Chapter 12

The Myth of Kalundborg: Social Dilemmas in Stimulating Eco-industrial Parks

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12.1 Introduction

In the field of environmental sciences, the concepts of industrial symbiosis and industrial ecology refer to the idea that the negative ecological impact of economic activities may be reduced more efficiently and effectively if the boundary of the system submitted to environmental management is drawn not around an individual firm, but instead around a group of firms. By looking at a larger system, it is possible to prevent problem shifting: the possibility that efforts to reduce negative ecological impact in one part of the system create additional impacts in other parts of the system. In a collective approach, firms achieve a competitive advantage by the physical exchange of materials, energy, water and by-products (Chertow, 2000).

The system boundary can be defined using a number of criteria: a sector of industry, firms that are part of the life cycle of a product, or a set of firms situated in a certain geographical area. Drawing the boundary in one of these ways opens up a wider range of technical and social options to reduce negative environmental impact. The social element is important since one of the main issues is the coordination of activities of the economic actors that are part of the system in deciding and implementing efforts to reduce environmental impact (Boons and Baas 1997). In this chapter, we focus on the geographical system boundary.

On the basis of the experiences in the Danish town of Kalundborg, the idea of industrial ecosystems, or *eco-industrial parks* (EIP), has received enormous attention from practitioners as well as scientists during the last ten years (Gertler, 1995; Ehrenfeld and Gertler, 1997; Jacobsen and Anderberg: Chapter 11 in this volume). Through an interesting process of dissemination, the concept of an EIP has spread rapidly to countries such as the Netherlands, Canada, Hong Kong, and the United States (Boons et al., 2000). As a result, participants of eco-industrial parks have tried to develop their parks towards sustainability, and governments have launched programs to promote such EIP initiatives. It has resulted in a number of conceptual and empirical studies on these initiatives.

There is some controversy about the stimulation of eco-industrial parks. Some scholars argue that there is nothing new about eco-industrial parks and that Kalundborg was nothing more than a re-discovery of old economic principles (Desrochers, 2001 and 2002). Others state that eco-industrial parks need to be designed at a larger organization level to derive even more economic and environmental returns than self-organized parks like Kalundborg (Hawken, 1993; Baas and Boons 2004).We suspect that both perspectives miss an important point, namely the need to overcome social dilemmas in order for industries to invest in infrastructure that allows systematic and cost-effective exchange of material flows.

The organisation of this chapter is as follows. The history of Kalundborg is shortly reviewed in Section 12.2. Next, Section 12.3 examines how it spread and generated new policy initiatives elsewhere. Section 12.4 argues that Kalundborg is not unique but a rediscovery of old principles. The results of policy initiatives are discussed in Section 2.5, where it is shown that it is difficult to design and stimulate eco-industrial parks that work in practice. In Section 12.6 the social dilemmas relevant to most eco-industrial parks are

studied. The chapter concludes with a discussion on which types of policy might stimulate eco-industrial parks.

12.2 Diffusion of the Kalundborg EIP concept

The long term development of the case of the Kalundborg eco-industrial park has been described in detail in Chapter 11. Currently it functions as a model for advocates of eco-industrial parks. It is not easy to track the dissemination of Kalundborg concept. Boons et al. (2000) reconstructed the process of disseminated by tracking Internet sources. The story of Kalundborg can be taken as a first approximation of the diffusion of the idea of EIPs.

The concept of 'industrial ecosystems' was coined in a paper presented at the 1977 Annual Meeting of the German Geological Association by an American geochemist (Erkman 1997). The idea resurfaced in an article in *Scientific American*, written by two employees from General Motors (Frosch and Gallopoulos, 1989). Later, this article was summarized in the language of business by a consultant from Arthur D. Little (Tibbs, 1991). According to Erkman, this document was instrumental in disseminating the idea of industrial ecology within business circles.

