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Industrial symbiosis opportunities for small and medium sized enterprises: preliminary study in the Besaya region (Cantabria, Northern Spain)

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ABSTRACT

In this paper we present the potential for small and medium sized enterprises grouped in industrial areas or parks for systemic eco-innovation through industrial symbiosis strategies. The study was carried out in an industrialised region in the self-governing region of Cantabria (Northern Spain), which comprises 161 inventoried firms, located in 9 different industrial areas. By sectors, 40% work in *commerce, the repair of motor vehicles, motorbikes and motorcycles and personal and domestic articles*, 16% in *metallurgy and the manufacture of metallic products*, 13% in *construction* and the remaining 31% work in such diverse sectors as *real estate services, the paper industry, food and the chemical industry*, among others. The information on resources and waste flows was collected by means of programmed visits, with a success rate of 104/161 enterprises. The preliminary results show opportunities both for substituting resources with waste products in real and virtual cases and for sharing waste management services and infrastructures. The diversity of synergetic opportunities is related to the number of enterprises that participate in each industrial area and with the occurrence of the types of waste products in the global system; thus we find options for action on different systemic levels. An optimistic scenario for escalating industrial symbiosis between small and medium sized enterprises is revealed from the project, thanks to both the companies' current behaviour and to the potential opportunities that were detected. This paper establishes the basis for advancing in subsequent stages of quantification and the evaluation of the feasibility of specific alternatives for turning the system under study into an industrial ecosystem.

1. Introduction

1.1. Industrial symbiosis as eco-business

The adoption of a systemic view of industry (Frosch, 1999; Graedel and Allenby, 2003) and the introduction of activities to close and optimise cycles of matter and energy (O'Rourke et al., 1996; den Hond, 2000; Brigenzu, 2003; Korhonen, 2007) are two pillars of Industrial Ecology that enable a better understanding of and improvement in the efficiency of the linear chain of production and consumption. The implementation of these activities may occur in different stages of the supply chain and can lead to Industrial Symbiosis (IS) networks when the waste products from certain processes or companies become income resources for others. As stated by Chertow (2004), these networks can be implemented in different ways depending on their spatial and organisational scale, for example, among companies in the same industrial park. With these strategies we achieve industrial systems that are more complex (Seiffert and Loch, 2005), but also more effective.

The reuse and recovery of waste products and by-products for use as resources is one of the main policies followed in waste management and pollution prevention in the European Union, under Directive 98/2008/EC (EU, 2008). The aim is two-fold; to reduce the disposal of waste products to minimum levels, and insofar as it is possible, the use of natural resources. Within this framework, a market of secondary resources and services arises, which should be promoted and accelerated within companies. Each member state of the EU must internally adopt and adapt the European policy to overcome the legal and administrative hurdles pertaining to the condition of by-products and the end of a waste

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product's life (Costa et al., 2010). In this regard huge efforts are being made to define the criteria that waste flows must meet in order to no longer be considered as waste. These include criteria for aggregates, paper, glass, metal, tyres and textiles. Of these, criteria have already been approved for scrap metal and glass (EU, 2011, 2012). Although this is not the only challenge, it is an essential technical driving element for developing new IS opportunities. In our opinion, a waste declassification would help companies reduce the uncertainty of trade-off and realise the value from wastes with a risk that can be accepted by them in the direct marketing of the secondary products.

In this work, we start from the basic principle that *a waste product might no longer be waste when it is marketable as a useful and environmentally safe product.* However, apart from this technical statement, it is important to mention additional issues related to business models so as to broaden IS practices. Both overcoming the current technical and administrative barriers and the effective implementation of specific actions aimed at sustainability require the adoption of new business models based on a systemic view of the life-cycle and of the long-term. This could also entail significant structural changes. Zott and Amit (2010) view the business model as a network rather than from a single firm-centric perspective. This emerging view has also led to the inclusion of IS among *systemic eco-innovations* (OECD, 2012). The recent work published by Bocken et al. (2014, 2013) defines eight archetypes of sustainable business models: maximising material and energy efficiency, creating value from waste, substituting it with renewables and natural processes, delivering functionality rather than ownership, adopting a stewardship role, encouraging sufficiency, repurposing for society/the environment and developing scale up solutions. *Industrial symbiosis* is among the examples provided for the *creating value from waste* model. Although the technical innovation component prevails in this model, social and organisational changes are closely related.

