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Quantifying 'geographic proximity': Experiences from the United Kingdom's National Industrial Symbiosis Programme

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ABSTRACT

Geographic proximity is said to be a key characteristic of the resource reuse and recycling practice known as industrial symbiosis. To date, however, proximity of symbiont companies has remained an abstract characteristic. By conducting a statistical analysis of synergies facilitated by the United Kingdom's National Industrial Symbiosis Programme during their first five years of operation, this article attempts to quantify geographic proximity and in the process provide practitioners with an insight into the movement trends of different waste streams. Among other it was found that the median distance materials travelled within a symbiotic relationship is 20.4 miles. It is argued that quantitative information of this form is of practical value for the effective deployment of industrial symbiosis practitioners and wider resource efficiency planning. The results and discussion presented within this article are specific to industrial symbiosis opportunities facilitated within the United Kingdom; the methodology and assessment of resource movement influences are, however, expected to be relevant to all countries in which industrial activity is similarly mature and diversified.

1. Introduction

1.1. Industrial symbiosis and the National Industrial Symbiosis Programme

Industrial symbiosis can be regarded as the establishment of close working agreements between normally unrelated companies that lead to resource efficiency. Working agreements include, among other, the direct reuse of one company's waste stream as another's raw material, the innovative reprocessing of problematic by-products and the sharing of underutilised power, water and/or steam.

Specific reasons for the establishment of industrial symbiosis agreements, otherwise known as synergies, are manifold. Apart from the business imperative of needing to improve profitability and competitiveness, drivers of symbiosis can also be social, environmental and/or regulatory in nature (Chertow, 2007). Within the UK, synergies are facilitated by the National Industrial Symbiosis Programme (NISP) as part of a deliberate attempt to encourage industry to look beyond their traditional markets for business opportunities capable of delivering resource efficiency.

Not restricted to working within geographic boundaries, such as individual industrial estates or municipalities, NISP is a Government supported private sector initiative charged with the national promotion and delivery of industrial symbiosis.[1] As of February 2010, NISP had recruited almost 13,000 member companies which are collectively served by 12 regional delivery teams located throughout England, Scotland, Wales and Northern Ireland. Engaging with companies on a "work with the willing" basis (Hitchman, Pers. Comms., 2010), NISP facilitated industrial symbiosis has helped to generate significant economic and environmental benefits for both Programme members and the UK Government (see Laybourn and Morrissey, 2009).

Though not every NISP member is currently engaged in an active synergy all have contributed to the Programme by way of supplying industrial resource flow data. Indeed, one of the by-products of NISP's delivery of industrial symbiosis is the generation of a significant amount of data pertaining to the production and management

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[1] The reciprocal 'top-down' influence of the UK Government and 'bottom-up' needs of the private sector, that have helped to shape the NISP delivery model, can be likened to the 'middle-out' approach to industrial symbiosis development discussed by Costa and Ferrão (2010).

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of industrial waste. NISP and their affiliated researchers are continually evaluating the data they possess in the pursuit of developing industrial symbiosis best practice. This article presents the results of one such study into the spatial movement of resources between NISP members.

1.2. Industrial symbiosis and 'geographic proximity'

As there is still some disagreement as to what differentiates a synergy from 'everyday' exchanges of resources (as evidenced by discussions held each year at the Annual Industrial Symbiosis Research Symposia and discussed briefly in Chertow, 2007, p. 12), it is sensible to clarify what constitutes a synergy within the context of this article. The working definition employed within this article derives directly from the biological description of symbiosis (e.g. Begon et al., 2006; Chapman and Reiss, 1999). Simply, the physical exchange of operational resources between distinctly unrelated companies, or sectors, constitutes a synergy. To be clear, a symbiotic partnership is effectively the opportunistic coming together of two or more actors from sectors that, under normal circumstances, would not come into contact and consequently would not necessarily possess a working knowledge of each other's operational processes. The mode of a given synergy, whether mutualistic or commensal, is defined by the outputs of the synergy and the specific objectives of the actors involved. For example, where all symbionts clearly derive tangible benefits from a synergy, mutualism is observed. Where a company freely donates a serviceable and/or saleable resource to another company or organisation (e.g. for philanthropic reasons) the tangible benefit of the synergy is wholly felt by the resource recipient and thus commensalism is observed. Though mutualism is the most prevalent and arguably preferential mode of industrial symbiosis, there is no specific requirement for a synergy to be mutually beneficial.