Fuelled among other things by the discussions following the Brundtland Commission Report, the Frosch and Gallopoulos article: "…sparked off strong interest […] The article manifestly played a catalytic role, as if it had crystallized a latent intuition in many people, especially in circles associated with industrial production, who were increasingly looking for new strategies to adopt with regard to the environment" (Erkman, 1997, p. 5). Apparently, industrial ecology became a new meta-concept that seemed to hold the promise of embracing existing techniques and practices as well as developing new and more effective ones designed to decrease the environmental impact of production and consumption activities. In short, industrial ecology has acted as an energizing and mobilizing concept.

In the beginning of the 1990s, a group of U.S.-based scientists and business people formed the Vishnu group. This saw as its role the dissemination of the concept of industrial ecology. After a visit to Denmark, one of its members had a student write a doctoral thesis on Kalundborg. This study (Gertler, 1995, also published on the Internet) appears to have been crucial in spreading of the Kalundborg story. It was also instrumental in corroborating the idea of industrial ecology and showing that it could, indeed, be more than wishful thinking and conceptual desk research. In addition, the study showed the evolutionary character of the Kalundborg symbiosis, stressing the complex interplay of technical and social forces in its origin and development: economic efficiency as a motivation for the various actors taking part in the symbiosis; the environmental regulatory regime's role as facilitator for innovative solutions; and, finally, the locally-embedded network of agents for sharing ideas, information and solutions to common problems. The Gertler version of the Kalundborg symbiosis thus contained lessons and visions as to the why's and how's of industrial ecology.

Separate from the Vishnu group, the idea of EIP was picked up by Cornell University in the US. At this university, there was a longstanding tradition in the social aspects of community development. The idea of industrial ecology, and more specifically EIP, fitted well with this tradition. These developments took on national policy relevance in the United States in 1995, when a US President's Council on Sustainable Development was devoted to the theme of EIP. Here, the different strands in US-activities around this idea were brought together.

More recently, the concept of industrial ecology (IE − of which EIP is an important element) has manifested itself in a journal, the *Journal of Industrial Ecology*, and an international society: the International Society for Industrial Ecology (ISIE).

Some interesting issues emerge relating to the way in which concepts are disseminated:

- the IE and EIP concepts are defined very differently by their adopters. Some use it as a label to denote the technical linkage of production processes and the use of wastes in production processes, while others use it as a concept which refers mainly to processes of cooperation, development and management of geographically bounded areas or communities. The concept thus serves as a *boundary object* (Adolffson, 2001): an idea or object which acts as a bridge between different social groups.
- Certain actors use concepts in a strategic way. By linking existing activities to a concept, they can profit from the popularity of the concept. This seems to be the case with the researchers from Cornell University.
- By themselves, concepts are fluid. They can be made visible, and therefore more suitable for rapid and effective diffusion, by writing them down. The Gertler-study is an example of this; it is widely cited, and seems to have been the basis for many other descriptions of Kalundborg, even when not cited as such.

12.3 Putting the Kalundborg story into Practice in The Netherlands

The former section provided insight into the ways in which 'Kalundborg' has been transmitted. At the receiving end of the communication line, there are practitioners in different countries who have picked up the idea and have based their actions on it. By way of illustration, this section describes how this has taken place, and is currently taking place, in the Netherlands.

12.3.1 Fertile soil

For an idea like EIP to find a successful destination, there must be some sort of connection possible with existing activities. We have found two such activities in the Netherlands: (1) revitalization of industrial parks, and (2) improving energy efficiency through cooperation.

Revitalization - At the beginning of the 1990s, efforts were undertaken to 'revitalize' industrial parks in the Netherlands. In the 1960s, these parks had been established by municipalities to move industrial activities away from the centers of towns, and concentrate them in parks located at their borders. In the years that followed, these parks evolved as certain companies left and others came, while the parks were enlarged to make room for growing industrial activities. At the end of the 1980s, a substantial proportion of these parks had developed into fragmented areas with no coordination of activities, often dangerous traffic situations, and deteriorating buildings and infrastructure. The 'revitalization'-effort directed at renovating consisted of a national subsidy program to enable municipalities to invest in the industrial parks. In a number of cases, this led to the establishment of coordination mechanisms between companies, such as Foundations for collective representation, and bureaus for 'park management'. Apart from its function of coordinating activities of the firms located on the industrial park, these mechanisms aimed at 'speaking with one voice' to the municipal officials.

