whose processes span across their respective borders and interconnect multiple social actors. Definition of appropriate approaches and analytic methods for acquiring new insights into industrial symbiosis and its socio-cultural antecedents will be followed by developing a theoretical model, which could be also utilized in alternative research streams dealing with industrial symbiosis.

The proposed program envisages two phases. First phase, which is currently under way, involves systemic review of literature and potentially applicable analytic protocols. Viable analytical techniques will be evaluated and examined for potentially required modifications to achieve a fit between the applied methodology and field-specific research domain, scope and objects. Network analysis and visualization algorithms will be applied to delineate inter-connected social actors, complemented by exploratory qualitative research to address existing research gaps, gain new insights and suggest further research directions. In the second phase the selected and modified analytical techniques will be applied to an

international dataset referring to the previously defined variables, as specified by the theoretical industrial symbiosis model. Thus the newly developed techniques could be tested with respect to their validity and robustness in analyzing networks at different stages of industrial symbiosis development. Ultimately, the interdisciplinary approach of combining mathematical theory with sociology, computer science and ecology should enable a more effective identification, modelling and analysis of industrial symbiosis, as it is also inherently a multi-faceted phenomenon: as much socioeconomic as it is eco-technological.

The issue of socio-cultural factor of industrial symbiosis network dynamics hinges on how social actors and their cognitive frameworks impact industrial symbiosis network structure and relationships within the network. Here, fuzzy-set analysis will be applied as a qualitative method to examine the inter-dependence between social networks, social actors, their cognitive frameworks and as to how they define their respective industrial symbiosis networks. Data for this part of the research will be collected using focus groups, semi-structured interviews and questionnaires in the form of online surveys and polls. Contribution originality may be justified by the interdisciplinary approach and treatment of a relatively new topic, which is gradually gaining an increasing interest from the research community. As such it thus holds the potential of going beyond the state-of-the-art and impacting further development of the research domain.

A. The Research Example with the Research Environment

Present contribution specifically focuses on five socio-cultural factors of industrial symbiosis – inter-organizational trust, inter-organizational cooperation, inter-organizational motivation, inter-organizational flexibility and inter-organizational creativity. According to the minimum threshold rule, applicable to determining whether a given group of companies actually constitutes an industrial symbiosis network as proposed by Chertow [2], there have to be at least three actors involved in the exchange of at least two material resources. With regard to the minimum threshold rule a framework for devising a research plan for examining socio-cultural factors of industrial symbiosis is demonstrated for the following case.

Three social actors are represented by medium-sized companies with up to 250 employees, where the first actor is a timber company, running logging operations and a saw mill, the second actor a paper and packaging manufacturer with a paper mill and the third a horticultural company, producing soil and mulch and running a plant nursery. For illustration purposes there are three material flows connecting the actors: the saw mill sells woodchips as a secondary (waste) raw material to the paper mill, which uses them in the production of paper products. Paper mill in turn captures heat and industrial water, used in their production processes, which is then fed to the plant nursery to provide heating and irrigation. Horticultural company at the same time buys sawdust from the timber company, which is then either added to their soil mixes or packaged and sold separately as part of gardening supplies.

Data collection for the given case covers the following social and economic actors:

- direct participants of the industrial symbiosis network (the three companies);
- indirectly involved actors that support the symbiosis interchange (waste management and transport companies, water utilities);
- local communities situated in the area of business operations;
- local, regional and state agencies or institutions.

Data from the direct participants should be for the purposes of examining socio-cultural factors of industrial symbiosis acquired from the department of ecology, project offices, financial department and senior executives. The local community would be included through district representatives and relevant city hall offices, while the state agencies covered include relevant ministries (Department for environment, Ministry for economic affairs) and state agencies for research and technology. Research methodology in the case of joint quantitative and qualitative paradigm consists of nine steps that form three stages: pre-empirical, empirical and perspective.

1. Step: Research problem definition
2. Step: Research domain overview
3. Step: Conceptualization of the research framework
4. Step: Data collection design
5. Step: Research object identification
6. Step: Data collection
7. Step: Data processing and administration
8. Step: Data analysis
9. Step: Interpretation and presentation of findings

Pre-empirical stage consists of the first four steps and is followed by the empirical stage comprising the second batch of the next three successive steps, with the remaining last two steps falling under the perspective stage.