A widely agreed and therefore often cited element of industrial symbiosis theory is, however: ". . .the synergistic possibilities offered by geographic proximity" (Chertow, 2000, p. 314). Apart from the obvious economic and practical benefits of local collaboration, the close proximity of potential symbiont companies is said to ease the development of trust and cooperation – two components that are believed to be prerequisites of any form of eco-industrial agreement (Hewes and Lyons, 2008; Sterr and Ott, 2004; Wallner, 1999). Trust and cooperation are said to be important to symbiosis because, without it, companies are unwilling to link processes in a manner that may affect the ways in which they choose to operate (Gibbs, 2003; Lambert and Boons, 2002). Trust can also be a key influence on the development of symbiotic networks as it helps to embed and maintain the level of relationships required to develop and distribute knowledge and technology (Murphy, 2006). Without trust and cooperation, the level of knowledge exchange required to facilitate symbiosis is both difficult and costly to obtain (Christensen, 1994 cited in Ehrenfeld and Gertler, 1997).

Importantly, the cultural or deliberate development of trust and ready collaboration among a network of potential industrial symbionts is believed to reduce "mental distances" between companies (Ehrenfeld and Gertler, 1997, p. 74; Gibbs and Deutz, 2007, p. 1689). Though the physical distances involved in a given synergy could be considerable, and thus potentially more problematic to facilitate than the outputs of any resource exchange is 'worth', the suggestion is that distances psychologically, if not physically, reduce if a relationship already exists between prospective symbionts. Though the supposition that reduced mental distances help to facilitate symbiosis is sound and well documented within eco-industrial planning literature, it is, however, not something that can readily aid the delivery of industrial symbiosis in a more strategic, targeted and, not least, cost-effective manner. To put it plainly: *short* mental distance and *close* geographic proximity are meaningless terms in relation to the active planning and facilitation of by-product exchanges. To improve a practitioner's ability to identify opportunities for industrial symbiosis, it is useful for them to be guided by and/or able to refer to quantitative synergy facilitation information. For independent industrial symbiosis practitioners who work on any scale greater than that of a physically or politically bounded industrial estate, deciding where to look for a partner for a prospective symbiont requires specific information on the spatial movement dynamics of a given resource.

Despite the numerous years of research that have been conducted into the development of symbiotic networks, quantitative information on the movement of resources is scarce. Arguably this is due to the simple acceptance that the physical movement of some resources, such as utilities, will always be restricted. Whilst within regional eco-industrial studies there is the common-sense belief that high value by-product exchanges should not be "spatially constrained" (Chertow et al., 2008, p. 1304). Indeed, it is accepted that some high value by-product exchanges may take place over several hundreds of kilometres (van Berkel, 2006). Is there any evidence, however, to corroborate these assumptions that can be applied to the deliberate development of an eco-industrial network? Despite an extensive review of the relevant literature, it has not been possible to find proof to validate these apparently sound, yet empirically unproven, statements. It could be argued that it is, perhaps, not necessary to ascertain the distances involved in utility based synergies as there is, on a case by case basis, a specific measureable limit to where one can look for potential recipient symbionts. In the case of materials, however, knowing how far a given material tends to travel within eco-industrial agreements, rather than how far they can theoretically travel before losing their residual economic and/or environmental value, is, potentially, of significant interest and practical planning use.

Though it is relatively easy to determine the distances involved in resource exchanges, it is, seemingly, rarely done. If any distances are obtained, specific figures are seldom provided within articles; particularly within articles relating to the development of regional eco-industrial systems. That said, a recent study into the evolution of the Tianjin Economic-Technological Development Area (TEDA), China, did consider the specific distances involved in the movement of materials. On average it was shown that the distance between companies involved in the symbiotic exchange of materials was 28.2 km (Shi et al., 2010, p. 196). When the identified synergies were broken down to material exchanges solely involving TEDA based symbionts, the average figure for material movements fell to 11.5 km. The average distance materials moved between a TEDA based company and a company based outside of the TEDA boundary was found to be 34 km (Shi et al., 2010, p. 196).

The material movement statistics from the TEDA study provide interesting reading in relation to pro-active implementation and nurturing of industrial symbiosis; particularly in comparison to the NISP model of national symbiosis delivery, when it is revealed that the majority of TEDA synergies are cross-boundary (59%). With further analysis it would be useful to determine, if possible, why and what materials are moving cross boundary and why and what materials stay within the TEDA boundary. There may be no material specific trends to be uncovered; however, possessing knowledge of these further details could help industrial symbiosis facilitators develop resource specific management models and, furthermore, append a quantitative platform to the notion of 'geographic proximity'. Accordingly, this article will continue by presenting the results of a study into the movement of materials within NISP facilitated synergies. Material movement statistics will be provided for all resources and also material specific exchanges. Also provided is an interpretation of what factors dictate the specific resource movement distances presented herein.