

Reconnoitering implementation barriers of industrial symbiosis through social and economic kpi's: a comparative analysis approach

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Abstract: *Industrial Symbiosis (IS) is currently seen as one of the most avantgarde concepts embracing circularity and business cooperation in almost all economic sectors. Industrial Symbiosis processes are novel concepts compared to traditional business models with profit based and business oriented. This paper aims to present key findings and insights from Poland and Albania, both in early stages of IS implementation, as a study within LIAISE COST Action framework. Since the industrialization process for both countries have had similar patterns from their centralized past, they face nowadays similar challenges and barriers. Using a comparative quantitative approach, the findings highlight shared obstacles, including high investments costs, limited awareness of IS benefits, low trust among firms, insufficient coordination mechanisms, and constrained access to finance for collaborative investments. This paper also suggests the importance of tailored policies for each country, as well as the importance of support from public institutions.*

Keywords: CIRCULAR ECONOMY, INDUSTRIAL SYMBIOSIS, SOCIO – ECONOMIC BARRIERS

1. Introduction

Traditional linear economic models have grown critical concerns related to overall and long-term impact on environmental and social sustainability. The growth of Industry 4.0 and 5.0 has imposed obligatory shifting from traditional linear model to circular economic concepts [23]. Making the 'circular transition' requires understanding the whole new business processes, as well as adopting novel methods to increase profitability [11]. In order to further advance into circularity, the role of industrial symbiosis implementation has emerged as a pivotal point. Within this logic framework, the circular economic system is becoming 'the ideal option' fitting all the requirements, in order to enhance waste reduction and resources prevention [22].

Industrial Symbiosis processes are new and avantgarde concepts compared to traditional business models with profit based and business oriented. Poland and Albania, traditionally come from a past linked to the centralized economy, totally oriented by the state control and organization, that has not allowed the process of industrialization to be normalized as in Western European countries and other advanced economies [10, 13, 20, 27]. After late '80s, Poland and Albania started their economic transition shifting from state-controlled economy to a market-oriented one. However, their path toward transition has not been the same. Due to their differences in size of economy, country area, population and technologic development, Poland passed the transition period way faster compared to Albania [3, 9]. In Albania, still nowadays, the country has negligible and insignificant amount of industrial contribution to the economy, with a very low percentage of industries contributing into Gross Domestic Product (GDP). From the difference's perspective, and from the past similar economic models, this has been one of the reasons while we chose to see the Industrial Symbiosis perspective in these two countries.

This paper aims to present the current situation of Industrial Symbiosis (IS) implementation in Albanian and Poland, exploring familiarity and perceptions about it. Moreover, the authors explore primary data collected by dedicated questionnaires in Poland and Albania, estimating the main economic barriers and obstacles hindering industrial symbiosis implementation. From more than 100 responses in both countries, quantitative data with Likert scale are being used to measure the main socio – economic barriers of industrial symbiosis implementation in Albania and Poland. Key findings emphasize the similarity in approach related to the vast majority of barriers, yet differences are seen in several of them.

High investment costs, insufficient funding sources, minor business collaboration, as well as financial inability to adapt industrial symbiosis projects are ranked as the most influential ones for Albania and Poland, even though with slight differences. Meanwhile, the lack of human resources, geographical barriers, lack of public awareness and legislative framework barriers are

evaluated as focal points for industrial implementation from social and environmental aspects.

The paper starts with a brief introduction of the concept of industrial symbiosis, followed by a dedicated literature review section exploring the authors' viewpoint for specific barriers and obstacles hindering industrial symbiosis. Then, the methodology section explores the main approaches related to statistical data analysis, as well as comparison between two countries data. The next topic summarizes the main key findings and discussion of data. The paper closes with the conclusion and recommendations.

