Industrial Recycling Networks as Starting Points for Broader Sustainability-Oriented Cooperation?

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Summary
Closing loops by intercompany recycling of by-products is a core theme of industrial ecology (IE). This article considers whether industrial recycling networks or industrial symbiosis projects can be used as a starting point for much broader intercompany cooperation for sustainable development. Evidence presented is based on the results of an empirical investigation of the recycling network Styria in Austria, the recycling network Oldenburger Münsterland in Germany, and the manufacturing sector in Austria.

Statistical analysis shows that the percentage of by-products that are passed on to other companies for recycling purposes is not higher in member companies of the recycling networks than in the other companies of the manufacturing sector in Austria. In terms of cooperation, the relationships with the respective recycling partners are found to be very similar to regular customer relations. Furthermore, the companies of the recycling networks remain unaware of the network to which they belong. Instead, one of the main findings of this study is that intercompany recycling activities are regarded by the company representatives as bilateral market transactions, not as collaborative network activities.

This has potentially significant implications for the use of industrial symbiosis networks as starting points for sustainability networks with broader cooperation toward sustainability. The findings raise interesting questions as to whether such broader cooperation might result from a conscious planning process or might emerge largely spontaneously as part of normal market coordination. In any case, intercompany recycling is clearly considered to be a very important field of collaborative action for sustainability in industry.
Introduction

Industrial ecology (IE) is being built around an eye-catching characteristic—the use of nature as a model. The fact that a natural ecosystem tends to recycle all materials biologically, using only energy from the sun to “drive” the system, is used as a metaphor for industrial systems (Frosch and Gallopoulos 1989; Ayres and Ayres 1996; Lifset 2002; Isenmann 2003). The main idea is to design industrial systems so that the by-products (“waste”) of one company are used as raw material by another company. The aim is to minimize industry’s impact on the environment by forming closed loops of material and energy use within the industrial system. Consequently, the concept of IE typically is applied at a local or regional level rather than at the level of a single company. Thus, interorganizational cooperation for sustainable development is one of the core issues within IE, whether in eco-industrial parks and regional networks or along the supply chain of certain product systems.

Many voices also postulate the importance of networks for sustainable development. Roome (2001) argues that environmental problems and poverty—that is, problems of unsustainability—are examples of metaproblems. Such problems are constituted of smaller sets of complex problems. The systems context for the problems of unsustainability is, at best, only partially appreciated by an individual organization. A response to a particular problem may provide immediate, short-term relief but tends to neglect connected problems. Thus, Roome maintains that responses to metaproblems need to be coordinated through interaction among many organizations. Interorganizational cooperation and networking are critically important for the metaproblems that make up the social and environmental dimensions of sustainability (Korhonen and colleagues 2004).

The central research question of this article is whether industrial recycling networks or industrial symbiosis (IS) projects can be used as a starting point for much broader intercompany cooperation for sustainable development. The research involves both a conceptual and an empirical perspective. The article presents evidence on existing recycling networks as a kind of IS project and their contribution to sustainable development. In addition, the question of further possible fields of cooperation toward a more sustainable (regional) development is discussed.

On the basis of a brief conceptual discussion of intercompany recycling cooperation for closing loops (a core idea of IE), I analyze empirical data. The data stem from a written survey of sustainability-related intercompany activities of firms in the manufacturing sector in Austria and member firms of the so-called recycling networks Styria in Austria and Oldenburger Münsterland in Germany. The main research concern is to determine how such intercompany recycling activities are organized within IS projects and what peculiarities exist in comparison with the reference sample of the Austrian manufacturing companies. Furthermore, the article’s main questions surround how companies perceive the concept of sustainable development, what issues and action fields they consider important, and in what fields they see advantages in intercompany cooperation. On the basis of this analysis, I draw conclusions about the possibilities for enhancing IS initiatives with respect to broadened cooperation for sustainable development.

From Industrial Symbiosis to Sustainability Networks

IS is a concept of interfirm cooperation that focuses on the exchange of by-products (waste) that can be used by another company as a substitute for raw material. Chertow (2000, 313; 2007, 12) defines IS as follows:

Industrial symbiosis engages traditionally separate industries in a 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.

The best documented example is Kalundborg in Denmark, which was even presented at the Earth Summit at Rio de Janeiro in 1992. In Kalundborg, a number of independent energy and waste exchanges between colocated companies and the local municipality evolved over a number of decades, resulting in economic benefits for all parties involved (Ehrenfeld and Gertler 1997; Christensen 1998; Jacobsen 2006). From an

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environmental point of view, the substitution of raw material generally also leads to environmental benefits (e.g., reductions in virgin material use, waste generation, or emissions).