Improving energy efficiency – In the same period, the Ministry of Economic Affairs was looking for options to increase the energy efficiency of Dutch industry. These efforts originated in the early 1970s, when Dutch companies suffered from an OPEC oil-boycott because of the pro-Israel stance of the Dutch governments'. This boycott made companies aware of their high level of energy use, and initiated efforts to undertake energy saving. Throughout the 1980s such activities were further developed. One of the options for further efficiency improvements was to consider groups of companies instead of individual firms:

notably, through the exchange of process heat. However, a test case initiated by the Ministry was largely unsuccessful, mainly because it was difficult to organize cooperation among firms.

12.3.2 Win-win solutions: looking for ideas

In 1997, the Ministry of Economic Affairs issued, together with the Ministry of Environmental Affairs (EZ) and the Ministry of Transport and Water Management, a policy note on "Environment and Economy" *(Nota Milieu & Economie)* (EZ, 1998). This policy paper had as its central aim to stimulate activities that combine ecological and economic benefits (win-win changes). In preparing this policy paper, public servants from EZ visited many firms to meet people involved in activities that could be incorporated into the study. One of the activities they encountered was brought to their attention by the Province of Noord-Brabant. Within this province there was a small group of public servants organized into what they themselves called *the Project Innovation Team (PIT).* Their aim was to initiate innovative activities in which provincial authorities play a non-traditional (non-legislative) role, often leading to a public-private partnership. One of the projects concerned an industrial park, known as *Rietvelden/de Vutter (RiVu)*. The environmental coordinator of the dominant company in this park, a plant of Heineken breweries, had been inspired by Kalundborg, and tried to develop and implement similar ideas about cooperation on RiVu. They found a willing partner in the coordinator of the PIT. Together they visited Kalundborg and wrote a report on it. They used the label 'duurzaam bedrijventerrein' (eco-industrial parks), the name under which such initiatives are now known in The Netherlands.

This initiative was taken on board by the EZ people, who started looking for, and found, similar projects in other parts of the Netherlands. A common characteristic of these projects was that firms located in the same geographical area were often cooperating to reduce their environmental impact, and at the same time reduced the costs of their activities.

The writing of the policy note was coordinated by a Professor in Environmental Management. Upon hearing about the enthusiasm of the public servants for this theme, he linked it to the activities he was involved in with his research institute. They had been working on a similar initiative in the Rotterdam harbor area, which had started some years before (Baas, 1998). From the 1990s on, companies in the Europoort/Botlek-area had joined forces to develop environmental management systems, and had been able to receive governmental funding in support. As the end of this funding was approaching, environmental officials were looking for new financial sources to continue the development of environmental management. As it happened, the national government had just issued a stimulation program for the improvement of the environmental performance of product chains. This stimulated the companies to search for options to develop cooperative efforts. The researchers, one of whom had contacts with Kalundborg, linked the ideas of Rotterdam companies to the Kalundborg example. In developing the Rotterdam initiative, called INES, the directors of the energy plant and Novo Nordisk shared their experiences. These visitors had a tour in the Europoort/Botlek-area, and stated that it would be possible to develop initiatives similar to those in Kalundborg.

The policy note of EZ contained a number of showcases ('boegbeelden') of the win-win philosophy that was the basis for the paper. In selecting these, the Ministry of Economic Affairs consulted the national association of Dutch industries (VNO/NCW). Although they were initially worried that additional legislation might ensue, in general the theme of eco-industrial parks met with great enthusiasm of the VNO/NCW people. In the version of the policy note paper that was eventually sent to Parliament, eco-industrial parks were one of the 'showcases', with the RiVu and Rotterdam harbor area as the two main examples.