Pre-empirical stage covers all the activities until the actual data collection in the field and the perspective stage is limited to the tasks succeeding data acquisition. The most important pre-requisite of the empirical stage is the formulation of adequate research questions. They are answered using sets of questions or statements, which are handed to the relevant subjects, whose responses are then recorded. Statements or questions form individual sections and each individual section consists of a certain number of those elements. Given a list of questions and the characteristics of each research paradigm, the most appropriate one or a mix of them is then chosen. In the case of industrial symbiosis socio-cultural factors, the following four sections or question sets are determined:

1. Set: social actors give general features about the organization – five questions;
2. Set: social actors evaluate other participants of the industrial symbiosis relationship with regard to the primary activities that are realized considering the observed socio-cultural factors – five questions;
3. Set: social actors describe the communication within the industrial symbiosis network – five questions;
4. Set: social actors define and assess inter-organizational trust, cooperation, motivation, flexibility and creativity as a socio-cultural factor of industrial symbiosis – five questions.

The four sets provide for 20 questions or statements. The makeup of these sections depends on what is the selected paradigm. Research plan that follows a quantitative paradigm calls for the use of questions, while a qualitative paradigm mainly requires the use of statements, however, it is possible to integrate the two of them and combine questions with statements as deemed appropriate.

B. The Research Plan for the Researching of Socio-Cultural Factors

The research plan for the investigation of socio-cultural factors of industrial symbiosis is thus designed according to the outlined sections and key features that apply to the collection, processing and analysis of data either within the quantitative or qualitative research paradigm.

The qualitative paradigm enables somewhat more options for exploratory research, however, this does not precludes the quantitative paradigm from being used for such purposes. Each has its own merits, and while both are feasible in the context of researching socio-cultural factors of industrial symbiosis on its own, a recommended solution would also be to use a combination of qualitative and quantitative methods in the sense of triangulation. Following Denzin in Lobe [40] the examination of socio-cultural factors in industrial symbiosis lends itself for the use of methodological and researcher triangulation. Methodological triangulation pertains to the use of multiple methods in one research study or the use of a single method at different stages or opportunities during the course of research. In contrast, researcher triangulation implies the cooperation of researchers with different backgrounds or specializations, which can enrich data analysis and interpretation and add greater reliability.

Depending on the type of data available, the qualitative paradigm is in general better suited for researching socio-cultural factors of industrial paradigm. The key advantage lies in the available data collection techniques, where, for the purposes of the research at hand, interview proves to be the most appropriate option for focusing on socio-cultural factors.

V. CONCLUSION

At the heart of industrial symbiosis networks lies the idea of building collectively aligned flows of tangible and intangible resources that seamlessly expand or complement multiple locally bounded life-cycles. They exist to exchange material goods and by-products, assets and services via closed and overlapping life-cycles, supporting sustainability of business operations. Cooperation of collocated actors through industrial symbiosis networks leverages the economic and environmental performance in a multilateral fashion through the use of wastes and byproducts, harnessing of energy outflows across individual entities and efficiency gains in production and distribution.

Nevertheless, despite showing great potential, in most cases industrial symbiosis networks are underdeveloped and the framework of their proper management poorly understood, which discourages policy-makers and other social actors to more actively pursue the implementation and maintenance of such relationships. In this context the role and importance of socio-cultural factors is two-fold: i) they determine the willingness and capabilities of actors to participate in industrial symbiosis relationships and ii) they determine to what degree a certain industrial symbiosis network is accommodated and accepted within the underlying social milieu. The first phase of our research that is geared towards the development of a theoretical model of industrial symbiosis networks fleshed out five socio-cultural factors that can act as success factors or conduits of industrial symbiosis relationships: inter-organizational trust, inter-organizational cooperation, inter-organizational motivation, inter-organizational flexibility and inter-organizational creativity.

The aim of our future work at this stage is to gain more understanding of how are these factors perceived by social actors on an inter-organizational level, what are their mutual inter-dependencies and how they affect individual social actors in an industrial symbiosis network and the functioning of an industrial symbiosis network itself as a whole. Conversely, the barriers to industrial symbiosis are an area which will require at least the same amount of attention as it can be examined from two perspectives: i) implicitly derived from socio-cultural factors as weak or absent positively contributing factors or ii) explicit inhibitors of industrial symbiosis.

REFERENCES

[1] M. R. Chertow, "Uncovering Industrial Symbiosis," School of Forestry and Environmental Studies, Yale University, 2007, pp.12-13.