A further well-known case of IS is the industrial recycling network Styria (Schwarz and Steininger 1997; Posch et al. 1998). Inspired by the IS in Kalundborg, researchers at the University of Graz in 1996 investigated whether similar recycling structures or networks also existed in the province of Styria. Their detailed analysis of 27 companies of different industries showed that these companies produced approximately 1 million tonnes of by-products. About 780,000 tonnes per year (77.5%) were recycled through direct intercompany waste exchanges, whereas about 200,000 tonnes (20%) were landfilled or incinerated, and only about 25,000 tonnes (2.5%) were handed over to professional waste management companies for recycling (Posch et al. 1998). In terms of quantity, the most important by-products exchanged within the Styria recycling network were cinder, waste paper, wood residuals, ashes, and scrap metal (see figure 1). The most important sources and sinks of by-products were companies of the primary industries; further important sinks were found in the construction industry. In addition to the enormous amount of already existing intercompany waste exchange, a further recycling potential of about 330,000 tonnes was identified in the analysis.

Similar to the IS in Kalundborg, the waste exchange relations among the companies of the Styria industrial recycling network evolved over time, driven by individual business interests. The main drivers were potential cost reduction from waste avoidance and savings on virgin raw material. In some cases, additional revenues for by-products could also be earned. Further advantages of the intercompany recycling activities were seen in the formation of stable and secure relationships. For example, a dairy produces many times more whey as by-product than curd and cheese. Thus, the dairy heavily depends on a secure recycling partnership for whey; otherwise, it would need to stop the production immediately because of a lack of storage capacity or alternative ways of removal. It is not surprising that most of the recycling relationships were found to be long term, with the common

Figure 1 Part of the Styria recycling network.
goal of by-product recycling and economic advantages, such as lower material or disposal costs and thus increased competitiveness for both partners. Schwarz and Steininger (1997, 49) stated, “When such goal-oriented collaboration of legally independent enterprises arises with relatively stable and most often long-term contractual relationships, the term “network” is commonly used. In our case a recycling network has been established.

A less well-known example of a regional recycling network is located in the so-called Oldenburger Münsterland in northern Germany. This recycling network has been the focus of several research projects financed by the German Environmental Foundation (Bundesstiftung Umwelt) and conducted by the University of Applied Sciences in Vechta−Diepholz; the regional waste management association (Abfallwirtschaftsgesellschaft Landkreis Vechta); the Steinbeis Technology Transfer Center, a nonprofit foundation in Oldenburger Münsterland; and the University of Graz. The resource conservation project Ressourcenschonung im Oldenburger Münsterland (RIDROM) was conducted in 1997−1998. The project’s aim was to establish a regional recycling network in the two neighboring counties, Cloppenburg and Vechta (Hasler and colleagues 1998). In this network, intercompany cooperation focused explicitly on the recycling of by-products, with considerable emphasis on the continuing exchange of information among the network companies (“communicative recycling network”). In a follow-up project in 2001−2003, the “Verwertungsagentur Oldenburger Münsterland” (Oldenburger Münsterland recycling agency) was institutionalized as a central agency responsible for network communication and coordination. A software-based regional recycling information system (REGRIS) was also developed and installed. In all, 24 companies were involved in Oldenburger Münsterland. The main drivers for the intercompany recycling activities were direct cost savings and the achievement of a better negotiating position vis-à-vis the few professional waste disposal companies in the region (Hasler 2003).

As described above, in the IS projects in Kalundborg, in Styria, and in Oldenburger Münsterland, the intercompany exchange of by-products (different kinds of material and energy) for recycling purposes plays the central role. Thus, these examples may be categorized as “first-generation” IS projects. The question arises whether such networks can be used as a starting point for broader cooperation in different fields. This would go along with the definition of IS by Chertow (2000, 2007) as well as that by Mirata and Emtairah (2005, 995), who define IS networks as a collection of long-term, symbiotic relationships between and among regional activities involving physical exchange of materials and energy carriers as well as the exchange of knowledge, human or technological resources, concurrently providing environmental and competitive benefits.

In the present article, the additional fields for cooperation are restricted to sustainability related activities—that is, activities that contribute to environmental protection or to social justice. Consequently, one must broaden the narrow view beyond mere recycling cooperation. This enlarged scope is outlined in table 1.

