Sustainable Value Generation through Collaborative Symbiotic Networks Planning

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Abstract. Industrial Symbiosis is an important component of Industrial Ecology which studies the collaboration and coexistence of companies to achieve mutual benefits. Its concepts have traditionally focused on eco-efficiency and its direct benefits such as costs reduction, resources optimization and environmental impacts reduction. The paper introduces the use of externalities and collaborative networks as tools to amplify the spectrum of opportunities and, consequently, the potential value of Industrial Symbiosis development. Externalities are related to side effects of companies' decisions and acts. They offer a broader systemic view to Industrial Symbiosis planning and execution. Sustainable value brings up intangible value drivers such as institutional, organizational and relationship capital as well as risk management consideration. It helps companies to visualize the totality of potential value of Industrial Symbiosis.

Keywords: Collaborative Networks, Industrial Symbiosis, Externalities.

1 Introduction

Industrial symbiosis concept has originated from industrial ecology in allusion to the mutualism between living beings, and it has been studied by academics with great impulse since the 1990s. It is an important form of collaboration between companies when considering that the value created by them becomes greater than the sum of the eventual value created by each one individually. Industrial symbiosis traditionally offers three types of opportunities: infrastructure sharing, services sharing and reuse of energy and materials (water and co-products). Their benefits include primarily economies of scale from physical assets, prevention of negative externalities and promotion of positive ones.

Externality denomination was pointed for the first time by economists, and refers to the positive or negative effects of a business decision over those who do not take part in it. It is constructive to apply the externality approach into the searching for symbiotic opportunities between industries or service companies, as it can enhance the potential for generating positive impacts over a larger group of stakeholders.

The goal of this paper is to present externality control and collaborative networks importance for industrial symbiosis development. The collaboration between partners from the symbiotic network is able to generate value to a more diverse public. If

analyzed from a business perspective, can minimize risks, maximize eco-efficiency, reduce costs, and generate revenue and increase institutional, organizational, relationship and intellectual capital.

2 Industrial Ecology: Concepts and Eco-Industrial Parks

The study of industrial systems that operate more like natural ecosystems is known as Industrial Ecology (IE) [13]. The term was coined in the early 1990s, but the current concepts involved have been around for decades. They involve the sustainable philosophies of Reduce, Reuse, Recycle applied toward industry. It is based on environmental awareness and good economic sense.

Industrial Ecology has numerous aspects including pollution prevention, product life cycles, design for environment and green accounting [6]. A key concept is that processes and industries are seen as interacting systems rather than comprising isolated components in a system of linear flows. This provides a basis for thinking about ways to connect different waste-producing processes, plants or industries into an operating web that minimizes the total amount of industrial material that goes to disposal sinks or is lost in intermediate processes. The focus changes from minimizing waste from a particular process or facility (i.e. pollution prevention), to minimizing waste produced by the larger system as a whole, as well as reducing materials inflow [17, 4].

Since the introduction of Industrial Ecology, the Industrial Symbiosis (IS) concept has been put in a new perspective. Chertow [6], defines the concept of Industrial Symbiosis as "(…) part of the emerging field of Industrial Ecology, demanding resolute attention to the flow of materials and energy through local and regional economies. Industrial Symbiosis engages traditionally separate industries in collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity".

Based on the principles of Industrial Ecology and Industrial Symbiosis, a new concept has been developed. An Eco-Industrial Park, or EIP, is a public/private partnership where the Industrial Ecology and Industrial Symbiosis approach to industry is contained in one development. Cote [8] define EIP as " (…) an industrial system which conserves natural and economic resources; reduces production, material, energy, insurance and treatments costs and liabilities; improves operating efficiency, quality, worker health and public image; and provides opportunities for income generation from use and sale of wasted materials."

The benefit of this arrangement is that the waste material or product of one company can be recycled into the manufacturing process of one or more companies with minimal transportation and production costs. EIPs are designed to produce minimal emissions, minimal noise and ground pollution, and minimal waste. EIP firms are designed to fit the environment instead of adjusting the environment to fit the firm [10].