[2] J. Howard-Grenville and R. Paquin, "Organizational Dynamics in Industrial Ecosystems: Insights from Organizational Theory," I. M. Ruth, and B. Davidsdottir, (Eds.), *Dynamics of Industrial Ecosystems*, Vol. 1., Edward Elgar, 2008, pp. 157-175.

[3] C. Gingrich, "Industrial Symbiosis: Current Understanding and Needed Ecology and Economics Influences," *Policy Engagement, Centre for Engineering and Public Policy*, 2012, pp. 44-49.

[4] P. S. Phillips, R. Barnes, M. P. Bates and T. Coskeran, "A Critical Appraisal of an UK County Waste Minimisation Programme: The Requirement for Regional Facilitated Development of Industrial Symbiosis/Ecology," *Resources, Conservation and Recycling*, Vol. 46, Elsevier, 2005, pp. 242-264.

[5] M. R. Chertow and D. Lombardi, "Quantifying Economic and Environmental Benefits of Co-located Firms," *Environmental Science and Technology*, Vol. 39, No. 17, 2005, pp. 6535-6541.

[6] J. Rui, and R. Heijungs, "Industrial Ecosystems as a Social Network," *Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference*, Delft, The Netherlands, 2010, pp. 1-11.

[7] S. Hartard, "Industrial Ecology and Industrial Symbiosis: New Concepts or New Branding*?!*" *Trier University of Applied Sciences – Umwelt-Campus Birkenfeld*, 2008, pp. 1-8.

[8] M. R. Chertow, "Industrial Symbiosis: Literature and Taxonomy," *Annual Review of Energy & the Environment*, Vol. 25, No. 1, 2000, pp. 313.

[9] S. E. Manahan, "Industrial Ecology. Environmental Chemistry and Hazardous Waste," *CRC Press LLC*, 1999, pp. 58.

[10] M. E. Porter, "Clusters and the New Economics of Competition," *Harvard Business Review*, Boston, 1998. pp. 77-90.

[11] F. Belussi, and K. Caldari, "At the Origin of the Industrial District: Alfred Marshall and the Cambridge School," *International Workshop: Marsall and Marshallians on Industrial Economics*, Mercury Tower, Hitotsubashi University, Tokyo, 2008, pp. 1-30.

[12] E. D´Arcy, and B. Guissani, "Local Economic Development Changing the Parameters." *Enterpreneurship & Regional Development*, 1996, pp. 159-178.

[13] Ministry of Economic Development and Technology, Strategija pametne specializacije 2014-2020, 2013 (2015, january, 17) [online]. Available: http://www.mgrt.gov.si/si/delovna_podrocja/evropska_kohezijska_politika/razvojno_nacrtovanje_in_programiranje_strateskih_in_izvedbenih_dokumentov/strategija_pametne_specializacije_2014_2020/.

[14] T. Dmitrović, "Industrijska Politika v Državah Srednje Evrope," Ljubljana: *Ekonomska fakulteta*, 1998, pp. 21.

[15] F. C. Genovesse, "An Examination of Proposals for U.S. Industrial Policy," *American Journal of Economics and Sociology*, Vol. 47, No. 4, 1988, pp. 442-452.

[16] T. Domenech and M. Davies, "The Role of Embeddedness in Industrial Symbiosis Networks: Phases in the Evolution of Industrial Symbiosis Networks," *Business Strategy and the Environment*, Vol. 20, 2010, pp. 284.

[17] B. J. Kurup, "Methodology for Capturing Environmental, Social and Economic Implications of Industrial Symbiosis in Heavy Industrial Areas," *University of Technology, Curtin University, Division of Science and Engineering, Doctoral Thesis*, Perth Australia 2007, pp. 19.

[18] T. Domenech, "Social Aspects of Industrial Symbiosis Networks," *Bartlett School of Graduate Studies, University College London, Doctoral Thesis*, 2010, pp. 19-22.

[19] H. Iglič, "Dejavniki nizke stopnje zaupanja v Sloveniji," *Družboslovne razprave*, XX, 46/47, 2004, pp. 149-175.

[20] J. O. Paliszkiewitz, "Inter-Organizational Trust: Conceptualization and Measurement," *International Journal of Performance*, Vol. 1., 2011, pp. 15-28.