IE and IS are thus linked to the concept of sustainable development (SD). Harris and Pritchard (2004, 99) state that a “regional IE network has the potential to provide an umbrella for any sustainability or resource efficiency initiatives in the area.” Generally, there seems to be broad consensus regarding the importance of company networks in achieving sustainable development (Sinding 2000; Kirschten 2003; Liedtke and Rohn 2003). Projects of broadened multilateral cooperation toward sustainable development could be called IS “of the second generation” or simply “sustainability networks” (SNs). The latter are defined as local or regional systems of voluntary but organized cooperation among different stakeholders that exhibit a common vision of sustainable development (Posch 2006).

Here, it is worth mentioning that the integration of and interaction among stakeholders is the most essential starting point of sustainability networks. Only on the basis of this stakeholder interaction can a common vision of sustainable development be established. Furthermore, only if the integrated stakeholders share this vision will cooperation consciously aimed at contributing to sustainable development take place—that
Environmental protection is more than the recycling of material.
In fact, recycling is an end-of-pipe activity and therefore counts only as a second-best solution. It does not aim to avoid or reduce the negative outcome of production processes at the origin but only tries to reduce the negative impact on the environment by reusing the already existing by-products.

Sustainable development is more than environmental protection.
There is now a broad consensus that sustainability implies three dimensions (i.e., economic prosperity, environmental quality, and social justice). The latter element has been largely overlooked for decades by both science and industry.

Transition toward sustainability requires the involvement of all relevant actors.
For the transition of a system, such as a region, toward a more sustainable future, there is definitely a need for the integration of all relevant stakeholders—industry, regulators, different interest groups, consumers and households, and so on.

is, the normative aspects of the shared vision for sustainable development will be transformed into concrete action. Consequently, the main focus— for research as well—needs to be put on the human actors and on the stakeholders and the cooperative culture created and maintained by them. Here, one needs to be aware of the fact that, in practice, cooperation will only take place when the advantages of interorganizational cooperation exceed those of mere intraorganizational problem solving. One cannot assume a priori that all companies are interested in cooperation in the field of environmental and social management. Rather, there must be an obvious benefit from participating in a sustainability network to justify the transaction costs of interorganizational cooperation.

A distinction needs to be drawn here between cooperation that contributes to sustainable development and sustainability-oriented cooperation. In the former, it is necessary to assess the effects of concrete cooperative outcomes on specific systems. This involves considerable methodological debate concerning the validity of assessment and aggregation technique. The latter refers not to the actual (ex post) effects of the outcome but to the (ex ante) objectives or the vision of the actors involved in contributing to sustainable development. Consequently, the cooperation can be called sustainability-oriented as soon as sustainable development is an intention or goal.

The next question concerns whether this vision must be shared by all stakeholders involved in a sustainability network or only by the actors involved in a concrete collaborative activity. The idea of a common vision among all network actors closely corresponds to the understanding of a network as a strongly coupled system with members that are at least aware of the network or even possess something like a common network identity. The less stringent interpretation corresponds to a view of networks as loosely coupled systems with a higher degree of adaptability and flexibility but lower continuity and less sense of identity among members (Boons and Berends 2001). Which of the two possibilities better matches reality is the subject matter of the empirical research in this article.

In any case, if such sustainability-oriented cooperation takes place, the concrete and physically observable outcomes can be quite heterogeneous. Recycling and cascading of the physical flows of matter and energy definitely cover only one category of possible outcomes in such a cooperation culture. There is also a possibility that similar or identical activities might eventually take place, even without any sustainability orientation of the actors involved.

The concrete outcomes of sustainability-oriented cooperation can generally be categorized as follows:

- **Recycling materials and cascading energy:** This is the core activity of IS projects of the first generation. The reintegration of production and consumption wastes in production processes simultaneously leads to a substitution of natural resources and to a reduction of waste release (Strebel 2003). As Lifset (2001, 1) states, “Closing the loop, that is,
diverting products and materials that would otherwise be destined for disposal into productive uses, is indeed a pivotal tenet of industrial ecology."

- **Cooperating in improving and integrating production processes**: In supply chain networks as well as in regional networks, such as industrial parks and clusters (Steiner 1998), the improvement and integration of production processes are often highly advantageous from both an economic and an environmental point of view. Common R&D activities for process improvements and efficiency gains can also take place. Moreover, administrative facilities and technical equipment (e.g., waste water treatment facilities) might be shared by the network companies.

- **Cooperating in the development of sustainable products**: In terms of the ecological impact of a specific product during its life cycle, the main impact usually occurs in the production or consumption phase. Such impact is determined to a high degree in the product’s development phase, where the shape and the composition of the product are fixed. Hence, the process of product development—that is, industrial design—is essential in sustainability. Products need to be developed that meet consumer requirements but have a minimum negative ecological and social impact along the whole supply chain.