There are three primary opportunities for resource exchange in EIP: 1) By-product reuse - the exchange of firm-specific materials between two or more parties for use as

substitutes for commercial products or raw materials. The materials exchange component has also been referred to as a by-product exchange, by-product synergy, or waste exchange and may also be referred to as an industrial recycling network. 2) Utility/infrastructure sharing - the pooled use and management of commonly used resources such as energy, water, and wastewater. 3) Joint provision of services - meeting common needs across firms for ancillary activities such as fire suppression, transportation, and food provision [5]

These resource exchanges are aimed to avoid disturbing the environment where the companies are located. Relocating the resources reduces the impacts since landfills, pollution and residues are reduced as well as natural resources necessity is reduced due to re-use. These are important tasks in Industrial Ecology and the limit of its development is known as Circular Corporation. According to Yang and Feng "Circular economy is an abbreviation of 'Closed Materials Cycle Economy or Resources Circulated Economy', aiming at the efficient use of resources, taking reducing, reusing and recycling as principles and 'closed materials cycles and recycled use of energy' as features" [20].

Technical reports [12,16] on Eco-Industrial Park show that they differ a lot depending on geographical location, participant companies, government involvement and motivation for establishing it. Independently of how Eco-Industrial Parks are initiated or developed, they have the potential to bring several benefits to communities, environment and business. Some of them are listed in Table 1.

Table 1. Potential benefits from Eco-Industrial Parks [7].

Communities	Environment	Business
Larger tax base	Better resource use	Enhanced market image
Community pride	Reduced waste	Increased employee productivity
Improved environmental health	Increased protection of natural ecosystems	Access to financing
Enhanced quality of life in area near EIP	Innovative environmental solutions	Reduction in disposal costs
Good jobs	Increased protection of natural ecosystems	Income from sale of by-products

3 Business Externalities

Companies referred to as leaders in sustainability are those which bear responsibility on their externalities, Externalities is the term used to signal the "side effects" on the operations of a business, whether positive or negative ones. They are the impacts a business produces in broad terms, be it directly or indirectly, but not being obliged to pay for them, or rather, consider them during their decision-making processes. [16]. "Externalities are those consequences of a production process, imposed on society or the environment, which are not taken into account in the product price. They are produced whenever production processes, or consumers` utility, are affected by variables not controlled by themselves, but by other economic agents. These effects may be positive (external benefits) or negatives (external costs)" [18], p.469.

The activities generating externalities can create positive or negative consequences on the stakeholders (Table 2). If positive, the social benefit provided by the business exceeds the traditional view of economic gain, and creates private social welfare for other stakeholder groups. In contrast, the activities that produce negative externalities end up penalizing different groups without their being able to enjoy any compensatory benefits coming from the activities of the business. As mentioned by Sankar [19] in situations with negative externalities, the social cost of business is higher than the private cost paid by them.

Table 2. List of business externalities [3,9].

Business Area	Activity	Externalities
Power plant	Coal burning	Economic development, job creation, pollution
Casino	Gambling	Job creation, tourism development, urban revitalization, crime, corruption, suicide, bankruptcy
Motor vehicle use	Mobility	Economic development, job creation, trade increase, air pollution, pain, suffering, death

Thus, one can say that economic development has brought a number of problems, or "side effects". According to the guide The Natural Step (TNS), this scenario is known as "the challenge of sustainability." Also according to TNS, the systemic conditions for sustainability depend on four factors: in a sustainable society, nature is not subject to systematically increasing concentrations of substances extracted from soil (1), the accumulation of substances produced by society (2) and physical degradation of natural areas (3). Nevertheless, people should also be able to meet their needs (4) [3].