[21] C. Lane, "Introduction: Theories and Issues in the Study of Trust," C. Lane and R. Bachman (Eds.). *Trust within and between Organizations, Conceptual Issues and Empirical Application*, Oxford University Press, 1998, pp. 1-30.

[22] F. Adam, "Še enkrat o zaupanju (replika)," *Družboslovne razprave*, XXI, 48, pp. 229-231.

[23] A. Kešljević, "Socialni kapital na organizacijski ravni in njegovi zunanji učinki," Kranj, *Organizacija*, 2003, pp. 6-12.

[24] A. Luca and D. Karyampas, "A New Proxy of Social Capital and the Economies Performance Across the Italian Region," *Birkbeck, University of London*, 2009, pp. 1-53

[25] W. Ashton, "Understanding the Organization of Industrial Ecosystems: A Social Network Approach," *Journal of Industrial Ecology*, Vol. 12, No. 1, 2008, pp. 34-51.

[26] L. Baas, "Industrial Symbiosis in the Rotterdam Harbour and Industry Complex: Reflections on the Interconnection of the Techno Sphere with the Social System," *Business Strategy and the Environmental*, Vol. 17, 2008, pp. 330-340.

[27] J. Ehrenfeld, and N. Gertler, "Industrial Ecology in Practice: The Evolution of Interdependence at Kalundborg," *Journal of Industrial Ecology*, Vol. 1, No. 1, 1997. pp. 67-79.

[28] L. Cummings and P. Bromiley, "The Organizational Trust Inventory (OTI): Development and Validation," In: R. M. Kramer and T. R. Tayler (Eds.), *Trust in Organizations: Frontiers of Theory and Research*, Thousand Oaks Sage: USA, 1996, pp. 302-330.

[29] A. Gardner, A. S. Griffin and S. A. West, "Theory of Cooperation," *Encyclopedia of Life Sciences*, John Wiley & Sons, 2009, pp. 1-8.

[30] L. Young and I. F. Wilkinson, "The Role of Trust and Cooperation in Marketing Channels," *European Journal of Marketing*, Vol. 23, No. 2, 2006, pp. 109-122.

[31] J. C. Anderson and J. A. Narus, "A Model of the Distributor´s Perspective of Distributor Manufacturer Working Relationship," *Journal of Marketing*, 1986, Vol. 48, No. 4, pp. 62-74.

[32] C. M. Fhionnlaoich, "Interorganizational Cooperation: Towards a Synthesis of Theoretical Perspectives," D. McLoughlin, and C. Horan, (Eds.), *Proceedings of the 15th Annual IMP Conference*, University College, Dublin, 1999, pp. 1-22.

[33] M. Saloluoma, "Developing of Supportive Context for Eco-Industrial Networks in Finland," *Lappeenranta University of Technology, Department of Industrial Engineering and Management, Master´s Thesis*, 2014, pp. 13-34.

[34] T. Baver, and B. Erdogan, "An Introduction to Organizational Behavior," 2012 (2015, december, 22) [online] Available: http://2012books.lardbucket.org/pdfs/an-introduction-to-organizational-behavior-v1.1.pdf

[35] M. Dulaimi and A. Bajracharya, "Organizational Motivation and Interorganizational Interaction in Construction Motivation in Singapore," *Construction Management and Economics*, Taylor & Francis (Routhledge), 2003, pp. 4.

[36] K. Kumar and M. M. Narasipuram, "Defining Requirements for Business Process Flexibility," *BPMDS'06*, 2006, pp. 137.

[37] E. Kopanaki and S. Smithson, "Examining Organizational Flexibility in an Interorganizational Context," *Ninth Americas Conference on Information Systems*, 2003, pp. 547.

[38] Q. Wang, K. Bradford, J. Xu and B. Weitz, "Creativing in Buyer-seller Relationships: The Role of Governance." *International Journal of Research in Marketing*, Vol. 25, 2008, pp. 110.

[39] J. Sydow, "Understanding the Constitution of Interorganizational Trust," In: V. C. Lane and R. Bachamann (Eds.), *Trust Within and Between Organizations: Conceptual Issues and Empirical Applications*, Oxford University Press, 1998, pp. 31-63.

[40] B. Lobe, "Združevanje kvalitativnih in kvantitativnih metod – stara praksa v novi preobleki?" *Družboslovne razprave*, Vol. XXII, No. 53, 2006, pp. 55-73.

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