2. Literature review

The rise of the industrialization process and urbanization in the last decades has led to an increase in carbon dioxide emission [16]. This has increased the attention of researchers trying to find alternative ways of cooperating, to reduce carbon emissions, also contributing to the reduction and waste management. Pioneers such as Chertow and Desrochers has predefined the concept of industrial symbiosis, as an alternative viewpoint of economy as a whole, as industrial symbiosis engages traditionally separate entities in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products [5]. Lawal and other authors has also emphasized the importance of industrial symbiosis and its relation to sustainability and industrial ecology [16]. Industrial symbiosis has now been documented in all continents, with sporadic or standardized cases [17]. Chertow and Ehrenfeld developed a 3-stage theory for IS, beginning with the synergy of the actors involved in IS [5].

The last decade has shown an immense improvement in adapting novel approaches to circularity in Poland and Albania. The industrial sector is way more developed in Poland, compared to Albania, due to several factors impacting the process like geographical conditions, country's size, population, industrial inheritance from past, etc. Nowadays, circular economy is developing rapidly in Poland, especially in regions like Małopolska [23]. The authors have also confirmed that the public awareness is still not one of the major forces embracing circular economy in Poland. Other late studies affirms the role of technological drivers and innovation as key players in emphasizing the importance of circular economy in Poland [4, 7].

The situation of circular economy in Albania is however still in its early stages, being implemented only in few sectors like light food industry, wood industry, livestock farming, etc. Late studies have confirmed that the readiness of Albanian consumers is still in low and moderate levels, thus hindering the circular economy [8], [19], [21].

As the economic cycles are considered now more and more dynamic, the implementation of IS faces significant barriers and challenges. These obstacles are related to all phases of

implementation, starting from understanding the importance of IS, technical aspects of implementation, socio – cultural barriers, etc. The barriers and obstacles of IS are analyzed from several authors, emphasizing the role of governments and learning from case studies, thus reducing the implementation challenges [18]. Previously, Islam et. Al has also emphasized the importance of clear policies to support IS implementation [12]. Neves et. Al noticed that the diversity of industries, geographical proximity, facilitating entities and legislation, plans, and policies are shown to be the main barriers of IS implementation. From the business perspective, the organizational challenges are most significant in the journey towards IS [28]. In addition, during IS Implementation, some firms are oriented by maximizing their own profit creating bilateral agreements [1]. Moreover, the latest studies also mention the lack of technology and infrastructure readiness as one of the most important barriers on IS implementing, especially in manufacturing industry [18, 24].

Industrial symbiosis, as a powerful tool promoting circularity, is now becoming more and more documented in crucial sectors in economic activity of Poland. Various studies have now documented the implementation of industrial symbiosis cooperation in dedicated industrial parks [14]. Industrial Symbiosis is becoming present in sectors like meat waste industry, sustainable energy parks, local communities, etc. [6, 7, 15]. It is also more present in urban regions, as well as promoting local government initiatives [7].

Notwithstanding, the industrial symbiosis cases are almost inexistent in Albanian economic framework. There are several businesses operating within circular economy framework but not fully implementing industrial symbiosis principles. Moreover, there are also very few studies dedicated to industrial symbiosis in Albania, aiming to identify main barriers and obstacles of IS implementation [25, 26]. Circular economy principles are more evident as part of decarbonization initiatives from specific businesses, with focus on food industry, metal production, and construction sector [1, 2].

3. Methodology

For methodological purposes of primary data collection, two dedicated questionnaires were conducted to gather data from Poland and Albania, in order to create a comparative approach of how business managers, professionals and other stakeholders' percept the level of IS implementation barriers. The questionnaires were shared among professionals predominantly with economics backgrounds, followed by others with juridical, engineering and information technology education. The questionnaires were identical for both countries, and are compounded by three different sections:

- General indicators impacting IS implementation;
- Social barriers that hinder IS implementation;
- Economic obstacles that challenge IS implementation.

The vast majority of questions related to IS implementation barriers are based on the obstacles that have been identified by late studies and research, with information provided in the2. Literature review, with focus on exploring the most important barriers that hinder industrial symbiosis from Economic and Social Key Performance Indicators (KPIs).