The systemic view of sustainability proposed by TNS has the role of showing the main lines to be followed by companies so as not to generate negative externalities. The perpetuity of enterprises depends on a positive balance of externalities, since only by ensuring a harmonious coexistence with their environment, may the companies receive a license to continue existing. May any phenomenon happen that make the sustainability of systemic conditions impracticable, negative externalities will emerge. In order to deal with scenarios like these, one shall adopt an approach to control the externalities. Figure 1 shows the main steps to be followed in order to act on the externalities of a business.

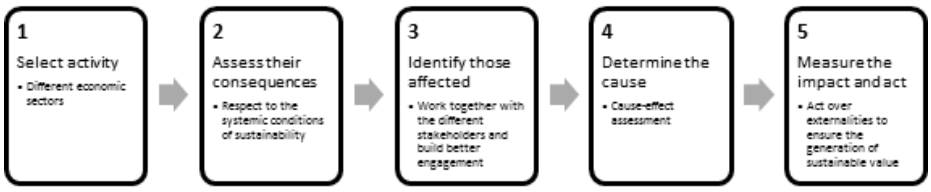

Fig. 1. Way to control business externalities.

By using the above approach to deal with externalities, one can enjoy good opportunities, be they represented by tangible gains, i.e. those associated with resource savings, or by intangible benefits, i.e. benefits for the brand and better risk

control. Sustainability actions designed to act on some externalities may simultaneously generate both tangible gains and intangible gains.

4 Externalities Control and Facilitating Structures for Symbiotic Collaborative Networks Development

As it is in previous sections, the growth of world industrial production has brought a series of negative developments, or "side effects", also known as externalities. The accumulation of unwanted material into the environment characterizes the industrial system as an open system. An objective of the industrial ecology is to transform the linear character of the industrial system into a cyclic system, in which raw materials, energy and waste will always be reused [14]. According with Beers et al. [1], one way to reduce emissions or disposal of wastes to water and atmosphere is through the realization of industrial symbiosis, also referred to as regional resource synergies. These concern the "capture, recovery and reuse of previously discarded by-products (materials, energy and water) from one industrial operation by other, traditionally separate, industries operating in their close proximity [1], p.831.

The desire to change the material flow from a linear view into another cyclic or circular is the target of the industrial symbiosis. It becomes an appropriate way to contain the generation of negative externalities of industrial activities over the population, respecting, thus, the systemic conditions of sustainability (Figure 2).

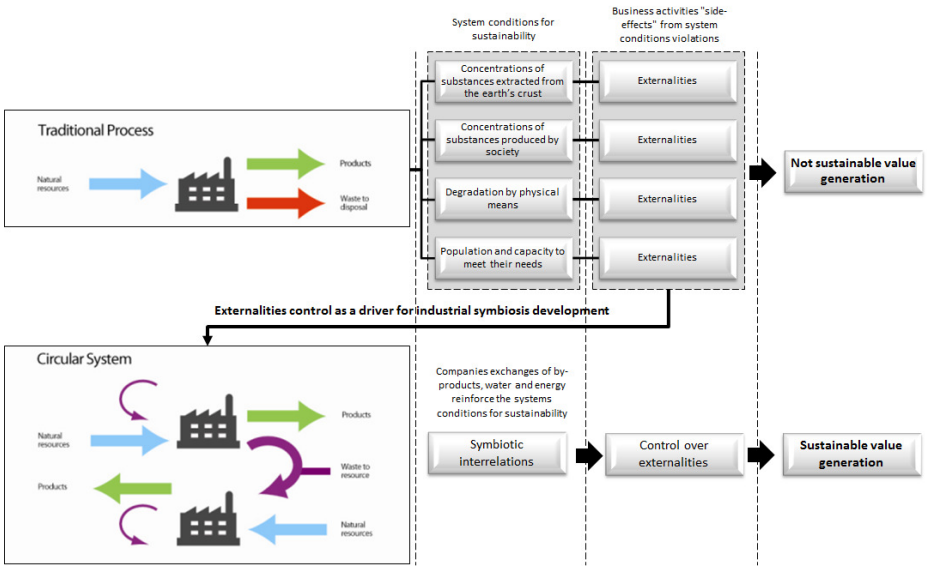

Fig. 2. Externalities control as a driver for industrial symbiosis development.

