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Freedom Versus Coercion in Industrial Ecology: Mind the Gap!

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Mr. Turnbull had predicted evil consequences, ...and was now doing the best in his power to bring about the verification of his own prophecies.

—Anthony Trollope (*Phineas Finn*, Chapter 25,
as quoted in Popper 1963)

Pierre Desrochers' article in this issue provides an extensive reply to my assessment of his early work on the utilization of by-products in the nineteenth century (Boons 2008a, hereafter referred to as "my critique"). I value the opportunity to engage in a debate about this topic, especially in a journal with a broader economic focus. Understanding the ways in which firms deal with the by-products of their production activities is crucial for understanding processes of innovation as well as improving insight into the ecological impact of economic activities, themes that are both at the core of economics.² Embedding this understanding in long-term economic development is valuable because it links the interactions of economic actors to macro-economic change. Such change is deemed necessary by many analysts of modern societies that are concerned with issues such as climate change and resource scarcity.

Understanding why clusters of by-product exchanges emerge and persist over time requires a careful collection and analysis of empirical data, a task that

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2. Although not every economist will place the study of ecological impact at the core of economics, when such impacts are seen in terms of relative efficiency of production processes I am quite sure they will concur.

is especially demanding when historical records are used. Historical sources never fulfill the requirements that one would satisfy when collecting data in the present. Part of my criticism of what I called *the Desrochers papers* dealt with what I felt to be a lack of care in dealing with such sources. In addition, through misrepresenting several key concepts in the analysis, conclusions were drawn that I felt to be simplistic.

I am sorry to say that in his reply to my critique, such simplicity again rears its head. In fact, all the points I raise below can be summarized into one sentence: Reality is more nuanced than represented by Desrochers. In this contribution I will try not to repeat my earlier critique. Instead, I add to points already made, and include some recent insights from the field to which Desrochers has pointed his arrows. My points are:

1. By-product use is a concept that needs to be carefully defined. If we adopt the definition of Desrochers, then the whole economy is rife with by-product use. For industrial ecology, the interest in by-product exchange is associated with its potential to reduce ecological impact, and therefore not all by-product use is equally relevant. A critique on how industrial ecologists conceptualize the coordination of such exchanges must work from the definition they use.
2. Industrial ecology (or sustainability science) is not one coherent set of ideas put forward by a group of scientists in full consensus. As in any scientific field, issues central to the field are hotly debated. The extent to which by-product exchanges are facilitated by the market mechanism is one of these issues. By pretending the field to be of one mind, Desrochers ignores such debates. This makes it difficult for him to see where he could contribute.
3. Governance in economic systems is complex and cannot be adequately represented by using a simple dichotomy between the free market and government, as Desrochers consistently does. Moreover, care needs to be taken to look at such governance in its temporal context.

Before I move on to these points, I feel the need to dwell for a moment on a central principle of the scientific method: falsification. Put briefly, it states that the best way to test a hypothesis is to search for evidence that forces one to reject it (Popper 1963). My motivation for writing an assessment of Desrochers' work was not that I disliked his conclusions. Although he implies as much, I am not out to prove that government is essential to solve the world's problems. If there is anything I believe in it would be 'context dependency', so I am highly suspicious of any conclusion unconditionally in favor of either the market, planning or another

'real world alternative' as a way of coordinating economic activities. What moved me in the first place was the apparent lack of attention for counter-evidence, even when it was readily available in sources used by Desrochers.

According to Desrochers, by-product exchanges are a product of autonomous economic agents searching for innovative solutions, unhampered by governments that restrict their creativity. An important conclusion consistently drawn by Desrochers is that free markets are essential for the widespread occurrence of by-product exchange, as they provide a necessary context. This is clear from the following quotations: "Whether contemporary or historical, all cases of interfirm recycling linkages were primarily the result of entrepreneurial actions triggered by cost calculations" (Desrochers 2002, 62), and "all successful, documented cases of industrial symbiosis to this day have been self-organizing" (Desrochers 2004, 1099). The repeated use of the word "all" indicates that the free market is considered by Desrochers to be a necessary condition for by-product exchanges to occur. To provide a solid foundation under this conclusion it is not enough to provide examples of free market societies where by-product exchanges occur. A strategy of falsification calls for sensitivity to evidence of situations where by-product exchanges occur *in the absence of* free-market conditions. I found it striking that the sources used by Desrochers provided such counter-evidence (i.e., nineteenth-century societies lacking free markets as defined by Desrochers, yet displaying examples of by-product use). What was even more surprising: this evidence was simply disregarded. Such selective use of sources again appears in his 2012 reply. Veiled in an advice to the reader ("*Millions from Waste* is best read as ..." (88)), Desrochers takes what he can use from Talbot's *Millions from Waste*, but dismisses observations by Talbot on the contribution that governments have made and could make.³

The scientific strategy of falsification also provides a solution to a problem otherwise facing Desrochers: no matter how much evidence he brings to the table that reveals by-product use in free-market societies, it does not prove that other societies have not displayed such exchanges in a similar frequency. In contrast, examples of societies that lack the characteristics of a free market where by-product exchanges occur provide compelling evidence that his hypothesis is incorrect.⁴ This is why such counter-evidence in his own sources cannot be easily dismissed, as Desrochers again does in his reply.