The dataset of more than 100 responses per country is being structured and adapted to better in-depth present the key findings from this study. As a precondition for primary data, some statistical tests for data significance and general descriptive statistics are provided below. Some of the questions are structured as a Likert scale estimation, to measure the perception of the importance of some factors.

3.1 Descriptive statistics of IS in Poland and Albania

Since the implementation of industrial symbiosis remains quite an avantgarde concept, there are no major datasets that have collected information dedicated to Poland or Albania. In that context, the two separate questionnaires prepared for this paper contribute to additional primary information related to IS. The questions reflect the main barriers and hinderances taken into consideration by the literature review process, enhancing the obstacles for developing countries in implementing industrial symbiosis. The questionnaires were shared anonymously with target groups for more than 9 months, collecting more than 230 responses [200 after data cleaning and outliers removing].

After the dataset were cleaned in R programming language (by removing n/a and error missing data), the two datasets for each country were merged to measure the consistency and stability of data, in order to have a preconfirmation for later use. One of the most used tests for data consistency and stability is the measurement of Cronbach's alpha. As measured, the Cronbach's alpha for the merged dataset [hereby: *IS_dataset*] was estimated to **0.82**, indicating a high-level of internal consistency in dataset. In this logic, this data can be used for further analysis.

Table 1: Cronbach's Alpha for IS dataset in Albania and Poland

Raw_alpha	std.alpha	avg_r	s/n	mean	sd	median_r
0.82	0.81	0.27	5	3.6	0.5	0.25

(Author's calculations in RStudio software)

From the first section of general questions, there are slightly different responses related to the familiarity, the types of industries with more potential on implementing Industrial Symbiosis, the main initiatives undertaken etc. The level of familiarity in Poland is relatively higher (68%), compared to the Albanian professionals and business managers that have knowledge about IS (56%). Additionally, the main industries precepted with the highest potential implementing IS in Albania are being considered the waste management sector, followed by the paper and pulp processing industry. In Poland the sector with the highest potential is being considered waste management sector, followed by the food and beverage industry.

In both countries, educational initiatives, as well subsidies for recycling are seen as the most effective ones, having high similarities in responses. Furthermore, in Albania, the corporates and big industries are seen as the main promoters, while in Poland the public institutions are seen as the most impactful ones (in Albania it is ranked as the second impactor). In Albania, more than 75% think that corporates can be the key-player, due to high potential of big companies to be involved in industry. These differences also reflect the strong institutional presence of the concept of state in the past for both Albania and Poland, which still estimate the role of government as crucial in promoting new economic initiatives.

Table 2: Differences in perception for IS general concepts in Albania/Poland

Factor	Albania	Poland
Familiarity of IS	56%	68%
Important sectors	Waste Management Paper/ Pulp Industry	Waste Management Food and Beverages
IS promoters	Educational Initiatives Subsidies	Educational Initiatives Subsidies
Economic agents	Big Industries Public Institutions	Public Institutions Corporates

(Authors' data preparation)

4. IS barriers discussion and analysis

4.1 Social barriers for industrial symbiosis implementation

There are several obstacles that hinders industrial symbiosis implementation in daily economic activities. Even though the vast majority of businesses are being positive on having the willingness to adapt more IS principles, yet they face social and economic barriers. The main social barriers on implementing IS are listed as below:

- Local culture
- Lack of information about industrial symbiosis
- Public awareness about industrial symbiosis
- Geographical conditions/ proximity

Local Culture

The local culture is one of the most important social barriers that creates a continuous problem on not promoting the industrial symbiosis in desirable levels. The chart below presents the perception for Poland and Albania.