- **Accepting a common social responsibility**: Corporate social responsibility (CSR) encompasses three main issues: first, social responsibility throughout the life cycle of products, including compliance with human rights; second, proper human resources management, including fair treatment of older employees, employees from different cultures, disabled employees, and employees of both genders; and third, corporate citizenship, which is not limited to the creation of employment but also includes activities to strengthen community links, to cooperate with local schools, to sponsor cultural events, or to increase local procurement.

- **Promoting intercompany learning and knowledge generation**: This issue is very closely related to the other issues briefly described above and highlights the great potential for gaining in common a better understanding of many sustainability-related issues and possibly finding solutions to the environmental and social challenges the network members face. Malone and Yohe (2002, 377) even state that distributing expanding knowledge and shared ethical values through emerging communications technologies could be the key to unlocking the sort of environmentally sustainable, economically prosperous and equitable future that is likely to be socially and politically stable.

**Empirical Analysis**

The objective of the empirical analysis is to gain insight into how existing intercompany recycling activities work and where representatives of industry identify the main potentials for broader sustainability-oriented cooperation. A further goal is to gain a better understanding of the relevance of conceptual statements of IE in regard to IS, especially with respect to intercompany cooperation in recycling. For example, it is highly interesting to analyze how such collaborative recycling activities emerge, to identify the drivers behind the cooperation, and establish the most important potentials for further cooperative actions beyond recycling. In conformance with the epistemological framework of critical rationalism (Popper [1959] 2004), I need to clarify that it is not possible to verify concepts; at best, one can only falsify them. Because there are as yet no international comparative studies of different recycling network examples, the present study is of an explorative character. I hope that it will, on the one hand, contribute to the future establishment of new cooperation or help extend existing cooperation within industrial recycling networks and, on the other, further scientific research in the field of IE.

On the basis of the theoretical and conceptual work on IE in general and on recycling networks in particular, I developed a written questionnaire...
to be completed by the environmental and waste managers of the participating firms. Most questions asked respondents to select a point on a 5-point ordinal scale (e.g., from very low to very high). In some cases, multiple choice or dichotomous either—or questions were used. A pretest of the draft questionnaire was conducted with six company representatives and led only to minor modifications in the wording of some questions.

In a first step, all companies of the Austrian manufacturing sector with more than 100 employees were surveyed. Thereafter, the same questionnaire was sent to all companies of the Styria and Oldenburger Münsterland recycling networks. (Note that the survey is provided as Supplementary Material on the Journal’s Web site—in the original German, along with an English-language translation.) The definition of these two samples is based on scientific work at the Institute of System Sciences, Innovation and Sustainability Research (ISIS; formerly known as the Institute of Innovation and Environmental Management) at the University of Graz. Both recycling networks have been scientifically assisted and investigated by this institute in former research projects.

Additionally, I contacted by telephone all companies of the two recycling networks and 150 randomly selected companies of the sample of the Austrian manufacturing sector to motivate them to fill in and return the questionnaire. Table 2 gives the size of the samples and the respective number of questionnaires finally returned.

### Results in Regard to Existing Intercompany Recycling Activities

In this section, I analyze the following questions in regard to existing intercompany recycling activities:

- What percentages of by-products are recycled externally, and how did the intercompany recycling activities emerge?
- Are the intercompany recycling activities characterized by close partnerships, or are they more like regular relationships with business partners or customers?
- How important is the recycling network itself and participants’ awareness thereof for intercompany recycling?

Concerning the amount of waste recycled externally, I initially assumed that companies that are members of a recycling network pass on a greater percentage of their by-products for recycling purposes than other companies. I was surprised to find that, on average, the companies of the Austrian manufacturing sector \((n = 114)\) passed on 52% of their by-products for external recycling, whereas the average rate of externally recycled by-products was only 39% in the case of the Styria recycling network \((n = 20)\) and 36% in the case of the Oldenburger Münsterland recycling network \((n = 12)\). The Mann–Whitney test, a nonparametric test for assessing whether independent samples differ significantly in their central tendency (similar to the Student’s \(t\) test for metric data), shows that the difference between the recycling network companies and the reference sample of the Austrian manufacturing industry is statistically significant, \(z(N = 146) = -2.025, p < 0.05\)—but in the direction opposite to that expected. Members of the recycling networks pass on a significantly lower, not higher, percentage of their by-products for external recycling than other companies. This strengthens the doubts concerning the significant environmental improvement associated with IE, as articulated by Gibbs and colleagues (2005) in their analysis of eco-industrial development projects in the United States and Europe.