As it is shown in Figure 2, an appropriate way to develop symbiotic relationships between enterprises in different economic sectors is based on the identification of

negative externalities which penalize one or more groups of individuals to then enable actions that transform the problem into a new opportunity of revenue generation and intangible gains.

Hence, Table 3 contains real examples of externalities and industrial symbiosis as solution to cope with. This table was constructed following the externalities approach of five steps. The case of the power plant in Denmark, which used to lose some of the heat generated from coal without there being some kind of compensatory benefits for the company and society, is a good example of how industrial symbiosis has come to bring economic, environmental and social benefits to stakeholders. In this case, the company, in partnership with the city of Kalundborg, invested in numerous underground pipes so that the heat that used to be wasted would be taken to the residences in the city, which in turn allowed better energetic efficiency to the burning process. The externality associated with the non-efficient consumption of non-renewable resources has been circumvented, and used to generate additional revenues, reduce the population cost of living and, more importantly, to make disappear the environmental impact of burning fuel oil in residential buildings, no longer existing.

Table 3. Main business externalities and alleviation acts via industrial symbiosis [1,11].

Business	Externality	Symbiosis	Outcome
Mining (Gladstone, Australia)	Use of water from local reserves during drought	8.5 km pipeline so that secondary treated effluent from Gladstone sewage treatment plant could be used for its mud washing process	During drought alumina refinery was able to continue to operate at full production; no need to install tertiary treatment AT Gladstone sewage treatment plant; water source conservation; no city effluents discharged to local waterways
Chemical; production of titanium dioxide (Kwinana, Australia)	Production of contaminated acid water	Hydrochloric acid reuse	Revenue from sale

Common goals and close collaboration are prerequisites to create industrial symbiotic connections among companies in different business sectors. According with Bititci [2, p.7], collaboration is "a process in which organizations exchange information, alter activities, share resources and enhance each other's capacity for mutual benefit and a common purpose by sharing risks, responsibilities and rewards". The same author ratify that collaboration arises from the inability of organizations to generate sustainable value working alone, aside from society. Therefore, companies should work mutually to generate positive externalities and to act against negative ones.

To generate a collaborative symbiotic network, third parties should focus not just on externalities control, but also on facilitating structures to speed the transformation process. An approach was constructed based on Harris [15] and described in terms of

industry facilitation and provision of technical assistance for symbiosis development (Figure 3).

Fig. 3. Facilitating structures to achieve industrial symbiosis.

The approach from Figure 3 presented industry leadership from prominent companies as a recommended factor to create synergy among other members. Leadership from local or regional government can also help to create more synergy. Another factor pointed as beneficial is the adoption of an effective symbiosis development process management by means of a working committee with representatives from key businesses, facilitators and other parts providing input to the synergy creation goal. The tasks associated with synergy development ("synergy development activities") are composed by the collection of data from process input and output maps, lists of synergy opportunities and, finally, open workshops to explore good opportunities and concretize this symbiotic exchanges. Provisions are needed to cover the costs for data collection, synergy opportunity identification and screening and industry facilitation, but not necessarily for the actual investment costs for the implementation of any particular synergy project [15].

The symbiosis promotion is also an important part and should be conducted as a facilitating structure. As Harris state [15, p.12], "it is generally beneficial to document and communicate regional synergy achievements to various stakeholders, including local industries (to enhance their participation), community and other stakeholder grouping".

5 Final Remarks

The proposed contribution of this paper was to present two important elements of industrial symbiosis development - externalities control and collaborative networks - and their importance to speed up the symbiotic connections and their effectiveness. Traditional references about industrial symbiosis work mainly on information about by-products exchanges and services sharing. Our intention was to point out

externalities control and sustainable value generation as additional information for symbiosis development. Their use can be more attractive for business companies and theirs stakeholders. Collaborative networks are the vehicles where this data can be concretized on symbiotic relations, leading to sustainable value generation.

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