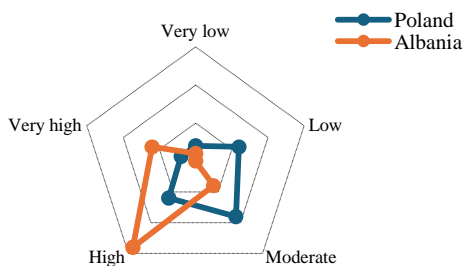


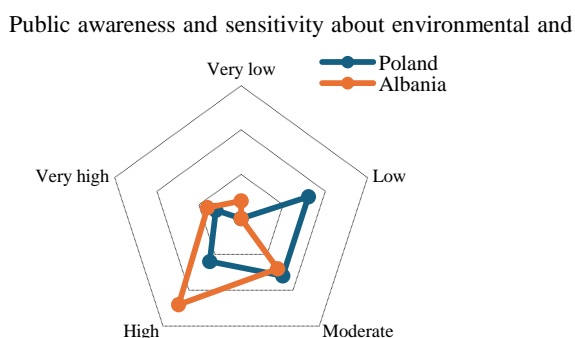
Chart 1: Local culture differences on IS for Albania and Poland

Local culture is being precepted predominantly with low to moderate impact, while in Albania, business managers and professionals see it majorly with high impact. This is the first difference between perceptions on IS. Due to lack of information (as another factor affecting implementation of IS), in Albania the local culture is seen as a more important factor.

Lack of information about IS

Following the first social barrier, the lack of information about the industrial symbiosis also tends to create obstacles for further promotion of IS. There are still differences in perception about this factor. In Albania, this is also being considered as an important factor, with most respondents ranking it as a high level, while in Poland, the lack of information is being precepted with low – moderate impact.

Chart 2: Lack of information about IS differences for Albania and Poland
Public awareness



economic aspects plays also a very important role in enhancing the power of circular economic concepts and particularly industrial symbiosis. However, public awareness perception has also slightly different responses comparing Albania with Poland. In Albania, public awareness about these concepts is being considered with high and very high levels of importance, while polish professionals and business managers think that this social barrier have lower impact. Even though the level is lower compared to Albania, in

Poland this factor is still estimated with moderate to high importance.

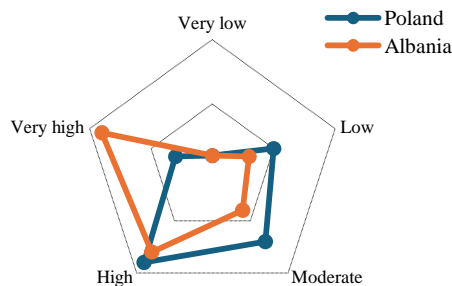


Chart 3: Social awareness differences on IS for Albania and Poland

Geographical barriers

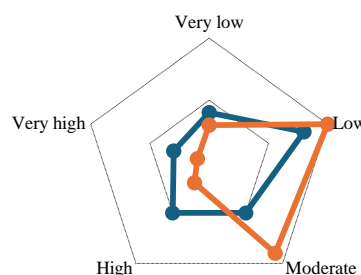


Chart 4: Geographical barriers differences for Albania and Poland

The change in the geographical features of a country can heavily influence the further development of industrial symbiosis, due to the importance of proximity of businesses to each other, in order to reduce costs of transportation and logistics. In that context, the geographical conditions of both Albania and Poland are not precepted as an important barrier to hinder IS, thus having low impact on IS implementation. The reason, however, is different for both countries. In Albania, the geographical barriers are estimated with low to moderate impact, due to small size of the country, while in Poland it is estimated to have low impact due to favorable terrain and physical conditions, with considerable plains and no mountains to hinder business cooperation.

4.1 Economic barriers for industrial symbiosis implementation

Beside the social aspects impacting industrial symbiosis, there are also economic indicators that can either enhance, or hinder the industrial symbiosis processes. There are several economic barriers [identified from literature review] that can create obstacles to IS, but the main factors identified are listed as below:

- Insufficient funding
- Cost of investments
- Minor business collaboration
- Inadequate fiscal regulations

These barriers are also precepted in similar viewpoint, yet with small differences on them.