### Table 2  Sample sizes, number of questionnaires returned, and rates of return

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of companies surveyed</th>
<th>Number of questionnaires returned</th>
<th>Rate of return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austrian manufacturing sector</td>
<td>1,451</td>
<td>138</td>
<td>9.5</td>
</tr>
<tr>
<td>Styria recycling network</td>
<td>28</td>
<td>27</td>
<td>96.4</td>
</tr>
<tr>
<td>Oldenburger Münsterland recycling network</td>
<td>22</td>
<td>15</td>
<td>68.2</td>
</tr>
</tbody>
</table>

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In regard to the initialization of intercompany recycling activities, the questionnaire asked for information on the most important (in terms of quantity) by-product that is delivered to another company for recycling purposes. This means that the following results refer to only the most important recycling relationship of each company, not to all intercompany recycling activities. The analysis of the data shows that about 91% of the most important intercompany recycling activities evolved solely from bilateral direct contact with the respective recycling partner that used the waste as a raw material substitute; only 9% of the recycling activities evolved as a result of third-party support (e.g., through another company or a kind of a network agency). Fisher’s exact test, a nonparametric significance test for small samples sizes that involves a $2 \times 2$ contingency table (similar to the chi-square test for large samples), shows that there is no statistically significant difference between the emergence of recycling relations among companies that are members of a recycling network and the reference sample that comprises the other companies of the Austrian manufacturing sector $df(N = 157) = 1, \ p = 0.516$.

Furthermore, the questionnaire asked how cooperative the companies perceive their relationship with their most important by-product recycler to be. Responses to the question “Is your relationship with this company in comparison to regular customer relations characterized by more or by less cooperation?” were graded on a 5-point ordinal scale from 1 (much less cooperation) to 5 (much more cooperation).

As can be seen in figure 2, the surveyed companies view their relationship with the respective recycling partner as very similar to regular customer relations. The mode of the answers is 3—that is, exactly the middle of the scale, between much less and much more cooperation. The median answer is 3.3 and thus only a little above the middle of the scale. The chi-square test, which is here applied as a test of goodness of fit assessing whether the observed frequency distribution differs from the theoretical rectangular distribution (where values occur in each cell with equal frequency), shows that the distribution of the answers differs highly significantly from the rectangular distribution, $\chi^2(4, N = 160) = 122.31, \ p < 0.001$. Furthermore, the Mann–Whitney test shows that there is no significant difference

**Figure 2** Extent of cooperation with the recycling partner in comparison with regular customer relations. RN = recycling network; Oldenb. = Oldenburger; manufact. = manufacturing.
between the perceptions of the companies that are members of a recycling network and those of the reference sample, \(z(N = 160) = -0.143, p = 0.894\).

In this regard, the findings seem to meet Lyons’s (2007) expectation that the materials loop could be closed similarly to other firm linkages, because firms operate within free markets. The results also correspond with the fact that the companies are unaware that they are part of the recycling networks analyzed. To the question “Do you take part in a company network that engages in intercompany recycling of by-products (wastes)?” only one company of the Styria recycling network answered “yes”; unfortunately it then named a completely irrelevant network. In the Oldenburger Münsterland recycling network, two companies (13%) were aware that they were part of the network.

This is a very clear indication that the intercompany recycling activities in these cases are bilateral relations. The idea of an industrial recycling network as a whole system seems to be quite irrelevant for the recycling activities of the companies, regardless of whether researchers see them as such. But it is obvious that in the case of the Styria recycling network, no centralized network organization or administration ensures that the network members get access to information that is likely to be relevant for interorganizational recycling or that supports the generation of a network identity or shared value system in regard to sustainable development. In the Oldenburger Münsterland recycling network, a central network agency does in fact exist, but network awareness is still very low.

Consequently, scientists in the field of IE need to consider that networks described in scientific journals as good and best practice examples might not even be known by the representatives of the companies involved, as is the case with the Styria and Oldenburger Münsterland recycling networks. Nevertheless, interorganizational recycling activities certainly take place, and undoubtedly it is always possible to draw charts that show networks with nodes as companies and edges as material or waste flows. These charts might help us gain a better understanding of waste-related linkages between companies and industries, but they do not as such indicate how interorganizational activities are organized.

In general, there seems to be a wide gap between the two possible extremes: On the one hand, one may understand interorganizational recycling as a market activity organized in a decentralized manner—as seems to be the case in the two networks investigated—and thus simply focus on stimulating a set of legal and other conditions that enable industry actors to initiate and realize environmentally and economically advantageous activities. On the other hand, there might certainly also be cases in which companies really are interested in taking part in an organized network that supports interorganizational recycling of by-products and wastes or that supports broader initiatives toward more sustainable development of the respective industry or region. The following section provides some information on how the surveyed companies perceive the concept of sustainable development and what activities they view as important for interorganizational cooperation for sustainable development and, hence, for IE.