Adopting industrial symbiosis strategies entails a social innovation component at firm level that the authors compare to a Product Service System (PSS) based business model. A PSS is an integrated product and service offering that delivers value in use (Baines et al., 2007; Beuren et al., 2013). Understanding that the business model not only covers the product and core service, but also all of the material and energy inefficiencies associated with production and manufacturing, IS strategies can significantly contribute to the sustainability value in the industrial system. For example, when a waste product is reclassified and becomes a product of value on the market, it could be likened to a product-oriented business, in this case for co-products or by-products. If the IS opportunity is a joint transport service for waste or shared space for the storage thereof, it would be a service-oriented business opportunity. Thus, a PSS approach provides the opportunity to decouple economic success from material consumption in an intentional manner that goes beyond the lateral effects produced by the classic servitization models. Likewise, industrial symbiosis only happens through networks and cooperation, thus the component of organizational innovation through models based on repurposing for society/the environment is implicit. In addition to the firm and customers, other stakeholders should be taken into consideration regarding the benefits and costs associated with changes, such as investors and shareholders, employees, suppliers and partners, the environment and society (Bocken et al., 2014, 2013).

From this broader view, it could be summarized that IS does not only deal with technical innovation, but it is part of a whole hybrid business model that consists of getting value from wastes under different social tactics at company level and repurpose for society/environment at the multiorganizational level. The combination and commitment to be reached between individual strategy at firm level on the one hand, and collective strategy at the industrial ecosystem level on the other, mean that the technical systems are complex and involve dynamics of change, or evolution, that are difficult to predict (Dijkema and Basson, 2009; Nikolic et al., 2009; Romero and Ruiz, 2013, 2014; Sterman, 2000).

In any case, resorting to one of the basic tenets of industrial symbiosis, the opportunities for environmental collaboration between companies, or synergies, are aimed at obtaining a collective financial benefit larger than the sum of benefits they could achieve individually (Côte and Hall, 1995; Lowe and Evans, 1995; Martin et al., 1996). In addition to researching and gaining further knowledge on the organizational and social processes that best suit each situation for the successful implementation of the projects, it is important to continue advancing in the field of technical demonstration in order to convince those involved and to speed up the escalation of IS. In this paper, we therefore approach the first stage, that is required but not sufficient in itself, which is to identify the opportunities for industrial symbiosis that are potentially feasible both technically and financially in an industrial system made up of SME clusters, pursuant to current levels of knowledge.

1.2. Small and medium sized enterprises (SMEs) and opportunities for industrial symbiosis

In the EU-27, SMEs accounted for 99.8% of the total number of enterprises, and they generated 58.6% of the total added value according to the latest data from 2008. They were also notably present in the member states of Italy, Spain and Portugal which accounted for 35% of the total enterprises population within the EU-27s (Eurostat, 2011). The activities were mainly in the manufacturing industry, construction, recycling activities, transport, commerce and services, and they employed over 75% of the Spanish and Italian working population versus 66.7% of the EU-27 average. In spite of the financial significance of this type of industries, the concepts of Industrial Ecology and cases of successful IS have been led by large enterprises that are highly consumption-intensive in materials and energy, which could lead to induced actions in SMEs (Beers and Biswas, 2008; Salmi, 2007; Shi et al., 2010; Van Berkel, 2007; Yang and Feng, 2008). When the focus is on the industrial system made up of SMEs, the situation is different from that of large corporations and industrial complexes. In general, they are enterprises with low individual motivation regarding the environmental impact they cause and the environmental legislation affecting them (Commission of the European Community, 2007), and they also show a sceptical attitude towards the potential benefits entailed by the environmental management of their processes (Hillary, 2004). In addition, when enterprises are co-located in industrial areas or parks they tend to behave in isolation. There is hardly any dependence between the companies and in general there is a low level of cooperative culture, even if it is common for activities to become redundant, for example automobile workshops. Moreover, the business activity of the park is influenced by an ever increasing change of companies (Lambert and Boons, 2002). However, as highlighted in the European guide recently published by the Eco-Innovation Observatory (EIO and CfSD, 2013), the opportunities for eco-innovation for SMEs can exist throughout the product's entire life cycle (whether goods or services), process, organisational change or marketing solution. Concepts such as circular economy, industrial ecology and C2C (Cradle to Cradle) are introduced as innovative business solutions.

There is a series of positive technical aspects that favour the conversion of systems comprising SMEs into industrial ecosystems; for example, the scope of a large section of the enterprises is limited to the local scale (micro and family-owned businesses are predominant), increasing the interest in improving their