3. I will not dissect the argument dealing with this; my 2008 critique has detailed references to the relevant sections in Talbot (1920, full text available at www.archive.org ([link](#))).

4. Thus, falsification is efficient. In that sense, the fact that Desrochers blames me for considering only part of his sources is beside the point. If I find in his sources (or elsewhere) *one* example that conflicts with his hypothesis, that suffices.

His counterargument is to attribute such examples to generic human ingenuity.⁵ But to remain consistent, this means that the free market is not a necessary condition for by-product use, and the hypothesis should be rejected. If the hypothesis is retained in the face of this evidence, the conclusion must be that the free market is not a necessary condition, but a much weaker condition. Indeed, in his reply Desrochers now states that his hypothesis is that market institutions are “better” than other real life alternative coordination mechanisms (2012, 87). Further research should then focus on what are additional, or alternative, conditions. As I will show below, looking at more complex constellations of conditions that produce by-product exchanges is exactly where the field of industrial ecology is currently heading.

Defining by-product exchange

Up till now I have used concepts in the way proposed by Desrochers in order to do justice to his formulation of the hypothesis. This does not mean I agree with his definitions. In fact, a central point in my critique concerns the conceptualization of by-product exchanges. In order for his attack on industrial ecologists to make sense at all, the way in which such exchanges are defined needs to match the definition as used in the field of industrial ecology.⁶ This definition includes three important elements:

- A by-product of the production process of one firm, previously unused, is used as an input for a production process of another firm. Thus, by-product exchange refers to a newly established relationship where a substance or flow crosses the boundary between two or more firms. It thus differs from loop closing and by-product development in general, which may take place in the same firm;
- By-product exchanges occur in regionally bounded clusters. Rather than being a bilateral phenomenon, they are considered as regional networks of exchange, often referred to as *industrial symbiosis*;

5. In addition to such ad hoc arguments, Desrochers uses faulty reasoning. One example is the immunizing argument about his sources being silent about the diffusion of by-product exchanges (2012, 80-81). This can be summarized as: “The fact that authors did not describe the widespread diffusion of by-product exchanges indicates that they were widespread.” If this is true, then his sources become completely unreliable as evidence: When they describe A, this is evidence that A occurred; if they do not describe A, it is also evidence that A occurred.

6. This discussion might give the impression that the field of industrial ecology deals mainly with by-product exchanges. In fact, it deals with much more. For a recent overview see Lifset and Boons (2012).

- The exchange is considered, at least by the researcher, because of its potential to reduce the ecological impact of the firms involved.

Desrochers uses various labels for his research subject throughout his work; in his article in this issue he refers to it as loop closing and by-product development. As I indicated in my critique, his definition differs from the one used by industrial ecologists (Boons 2008a, 152-153). Loop-closing and by-product development indicate the economically viable use of by-products within and across the firm's boundary, and at least some of his historical examples occur within firms, or are silent about whether an organizational boundary is crossed. His definition is thus broader in the sense that it refers to any use of waste (also within a firm's boundary). Also, Desrochers does not address that by-product exchange, and its development over time, is conceptualized by industrial ecologists in terms of the emergence of larger regional industrial clusters that engage in such exchanges.⁷ Indeed, the iconic example of industrial symbiosis is a set of exchanges that evolved in Kalundborg, Denmark. While broadening the concept in one direction, Desrochers' definition is stricter in the sense that it only considers loop closing that is economical. As a result of this definition, his research subject is ubiquitous in economies. In fact, it defines exactly that which constitutes an economic system, i.e., the exchange of scarce goods among social individuals. At the same time, it has lost most of its relevance as a separate research subject for industrial ecologists.

As a result of his specific conceptualization, ecological impact remains obscure and thus his reply to a major point of my critique comes almost as an afterthought. Desrochers gives two arguments regarding ecological impact. One is provided halfway in the article (86-87), and frames pollution as a temporal distortion from the market equilibrium. The second argument appears in the concluding remarks, where ecological impact is framed as the result of deliberate weighing of values in a process of collective choice. The latter point simply states that people will make trade-offs, and whatever comes out of that is acceptable without further discussion. This disregards a whole literature that deals with the fact that social life is a little bit more complicated, and can only be understood if that complexity is taken into account.⁸ I devoted the second half of my critique to sketching a conceptual framework to do so, which I will not repeat here.