Results in Regard to Potential Sustainability-Related Activities

Given that the results above show that the members of the Styria recycling network have absolutely no network awareness, in what follows, the distinction between members of recycling networks and other companies is abandoned. Hence, the remaining analysis no longer considers those companies of the Styria recycling network that did not respond to the questionnaire that was first sent to the Austrian manufacturing sector or any of the companies of the Oldenburger Münsterland recycling network. Consequently, the following results refer to the sample of the Austrian manufacturing sector plus those four companies of the Styria recycling network that did not respond to the questionnaire on the first mailing to the manufacturing companies in Austria (\(n = 142\)).

In the questionnaire, the company representatives were asked to assign percentages to the three sustainability dimensions, economic success, environmental protection, and social responsibility,
that correspond with the importance of each dimension within their respective company.

As can be seen in figure 3, the companies surveyed consider economic success (Median = 60%) to be by far the most important sustainability dimension for their own company. The Wilcoxon’s test, which is a nonparametric test for assessing whether two related samples differ significantly in their central tendency, shows that this result is statistically highly significant, in comparison with the dimensions of environmental protection, $z(N = 133) = -9.227, p < 0.001$, and social responsibility, $z(N = 132) = -9.482, p < 0.001$. It is worth mentioning that environmental protection and social responsibility were rated as almost equally important, both with a median of 20%. There is no significant difference between these two sustainability dimensions, $z(N = 132) = -0.786, p = 0.432$.

For the interpretation of these data, two methodological problems need to be mentioned. First, a comparison of the three sustainability dimensions and a weighting of their relative importance requires a clear and precise definition of the concepts. This might be possible for economic success and maybe for environmental protection; however, there is still no precise common understanding of the term social responsibility. Second, it needs to be stated that a direct comparison of the sustainable development dimensions is problematic from a decision theoretical point of view. This requires that the surveyed people implicitly assume similar ranges of possible parameter values. Only under the assumption that the surveyed people have a similar understanding of what is understood to be a low or high degree of economic success, environmental protection, and social responsibility does a weighting of the relative importance of the three sustainability dimensions makes sense at all.

A more detailed picture results from the question concerning the importance for respondents’ own company of different sustainability issues. The surveyed people were asked to indicate the relevance of the following sustainability issues for their respective company on a 5-point ordinal scale from **highly irrelevant** (1) to **highly relevant** (5). Moreover, the company representatives were asked to provide information on the extent to which they believe that participation in a sustainability network would be beneficial. Again, a 5-point ordinal scale, from **not beneficial at all** (1) to **highly beneficial** (5), was provided for responses.

The sustainability issues surveyed are presented in table 3. The issues a, c, and h are clearly...
Table 3  Relative relevance of sustainability issues to surveyed companies and perceived benefit of intercompany cooperation

<table>
<thead>
<tr>
<th>Sustainability issues</th>
<th>Relevance of issue</th>
<th>Benefits of cooperation</th>
<th>Spearman Rho correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Environmental protection carried out by suppliers of inputs</td>
<td>3.49</td>
<td>3.18</td>
<td>0.250**</td>
</tr>
<tr>
<td>b. Respect for human rights throughout the value chain</td>
<td>3.83</td>
<td>2.89</td>
<td>0.390**</td>
</tr>
<tr>
<td>c. Comprehensive environmental protection in the company’s production units</td>
<td>4.29</td>
<td>3.52</td>
<td>0.206**</td>
</tr>
<tr>
<td>d. Support of disadvantaged groups and gender issues</td>
<td>3.41</td>
<td>2.69</td>
<td>0.413**</td>
</tr>
<tr>
<td>e. Employee safety and security (job-related illness, accident prevention, etc.)</td>
<td>4.58</td>
<td>3.62</td>
<td>0.239**</td>
</tr>
<tr>
<td>f. Regional responsibility as an employer</td>
<td>4.12</td>
<td>3.21</td>
<td>0.395**</td>
</tr>
<tr>
<td>g. High quality and safety of the company’s products</td>
<td>4.82</td>
<td>3.58</td>
<td>0.105</td>
</tr>
<tr>
<td>h. Environmental protection in the use and disposal of the company’s products</td>
<td>4.10</td>
<td>3.64</td>
<td>0.295**</td>
</tr>
</tbody>
</table>

Note: Values are median responses on a 5-point ordinal scale from very low (1) to very high (5).