12.3.3 Implementing ideas

After the policy paper was issued, EZ decided that it would be good to install a steering group that would monitor the diffusion and implementation of the eco-industrial park concept. This group had a diverse membership: apart from representatives of three Ministries (EZ, the Ministry of Traffic and Transport, and the Ministry of the Environment and Spatial Planning), there were representatives of industry, local and regional authorities, and the two main initiatives, i.e. RiVu and INES. This group developed several projects to stimulate the diffusion of the EIP concept, the most important of which was a program aimed at providing financial resources for initiatives taken by local communities. As EZ provided most of the money, there was a focus on energy efficiency in this program. At the same time, it focused on the process of cooperation. In preparing their activities, the steering group had asked a large consultancy company, KPMG, to provide them with input. This resulted in an overview of 'examples', as well as a framework for how to go about making an industrial park more sustainable (KPMG, 1998). Part of the consultants' input was the observation that the cooperative process was the main bottleneck in developing eco-industrial parks; not the development of new technical possibilities, but their acceptance and organization was the main barrier.

The stimulation program has been in place since 1999, and the number of projects that have been submitted surprised all the members of the steering group. It was decided to apply the principle 'let a thousand flowers flourish', i.e. give a chance to any initiative that is taken by either local authorities or local groups of companies. The selection that was applied to submitted projects focussed on the following criteria:

1. clearly developed and measurable goals for the project period
2. a slight bias towards projects that included the implementation of energy saving schemes. This criterion was a result of the fact that the organization responsible for implementing the subsidy-scheme has energy saving as an important focus.
3. the set of projects should cover different types of initiatives; both existing industrial parks and parks to be developed should be included, and the initiatives should be in different phases of development.

The first round of the EIP-program coordinated by NOVEM (2001) resulted in the co-financing (usually 50% of costs calculated) of 62 projects. Tables 12.1 and 12.2 provide some insight into the type of projects that were granted; they show the coverage of different types of initiatives.

Table 12.1. Type of park

New parks	Existing parks	Other (virtual, unknown)
26	34	2

Table 12.2. Phase of project (projects usually span more than one phase)

Initiation	Orientation	Design	Decision making	Implementation
22	34	28	15	5

The second table shows that most projects were in the first phases of development of EIP: the development covered the initial or orientation phase of 56 of the 62 projects. In these phases, the establishment of the organization of of park management, as a basis for further activities, was the main goal. Projects that also covered later phases, such as the design &

implementation of technical linkages between companies, or decisionmaing about sharing utilities, often are activities that were already initiated, and subsequently put in projectform in order to obtain a subsidy. The projects also show a wide diversity in terms of who was the central initiating actor; sometimes this was one firm, seeking to establish a linkage with one or more other firms, sometimes a local governmental authority; in other cases it was a group of entrepreneurs.

12.4 Is Kalundborg unique?

Since the Kalundborg example diffused and inspired policy elsewhere, the question emerges whether Kalundborg was really unique. If so, what where the reasons? If not, what are other examples? Desrochers (2001) argues that EIP is not new, and in fact is nothing more than a rediscovery of inter-firm recycling linkages. In the 19th century, waste recovery and exchange between independent firms was widely practiced in the Western world. Perhaps, changes in labor costs, environmental regulation and globalization during the past decades have made it less attractive to exchange materials at a local scale.

After the discovery of Kalundborg, scholars started to look for other examples and found these all over the world (Desrochers, 2002): within the Austrian province of Stryria, the Ruhr region of Germany, the Jyväskylä region of Finland, and the petrochemical complexes of Los Angeles, Houston and Sarnia (Canada).