The temporal distortion argument is interesting because it brings in a dimension I hinted at elsewhere (Boons and Howard-Grenville 2009), and that I now think should be more central in the analysis of industrial ecology. This concerns the

7. In his later work Desrochers has started to analyse such larger regional clusters. There he refers explicitly to *industrial symbiosis*.

8. Public choice theorists have encountered many problems in developing a market perspective on collective decision-making.

dynamic aspect of exchanges among firms (Boons et al. 2011). Desrochers states that ecological impacts in terms of unused by-products are temporal problems, because it takes time to find ways of utilizing waste streams. In itself, this argumentation is incomplete; I am curious what he has to say about the waste that results from nuclear energy production. How long do we have to wait for human ingenuity to find an economical use for that?

I fully agree that the temporal dimension needs to be taken into account in the analysis of by-product exchange, but not in the way suggested by Desrochers. He assumes an equilibrium, and negative effects are construed as temporal distortions of that situation. Given the emphasis he places on innovation, this is awkward. If I build on Desrochers' assumptions, I envision an economy where human ingenuity leads to a continuous stream of innovations at the level of individual entrepreneurs. Some of these provide solutions to existing by-products, while others create new by-products.⁹ Thus, at the macro-level it is incorrect to assume an equilibrium; instead, we have a complex system where exchanges are continuously evolving. In such a system, a certain system state (such as an equilibrium where negative ecological impacts are absent) cannot be assumed; it must be empirically assessed. Such an empirical assessment would need to look at:

- The way in which exchanges evolve over time, i.e., what by-product exchanges are realized and to what extent they continue to exist over a longer time period (either as long-term relationships or as repeated market exchanges among pools of suppliers and customers);
- The way in which by-product exchanges are widespread through an economy; and
- The extent to which such by-product exchanges result in decreased ecological impact.

In my opinion, such an empirical assessment will bring us a better understanding of the way in which by-product exchanges emerge, evolve, and disappear in an economic system. However, this kind of analysis is not provided by Desrochers.

Industrial ecology is an evolving field where concepts and hypotheses compete

My second point concerns industrial ecology as a scientific field. In his conclusion, Desrochers states that "Like most sustainable development theorists,

9. Given the laws of thermodynamics, any use (i.e., transformation) of existing by-products will also result in new by-products.

Boons discounts the notion that free enterprise might be capable of directing individuals towards both economic and environmental progress.” (94). He ends his conclusion with an indiscriminate call to all sustainable development theorists to be more open-minded. This lumping together of scholars into a huge category is again an act of simplification. I will not begin to discuss the diversity of “sustainable development theorists”; I am not sure where Desrochers draws the boundary here. I can say something about the field of industrial ecology though, and the alleged preference of its members (being part of the larger population of sustainable development theorists) for relying on governments for coordinating economic activities.¹⁰

In the field of industrial ecology, as in any living scientific field, full agreement over any conclusion is unlikely. Even in the conceptualization of Thomas Kuhn, where scientific disciplines come to a paradigmatic stage in which a coherent set of ideas guides the activities of scientists, there is room for anomalies, disputes, etc. In my experience, scientific fields evolve gradually, with concepts, methods and evidence competing (Toulmin 1972). Ignoring this reality by putting up a straw man (i.e., the sustainable development theorist) may be an effective rhetorical strategy, but I doubt if it is helpful in advancing the historical analysis of by-product exchange.

Within the field of industrial ecology, by-product exchange is studied under the label of industrial symbiosis. A recent special issue of the *Journal of Industrial Ecology* on industrial symbiosis deals with many aspects of this phenomenon, including the question of coordination mechanisms. Paquin and Howard-Grenville (2012) discuss how symbiotic networks in the United Kingdom evolved over an eight-year period. These networks were facilitated by NISP, a private initiative supported by government. This program and its role in facilitating by-product exchanges show that the dichotomy between market and government is a false one. NISP shows how private initiative and governmental support complement each other in making regional markets for waste products more transparent. Paquin and Howard-Grenville also find that, over time, this leads to more advanced, innovative exchanges.

Based on several research articles, Shi et al. (2012) provide an overview of the efforts of the Chinese government to develop eco-industrial parks as part of its national effort to become a Circular Economy. Such parks are regional clusters of symbiotic exchanges. The Chinese experience also reveals that by-product exchange has different shapes depending on local institutional contexts. The

10. The International Society of Industrial Ecology, founded in 2001, is an association with global membership; at the 2011 biannual conference over 500 participants presented their work. I am sure they do not all fit into the mould fabricated by Desrochers.