**p < 0.01.

related to environmental protection. The issues b, e, and g are connected to social responsibility and CSR. The issues e and g are directly related to the quality and safety features of firms and thus primarily reflect economic motives. The relative relevance of the issues for the surveyed companies as well as the relative perceived degree of benefits resulting from intercompany cooperation are clearly visible.

At 4.1, the mean value for all answers regarding the relevance of all the topics is very high. The mean for all answers regarding the benefits of cooperation is 3.3, not surprisingly lower than the figure for relevance but still above the middle of the ordinal scale. The Friedman’s homogeneity test shows that the distribution of the ranks in regard to both the relative relevance of the sustainability issues, $\chi^2(N = 137) = 335.04, p < 0.001$, and the perceived amount of benefits of intercompany cooperation, $\chi^2(N = 131) = 155.70, p < 0.001$, is statistically significant. There is also a significant positive correlation between the grading of the topics regarding their relevance and their benefits of intercompany cooperation (except for the issue of ensuring high quality and high safety of the products; see table 3).

It can be seen that ensuring high quality and high safety of the products (issue g) is clearly the most important issue for the companies, followed by employee safety and security (issue e). The Wilcoxon test shows that the higher relevance of these primarily economic issues is statistically highly significant, $z = -4.471, p < 0.001$. Furthermore, comprehensive environmental protection in the company’s own production units (issue c) is seen as quite important. Environmental protection in the use and disposal of the products (issue h) as well as the company’s regional responsibility as an employer (issue f) are also both considered as quite relevant for the companies (above median of all answers). Here, it is noticeable that for the latter, the perceived benefits of intercompany cooperation are clearly lower, $z = -3.283, p = 0.001$.

Within the environmental topics, environmental protection carried out by suppliers of inputs (issue a) is considered as least relevant for the companies, $z = -5.544, p < 0.001$. Here, the expected benefits of intercompany cooperation are clearly lower than for the environmental protection in the use and disposal phase of the products (issue h), $z = -4.693, p < 0.001$, and—which comes as a surprise—also lower than for the environmental protection in the company’s own production units (issue c), $z = -4.022, p < 0.001$. The two topics with the lowest benefits of intercompany cooperation are related to the social sustainability dimension: respecting human rights.
throughout the value chain (issue b), and, of even lower perceived relevance, supporting disadvantaged groups (issue d).

In a later question, the company representatives were asked how important they consider different areas for cooperation in a sustainability network (see also the From Industrial Symbiosis to Sustainability Networks section). Figure 4 shows the median values of the answers on a 5-point ordinal scale from very unimportant (1) to very important (5).

These results correspond to a high degree with the answers shown above concerning the relevance of sustainability issues and the benefits of intercompany cooperation. It can be seen that intercompany cooperation for recycling purposes is considered most important. The difference with respect to the next topic is highly significant, $z = -3.941$, $p < 0.001$. Remember, the benefits of cooperation for environmental protection in the use and disposal of the products (issue h) were considered to be very high, although the importance of the issue itself was not. In other words, companies consider recycling cooperation beneficial not because of the high importance of environmental protection in the disposal phase of the products but because external recycling in many cases has further (economic or technical) advantages over internal recycling. This is quite plausible because the potential for internal recycling is highly determined by a company’s own production processes, whereas recycling cooperation makes a variety of completely different production processes accessible for the recycling of by-products or used products.

The lowest importance in figure 4 is assigned to cooperation for common acceptance of social responsibility, although the difference is not statistically significant with respect to cooperation on the development of sustainable products, improvement and integration of production processes, and intercompany learning and knowledge generation.

**Conclusions**

Concerning intercompany recycling activities within the IS networks, several important new insights are evident. About a decade after the first scientific investigation and documentation of the Styria recycling network, none of the network companies is aware of the existence of the network. In the case of the Oldenburger Münsterland recycling network, 5 years after a research project aimed at installing a network agency, only two companies had any network awareness. For the scientific community in the field of IE, this is of crucial importance: Clearly, the descriptions and charts of intercompany material and energy flows for recycling purposes alone are no evidence that a company network really exists, in the sense that these network companies are aware of the network and develop a shared network identity, common objectives, a network culture, and so on.

Certainly, the term network is quite vague. At a most abstract level, networks can be defined as the totality of nodes or positions that represent entities such as individuals, households, companies, associations, or other types of organizations and links and symbolize some kind of
interaction or interrelation among the entities. Sydow (1992) even states that almost any empirical phenomenon can be considered as a network. Networks are nothing more than a methodological construct of the researcher, who has to decide, first, what object of investigation should be understood as a network and, second, how the boundaries of this object are to be defined. Araujo and Easton (1996, 64) state,

It is clear that the term network has acquired the character of an umbrella, catch-all term under which a variety of theoretical and methodological positions in the social science have sought refuge.