Insufficient funding – Cost of investment

The process of adapting new business technologies and processes requires high capital investments. It is closely related to investing in new machineries, production lines, new implants, etc.

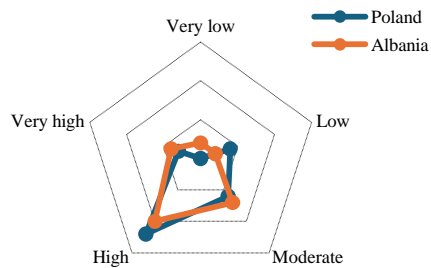


Chart 5: Insufficient funding barrier on IS implementation

Insufficient funding is seen almost identically in Poland and Albania, having high importance to impact IS. This reflects the business logic that is almost the same in both countries. Moreover, there are no responses that evaluate the funding barrier with very low or low impact.

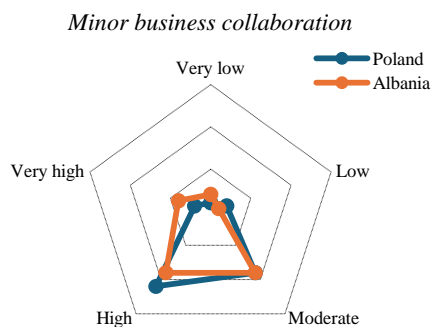


Chart 6: Business collaboration barrier in Albania and Poland

The level of business collaboration is also a barrier that is estimated almost identically in Albania and Poland, having moderate to high impact. In some cases, the minor collaboration between businesses does not derive from the unwillingness of businesses to collaborate, but due to the lack of information about other businesses offering by-products or waste that can be used as an input.

Inadequate fiscal regulations

Fiscal regulations can also influence the further industrial symbiosis implementation. Businesses dealing with IS and circular economy are expecting fiscal ease in terms of tax exemptions, subsidies, reimbursements, etc.

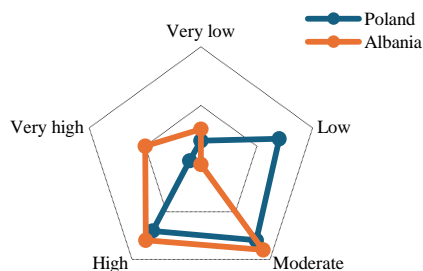


Chart 7: Inadequate fiscal regulations as barrier for IS

Fiscal regulations are perceived as a barrier with moderate to high impact in Albania, while in Poland there is no clear trend on

what professionals and businesses think about business collaboration.

4. Conclusions and recommendations

Industrial symbiosis, as a relatively new economic concept is closely related to the circular economy. The collaboration between industries and businesses in local and regional context is seen as vital in the near future to prevent waste management, carbon emission reduction and other consequences with climate and environmental impacts. However, industrial symbiosis implementation in different countries face several barriers and obstacles. For analytical purposes, this study classified barriers and socio-economic factor to make a comparison between Poland and Albania. Technological barriers to IS implementation are significant and multifaceted. Investments in industry and local culture make it difficult for industries to adopt advanced solutions. Many organizations face insufficiently developed infrastructure and limited availability of advanced recycling technologies, hindering resource exchange. Additionally, lack of public awareness and inadequate regulations further hinder industrial symbiosis in Poland and Albania, seen similarly in both countries. Poland as EU member has made significant progress on IS regulations and implementation in several industries in the agricultural sector, service industry, processing industries, etc. However, there are neglectable cases in Albania adapting industrial symbiosis concepts. Albania, as a non-EU country still faces highly important barriers related to the factors mentioned above, combined with the slow adaptation culture of circular economy and recycling. High promotion of IS via media and other channels, fiscal incentives for companies adapting processes of IS, increased capacities and technologies for IS implementation are highly recommended, to ease the implementation of industrial symbiosis.

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