According to Desrochers (2001), cost-benefit considerations cause firms to look for the most effective way to deal with waste. This often leads to reuse by the same firm or by others as a cheap resource. As entrepreneurial firms are creative in finding new ways of reuse and recycling their waste in monetary beneficial ways. Such processes are not easily being designed top-down by public agencies. Some scholars argue that designers come up with better symbiotic relationships of it is started from scratch, locating and specifying industries and factories according to a grant scheme (Hawken, 1993). However, bureaucrats and public planners have only limited knowledge of the information that is required to organize profitable synergetic relationships between firms. An important problem, according to Desrochers, is that environmental policies which define the conditions for waste treatment restrict firms to be innovative to reuse and recycling. Environmental regulation can therefore act as a barrier to the emergence of eco-industrial parks.

The question arises how to stimulate eco-industrial parks. Even if they are not new or unique, it is desirable from an environmental perspective to reuse, recycle and reduce waste. We will first discuss what are the results of the use of the Kalundborg example by policy makers, before we address what we see as the real problem in stimulating eco-industrial parks.

12.5 Lessons from a long term case: The INES eco-industrial park

One of the industrial parks in the Netherlands with a fairly long history is situated in the Rotterdam harbor area. It contains firms from the processing industry. This park has been studied by Baas (1998, 2000).

At the end of the 1980s, the Dutch government and Dutch industry agreed on a voluntary scheme to implement environmental management systems in industrial firms within the period until 1995. Companies in the Europoort/Botlek-area, located in the Rotterdam harbor, decided to work together for this purpose. Coordination was made available by the regional industry association, Europoort/Botlek Interests (EBB). Consultants as well as researchers were involved in the project, which came to be known as the INES-project (Baas 1998).

The network that subsequently was created served as the basis for identifying options to diminish the environmental effects of the companies involved. This occurred through looking

at possible linkages of production processes and the sharing of utilities. The network was formed by contacts among environmental managers of the various companies. They took Kalundborg as an explicit model for their effort. Representatives of the Danish region were invited to Rotterdam to provide information about its success-story.

The goals of the INES-project were the following (Baas 1998, 191):

- To stimulate cleaner production approaches within individual companies.
- To perform network analyses of activities, material and energy streams, and options to reuse materials, byproducts and energy.
- To develop a knowledge infrastructure to support the development of an eco-industrial system.

The project, which formally started in 1994, was expected to last until 1997. It was divided into three phases:

(a) Communication of goals of the projects to companies, and building support.
(b) Pre-feasibility studies.
(c) Design for implementation of selected projects.

An important point on which all companies agreed was that any activity that would be implemented had to be at least cost neutral; in other words, companies did not want to invest in activities without being certain that return on investment would be certain, and would not result in additional operational costs. The fact that EBB was able to raise subsidies for implementing projects thus provided substantial help as the pressure of project costs was alleviated.

The network analysis gave insight into technically feasible projects. From this set, three projects were selected: compressed air utility sharing; waste water treatment, and reduction of bio-sludge. Baas (2000) describes that it took five years to implement one of these projects, the sharing of compressed air. Although there was an initial level of trust between the companies in the region, it took time to build up support for the specific project. Moreover, the information initially collected proved to be inaccurate. In addition, the supplier initially involved revised its priorities. Ultimately, another supplier of compressed air took the opportunity and installed a system which has been operational since the beginning of 2000.

Currently, a second INES project is being implemented. This followed a period of over two years in which there was no involvement from EBB, the coordinating actor. But eventually the INES-philosophy was taken up again, this time with the explicit goal to develop a more strategic approach to building an eco-industrial system. In order to move beyond the technical-operational approach that dominated the first project, the second project has chosen to start a dialogue on strategic issues, such as ‘the future of fossil fuels’, an important topic as a major part of the companies involved is (in-)directly related to the oil industry. This dialogue involves actors operating at strategic levels within government and industry. Getting actors interested in this dialogue, and linking a more strategic discussion to concrete activities, remains a major challenge for the industrial park.