Thorelli (1986, 38), in a similar vein, states, “The point here is that the entire economy may be viewed as a network of organizations.” This also holds true for intercompany recycling: The whole Austrian manufacturing industry could be presented as an Austrian recycling network, or IS network. Neither the percentage of by-products that are passed on to other companies for recycling purposes nor the degree of perceived cooperation in these intercompany recycling activities really justifies drawing a definite network boundary.

Undoubtedly, material and energy flow charts, such as the best known example of the IS Kalundborg, help us to understand the physical flows among the network entities, but they definitely do not provide any information about the organizational or social level of the network. An IS network can be, but does not need to be, a social network—that is, a specific set of linkages among a defined set of persons, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behaviour of the persons involved. (Mitchell 1975, 2)

Thus, further integration of social sciences in the scientific discourse in IE is clearly necessary.

These considerations certainly also have a strong impact on the question of whether industrial recycling networks are appropriate starting points for potential extensions toward sustainability networks, entailing much broader cooperation than mere interfirm recycling. In other words, the question arises whether the loose ties among the companies of a recycling network can be the channels through which new ideas about sustainability are developed as a form of collective or regional learning (Baas and Boons 2004).

This question is also directly related to the ongoing scientific debate around whether industrial ecosystems are a case of market coordination (Desrochers 2004; Boons 2008) whereby the emergence of IS is a spontaneous or self-organizing development (Korhonen et al. 2002) or whether such networks arise out of a specific planning process, either by regional authorities or by focal network organizations (e.g., in eco-parks, where much greater company proximity may automatically lead to an eco-park identity). Here, intercompany material or energy flows for recycling purposes could have a binding effect on partner firms. In such a context, however, the relative lack of a broad variety of different production processes may act as a limiting factor: “Closing the loop locally may be possible for some items, but it is probably the exception rather than the rule for heterogeneous wastes” (Lyons 2007, 51).

In the case of the Styria and Oldenburger Münsterland recycling networks, it must be stated that there is definitely no network identity at all. Thus, for a planning process, it would first be necessary to create such an identity. Then, as a possible second step, a process of joint development of a network vision toward sustainability might be initiated, and such a vision might be implemented within the different fields of potential cooperation. The effort does not seem promising at the moment, however, given that waste management is not a major concern of top management in most companies. Without management commitment, a sustainability network simply cannot be developed. Because the results above show that intercompany recycling activities do not significantly differ between the companies of the Styria recycling network and the other companies of the manufacturing sector in Austria, how can we decide which companies should be included in the process of developing a network identity and which should be excluded? Hence, the empirical results of this study imply that centralized planning and coordination by any kind of network agency are not really needed for interorganizational recycling initiatives in industry, but we do not know yet whether decentralized decision structures also will lead to the broader sorts of
sustainability collaboration. Hence, the empirical results of this study provide a strong indication that self-organization with decentralized decision structures needs to play a crucial role in the emergence of sustainability-oriented cooperation among organizations and industries.

Nevertheless, the empirical analysis also shows that recycling is considered to be the most important field of collaborative action for sustainability. Correspondingly, beyond the environmental and social sustainability issues, cooperation for environmental protection in the use and disposal phase of the products—which, again, is strongly linked to recycling—is considered to be most beneficial. Those issues that are highly predestined for sustainability-oriented collaboration along the supply chain—that is, the environmental protection carried out by suppliers of inputs and respect for human rights throughout the value chain—are considered as significantly less relevant and less beneficial for cooperation. This shows that the shift from end-of-pipe strategies, such as the recycling of already existing by-products, toward sustainability-oriented improvement or integration of production processes, as well as sustainability-oriented product development, is still ongoing.

Here again, IE researchers need to be aware that the initiation of more sophisticated forms of cooperation toward sustainable development is not a mere technical problem. Instead, it always revolves around decisions made by particular people in particular organizational and social settings. How such individuals perceive their concrete situation, their possibilities, and their responsibilities determines whether sustainability networks emerge.

**Note**

1. One tonne (t) = $10^3$ kilograms (kg, SI) $\approx 1.102$ short tons.

**References**


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Supplementary Material

Additional Supplementary Material may be found in the online version of this article:

Supplement S1: This supplement contains a questionnaire that was distributed to environmental and/or waste disposal managers. The original questionnaire is in German. It is followed by an English translation.

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