Circular Economy is an encompassing concept building on Asian principles, and symbiotic exchanges are one of the forms through which the Chinese government seeks to diminish the ecological impact of its rapid economic development. Likewise, in South Korea the government has engaged with the National Centre for Cleaner Production in implementing a series of five-year plans to build up an infrastructure of industrial parks that facilitate symbiotic exchanges (Park et al. 2008).

Each of these developments shows how governmental agents take an active role in establishing regional networks of symbiotic exchanges. They all provide counter-evidence to the strong version of Desrochers' hypothesis and the conclusion he consistently draws about the superiority of the free market. In order to test the weaker version of his hypothesis, these "real-world alternatives" to the free market need to be empirically assessed rather than dismissed at face value, lumped together into a category labeled "coercion."

Desrochers is right in stating that in the early days of the field, there was an assumption that industrial symbiosis required something additional to the market mechanism. This assumption was based on the case studies of regional symbiotic clusters then available (Boons et al. 2011). With increased availability of data this assumption can now be put to the test. In an analysis of a dataset of 233 symbiosis projects, Boons and Spekkink (2012) find that a social infrastructure as a complement to the market mechanism is not a necessary condition for industrial symbiosis. This finding leads to a further refining of the concept of by-product exchanges. When such exchanges involve standardized commodities of little strategic interest to firms, the market mechanism suffices. If exchanges involve more strategic resources and specific investments, additional conditions (i.e., social infrastructure) need to be fulfilled. The government may play a role in bringing about these conditions.

In all, the results of current research reveal that the coordination problem for industrial symbiosis is more complex than a dichotomous choice with only one right answer. Moreover, researchers in the field of industrial ecology have always had the market mechanism as one important option in their conceptual frames. In fact, from my perspective it is curious to see Desrochers hitting so hard on the field of industrial ecology for its alleged reliance on government. Actually, industrial ecology can be seen as one of the research fields dealing with sustainability where people are sensitive to the idea that interacting firms within a market context can to some extent move towards sustainability, and that planning is not the only way (Costa and Ferrão 2010).

Governance beyond a simple dichotomy

A third important simplification takes place by narrowing the contest among coordination mechanisms down to two alternatives: the free market against government. The former is defined in the reply by Desrochers; the definition of the latter can be built up by collecting the adjectives and examples throughout his work: it amounts to something like a coercive socialist planning bureaucracy making five-year plans. This imagery, and the argumentation against it, is clearly inspired by the work of Hayek.¹¹ However, the insight that the market is an efficient mechanism when information is distributed among a large group of autonomous economic actors does not prevent a positive role for governmental agencies in economies. While interesting as a philosophical and theoretical argument, Hayek's conclusions cannot be applied without further specification to any topic.

In my work on industrial symbiosis, I have found that first of all, not all governmental involvement in stimulating by-product exchanges is of the five-year plan, coercive, socialist kind.¹² Governmental agencies have different tools at their disposal, ranging from experimental projects to setting standards to inducing private firms to pick up opportunities earlier ignored. Secondly, such instruments are not often used as an alternative to the market; they are used in conjunction with the market mechanism, or even seek to institute a market where none formerly operated (see the example of NISP above). I have shown the delicate interplay between different forms of governmental action and the activities of firms in my longitudinal analysis of industrial symbiosis in the Rotterdam harbor area (Boons 2008b).

Being sensitive to the precise ways in which governmental agencies influence firms and the operation of markets is especially relevant when dealing with historical evidence. In the second half of the nineteenth century, government was not in any way like the caricature sketched by Desrochers. Instead, it was in full development, and local pollution served as one of the issues around which governmental rule setting and enforcement at the local and national level crystallized. And moving to the situation from the 1990s onwards, the governments that industrial ecologists are referring to are hardly comparable with socialist planning regimes. In the Western world, many politicians and civil servants have embraced liberal

11. For a link between Hayek's critique of socialism and the ecological embeddedness of economies, see the work of O'Neill (2002, 2004).

12. It is interesting that in the one article where Desrochers deals explicitly with societies that lack a free market (Desrochers and Ikeda 2003), his examples are not taken from the nineteenth century but are instead socialist economies of the kind that Hayek criticized.

principles, bringing the market mechanism to fields previously considered to be in the public domain. At the same time, several of the societies where by-product exchanges are rapidly developing are Asian economies that depart in some way from the free-market ideal type. In my view, these constitute evidence for developing insight into the topic Desrochers claims to be interested in: the way in which by-product exchanges can be brought about.

To conclude, I am not impressed by the additional evidence provided by Desrochers in his reply to my critique. What I have tried to show is that the field he is attacking has developed substantially since he launched his first attacks, and it continues to be engaged in a process of deepening our insight into the ways in which symbiotic exchanges can be brought about. In my estimate, careful consideration of evidence in current societies will provide more material for developing our understanding than will searching for more material that verifies a simplistic argument pitting freedom against coercion.

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