Coordination and cooperation

These previous examples show that cooperative activities between firms can emerge, possibly stimulated by governmental policy. Examples of successful cooperation are, however, scarce. The development of EIPs is often hampered by problems of coordination and cooperation, which manifests itself in different forms:

1. Although located in close geographical proximity, firms in an industrial park often have no close relationship. There are local industrial clubs which can serve as a starting point for coordination, but they are insufficient in terms of commitment, membership, and level

of trust to allow a tight coordination mechanism. Developing the commitment, shared vision and level of trust is a difficult and time-consuming process. Taking ideas like Kalundborg and transplanting these into a totally different context therefore often will not function. Gertler's (1995) analysis of the social network that underlies the technical linkages between firms in Kalundborg shows the long time it has taken for these to evolve.

2. Firms in an industrial park are often production plants of large businesses. Decisions concerning their activities are taken in some headquarters far away. This implies that even if site managers are willing to consider linkages with other firms in the park, they still need to convince company managers who are not part of the local social group.
3. A problem discussed more by scientists than practitioners relates to the adequate system boundary. In general terms, the question is: what system can be best optimized? A Cleaner Production approach focuses on optimizing the system of the individual firm. Looking for an optimum within the group of firms in an EIP may cause individual firms to stop consider preventing the production of waste within their firm, as they are looking collectively for ways to use waste of one firm as an input for another firm in the park. In addition, firms are part of product chains, and there are also demands made by suppliers or consumers towards a firm in order to reduce the environmental impact of the product chain as a whole. In other words, the firm is a nodal point in different systems, and optimizing the ecological impact of one system may contradict changes that would benefit the optimization of the ecological impact of another system.
4. Over the past ten years, many firms have changed dramatically, focusing on core activities and outsourcing of non-core activities. On the one hand, this has made them more experienced in developing partnerships, because they often need to control the activities they have outsourced by a mechanism that allows more influence than a market. On the other hand, it makes them more sensitive to the fact that each additional link, be it technical or organizational, makes them more dependent on other firms. The idea that organizations have a fundamental need to reduce dependency has been developed theoretically (Pfeffer and Salancik 1978), and is also recognized in practice.

The INES-case shows how the coordination of activities of firms situated on an industrial park can be hampered by the fact that these firms are part of other systems (the multinational corporation, a product chain), and thus receive multiple and often conflicting demands regarding their activities and their ecological effects. Developing an eco- industrial park requires that firms, individually and as a group, develop capabilities to deal with these conflicting demands. In that sense, the main lesson from the Kalundborg-example is that such a development requires a long period of time.

12.6 A collective action theory of eco-industrial parks

The combination of emergence of cooperation as happened in Kalundborg, and cases in which it did not happen, presents a fundamental puzzle in the study of social organization. Conventional economic theory assumes that people make decisions in their own interest. However, cooperative behavior is observed that does not fit with the concept of the selfish individual. Mancur Olson states that "*rational, self-interested individuals will not act to achieve their common or group interests*" (Olson, 1965: 2). The reason for this claim is that, when interests are shared, rational actors should prefer to free-ride, that is, to let others pay the cost of goods that will benefit others. If we nevertheless do see groups acting to further their joint interests, this can be explained by private incentives relating to rewarding contributors or punishing non-contributors.

Since the 1980s, empirical evidence that individuals are able to develop cooperative solutions abounds. Many examples can be given where people have organized themselves to achieve much higher outcomes than is predicted by the conventional theory (Ostrom, 1990). Laboratory experiments show that communication is a crucial factor to derive cooperative behavior (Ostrom et al., 1994). Furthermore, the ability of participants to determine their own monitoring and sanctioning system is critical to sustaining cooperative behavior (Ostrom et al., 1994). The reasons why these factors are important are not precisely known, but the hypothesis is that they relate to the development of mutual trust during interactions between resource users.

Translating these insights to industrial symbiosis, we see a number of individual firms who can derive a better performance by cooperation. Here we do not mean a buying and selling of waste, but adjusting production processes such that neighboring firms can be connected. According to the arguments of Olson, firms only want to invest in adjustments in their production process when they directly derive a financial benefit or when governmental regulation prescribes such adjustments. Firms, who have adjustment investments with high pay-back times, experience uncertainty of the actions of their neighboring firms. Will they be able to deliver the anticipated waste flows in the right conditions? What if the other firms find new cost-effective ways to reduce waste? What if the neighboring firm got bankrupt or move to another location. Therefore, structural and costly adjustments in the production process are more risky. The question is when such investments may happen.

However, the success of Kalundborg and other self-organized EIP might indicate the existence of long-term benefits. Table 11.1 shows high investment levels that are be paid back after a number of years. The insight that the network of social interactions seems to have been crucial in the development of the social symbiosis, can be explained by the arguments of Elinor Ostrom (2000). The existence of norms in a group that place group interests above those of individuals gives individuals the confidence to invest in collective activities, knowing that others will do so too. Reciprocity and trust are important social norms which can be developed in a group (Ostrom, 2000). Another important norm is to agree on sanctions for those who break the rules. Finally, social norms can be developed during repeated interactions, but can decay easily by cheating.

It has been rumored that the success of Kalundborg actually relates to the frequent gathering of managers in a local pub. The local pub might well have acted as one of the places where agents repeatedly interact. Another element is that the managers of most of the firms came from the local community. This can have meant a high level of initial mutual trust.

We will now describe the problem of creating industrial symbiosis as a formal model (Figure 12.1). If a firm *i* invests in providing output as an input for another firm it will cost an amount c_i. If this other firm j derived the inputs from firm *i*, it will benefit by an amount b_j. The resulting problem can be described in a pay-off table. In a one-shot game, a firm can decide to invest in exchanging waste or not. If $b_i > c_i$ then the benefit for the park will be that both firms exchange waste, but since they do not know what the other firm will do (e.g., uncertainty in future activities of the other firm, how long it will exist) the best action from the perspective of individual rationality is not to invest. The values of *b* and *c* might be influenced by policies like tax on waste or subsidies for adjustment of processes. But more is needed than only changing the payoff matrix.

Firm A

	Exchange	No exchange

Firm B	Exchange	(b_a- c_a, b_b- c_b)	(b_a, -c_b)
	No exchange	(-c_a, b_b)	(0,0)

Figure 12.1. Formalizing industrial symbiosis

Insights from the literature on collective action and on the evolution of cooperation provides some guidelines to overcome mutual defection of the players (Axelrod, 1984; Ostrom, 1998). The players need to repeatedly interact in order to build up mutual trust relationships. If players do not interact frequently, an attempt to cooperate may fail since they do not trust each other enough to enter into cooperative action. Creating interaction in an industrial park might coincide with already-ongoing activities like security, energy supply, infrastructure. If an increasing mutual trust develops, new projects might be initiated which have longer payback times. The fact that, in the 19th century, the recovery of waste was more common might be due to more local economic interactions and lower mobility of firms. Nowadays, many firms are players in a global market and interact less with physical nearby neighbors.

One of the main benefits of the self-organization of collective action is the strong commitment of local actors. Especially when actors are able to define their own monitoring and sanctioning regimes, long-term cooperative solutions can follow.

The story of Kalundborg is mainly a story of self-governance. In order to mimick the success of Kalundborg, one needs to create the conditions for self-governance. It is not a matter of technological feasibility.

A suggested research agenda is to investigate what are the characteristics of successful eco-industrial parks in the contemporary economic perspective that make them establish long-term commitment. And what is the role of the type of waste production, the style of management, historical and regional relations of firms, average duration of firms located in the park, and regulation on cooperative activities, such as security, etc?

Once critical factors can be identified that stimulate cooperation between firms. We suggest that the government can indirectly stimulate eco-industrial parks by creating the right conditions. For example, by selecting the types of firms to get permission to establish in new parks.

Some conclusions on problems of collective action

As discussed in Chapter 2 of this volume, industrial ecology is based on the metaphor of groups of companies functioning as a natural ecosystem. Boons and Baas (1997) have critically assessed the use of this metaphor, and concluded that there is an implicit or explicit idea that ecosystems are associated with an optimal use of resources and exchange of waste streams. This obscures the fact that ecosystems can arrive at an equilibrium which is less than optimal (if they ever do reach an equilibrium).

The interpretation of this metaphor is important in assessing EIP. We can distinguish between the following levels of connectedness:

- Economic actors have exchange relationships, and thus there is coordination between their activities, which is based on autonomous decisions by dependent units. This is a normal situation in most industrial parks. At the outset, there may have been some planning, but over the years companies have come and gone, and existing ones have changed direction, grown or declined. The majority of industrial parks in the Netherlands are of this type (Lambert and Boons, 2002).

- Companies located in an industrial park strive towards some collective goals, which introduces the idea of group coordination. The individual elements are still autonomous, but they can examine whether joint activities lead to win-win outcomes. These activities are decided upon on a project-to-project basis.
- Companies in an industrial park function as the constituents of an ecosystem as it is conceived by advocates of industrial ecology. This makes it possible to implement options that may be detrimental to some or most companies, but nevertheless contribute to the functioning and stability of the ecosystem as a whole.

These levels of connectedness can be related to the discussion on collective action in the following way. At the first level, there is nothing indicating collective action. Actors interact, but on a low level of intensity, and there is no social structure in terms of trust and mechanisms for monitoring and sanctioning that could be helpful in bringing collective action about.

The second level can be seen as a pre-collective action phase. Actors develop joint activities that are based on the direct pay-off that cooperation brings (hence the term 'win-win'). These joint activities do not constitute collective action. Nevertheless, they can only be successful if some coordination mechanisms are developed. Thus, they lead to the emergence of a basic level of trust, as well as mechanisms that can be used as sanctioning and monitoring instruments. Such a pre-collective action phase corresponds to the historical analysis of organizations that produce public goods (such as labor unions) (Hechter, 1981); they seem to have started out by providing private goods, and later developed into collective action organizations. The first period in the INES case is an example of this level of connectedness.

The third level of connectedness constitutes collective action. On the basis of coordination mechanisms and trust between parties, it is possible to develop actions that have differential costs and benefits for the actors. Given this social structure, they are willing to accept certain costs in the present because they expect benefits in the future. The current state of affairs in the INES case seems to be an attempt to attain this level.

These levels of connectedness are implicitly recognized in the more general literature on 'network development' (Chisholm 1998) and 'systems development' (Checkland 1981). This literature aims to develop tools for actors in communities, or more generally, social systems, to move from the modest level of coordination of autonomous activities towards connectedness that serves longer term strategic goals for the network as a whole. Such a process involves a recurring cycle of action (cooperative projects between network members) and reflection (evaluation of projects and reformulation of network goals, structure and processes) (Checkland 1981: 163). One of the central insights of this literature is that the process of network development is successful only if the actors in the network themselves learn how to improve their connectedness.

12.7 Conclusion

The Danish Kalundborg has functioned as a successful illustration of an EIP within the field of industrial ecology. The Kalundborg case is used by policy makers, scholars and consultants as an example project of how to redesign industrial parks. However, the success of these designed EIPs has been limited so far. The conditions to create an EIP are context dependent. In fact, the Kalundborg development happened due to specific local social circumstances that stimulated the mutual trust building between industries and created an environment for cooperative action.

To stimulate long-term cooperation in industrial parks, local firms need to build up a mutual trust relationship and the technical advantage for cooperation needs to be significant. Subsidies are to a great extent aimed at improving the technical conditions and not the social conditions or the composition of firms in a park. The evaluation horizon is usually so short that long term goals cannot be expected to be met. More research needs to be performed to assess the conditions that make industrial parks susceptible for long-term synergetic relationships between firms.

A top-down design of eco-industrial parks by bureaucrats and public planners is unlikely to be the most successful avenue to follow. As research on collective action problems shows, such top-down arrangements are often not effective in creating sustained cooperative arrangements. More might be expected from incentives for self-organized interactions by changing restrictive environmental regulations, providing tax incentives and subsidies for firms to explore innovative ways to reduce their costs and waste.

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