Geoforum 90 (2018) 159–173

Contents lists available at ScienceDirect

Geoforum

journal homepage: www.elsevier.com/locate/geoforum

Industrial clusters and industrial ecology: Building 'eco-collective efficiency' in a South Korean cluster

Sukjin Yoon*, Khalid Nadvi

Global Development Institute (GDI), School of Environment, Education and Development (SEED), University of Manchester, Arthur Lewis Building, Oxford Road, Manchester M13 9PL, UK

ARTICLE INFO

Keywords:
Industrial clusters
Industrial ecology
Textiles
Environmental performance
Asia
South Korea

ABSTRACT

The industrial clusters literature has shaped contemporary thinking on the potential of small firms to become globally competitive through agglomeration gains and collective action. However, clusters often generate negative environmental externalities. The industrial ecology framework suggests that producer agglomerations can spawn closed loop production arrangements that reduce environmental diseconomies. To date there has been little engagement between the industrial cluster and industrial ecology approaches. This paper addresses this critical gap by integrating the industrial cluster and industrial ecology frameworks. It analyses case evidence from the Banwol-Sihwa textiles dyeing cluster in South Korea to show that 'eco-collective efficiency' is achievable through cluster-based collective action. This can result in closed loop production and cluster-wide economic and environmental gains. Critical to achieving this is local social embeddedness, cluster-based institutions and the role of coordination powers.

1. Introduction

There are many interesting stories from across the world about how small firm clusters can become the basis for economic success and international competitiveness (Schmitz and Nadvi, 1999). However, clustering does not always generate positive outcomes (Kennedy, 1999; Nadvi, 1999b). Environmental concerns are one example of the potential negative effects of clustering. Clustered firms can, and often do, generate external diseconomies by increasing pollution costs and demand for scarce resources. While some studies have investigated environmental aspects of clustering (most notably Kennedy, 1999; Blackman, 2006; Crow and Batz, 2006; Almeida, 2008; Konstadakopulos, 2008; Lund-Thomsen, 2009), the dynamics underlying the environmental upgrading of clusters remains relatively underresearched in the industrial cluster literature (Jabbour and Puppim-de-Oliveira, 2012). In order to address this gap, we ask the question: *how can clustered producers upgrade their environmental management practices from rudimentary 'end-of-pipe' measures to a 'more holistic' system?*

Our answers are based on an analysis of the Banwol-Sihwa textiles dyeing cluster in South Korea. Dyeing and printing activities are essential to increasing value of garment products. This quality conscious segment of the global textiles and apparels market, however, consumes various chemical inputs, a large amount of water and energy, and generates pollutants such as effluent, odour and wastewater sludge, which cause health hazards to workers and to the wider community. The dyeing and printing mills in Banwol-Sihwa have been under pressure to comply with South Korean and international regulations, respond to complaints from nearby residential communities and engage with their buyers' codes of conduct. The dyers' first response to the environmental problems was to invest in collective pollution prevention facilities like common effluent treatment. Subsequently, the dyeing cluster moved to a new stage of environmental upgrading, becoming an eco-industrial park (EIP). An EIP is a spatial platform to facilitate by-product exchange, waste recycling and energy cascading between neighbouring firms. This offers the potential for a closed loop system. The Banwol-Sihwa textiles dyeing cluster shows that clustered firms can bring about environmental gains through joint actions. We call this 'eco-collective efficiency'.

This paper is structured as follows: The next section briefly reviews the discussion of environmental issues in the industrial cluster literature and the industrial ecology literature. Through this literature review, we identify the theoretical gap that could be filled by 'building bridges' between these two academic fields. Section 3 introduces the Banwol-Sihwa dyeing cluster's business structure. Section 4 explores the cluster's environmental upgrading process in sequence of pollution control, cleaner production and industrial symbiosis. Section 5 analyses the environmental performance of the dyeing cluster and its underlying dynamics, which we call 'eco-collective efficiency'. Section 6 concludes.

* Corresponding author.
E-mail addresses: sjyoon@idi.re.kr (S. Yoon), khalid.nadvi@manchester.ac.uk (K. Nadvi).

https://doi.org/10.1016/j.geoforum.2018.01.013
Received 14 February 2017; Received in revised form 16 January 2018; Accepted 23 January 2018

2. Industrial ecology and industrial clusters: A critical review

2.1. Industrial symbiosis and its social dimension

An academic field specialising in environmental performance based on the inter-firm synergy effect, what has come to be called industrial ecology, has developed rapidly over the last two decades. The basic argument of industrial ecology is that existing industrial systems can, and should, be transformed to behave like ecosystems (Frosch, 1992; Erkman, 1997; Gibbs, 2003). An ecosystem in nature is a cyclic system where waste and by-products from animals and plants are reused by other species. In contrast, the traditional industrial system is a collection of linear flows in which humans extract materials and fossil energy from nature and dump wastes back into nature (Tibbs, 1993). Industrial ecologists argue that the fundamental solution to solving environmental problems is to reform the traditional industrial systems by imitating the biosphere to generate so-called *closed-loop* flows that result in a circulating process of materials and energy (Jelinski et al., 1992; Socolow et al., 1996; Korhenen, 2003).

Industrial ecology has two lines of research: the regional approach and the product chain approach (Boons and Howard-Grenville, 2009). The regional approach of industrial ecology is particularly relevant to the industrial cluster literature with its practical models on industrial symbiosis and eco-industrial parks (EIP). Industrial symbiosis can be defined as symbiotic inter-firm links to seek out collective benefits and synergistic possibilities based on geographic proximity. An eco-industrial park (EIPs) is almost similar to the term industrial symbiosis. It pertains to spatial agglomerations (Chertow and Ashton, 2009) where firms intentionally co-locate in a planned fashion on the basis of industrial ecology principles (Gibbs, 2009). Since the iconic case of Kalundborg in Denmark, reported as the origin of EIPs, a growing number of EIPs have been discovered across the world. These include: for example, the national industrial symbiosis programme in the UK (Mirata, 2004), the Dutch EIP projects (Heeres et al., 2004), the EIP initiative in the USA (Gibbs and Deutz, 2005), the EIP programme in Ulsan, South Korea (Behera et al., 2012), the EIP development in Tianjin, China (Yu et al., 2014), and the Xinfa Group's industrial symbiosis cluster in China (Yu et al., 2015).

Industrial ecology is substantively rooted in an engineering and a 'nature as science' perspective (Korhenen et al., 2004). However, given that industrial ecology is intrinsically embedded within a social system, some authors underline the necessity to consider the human dimension in the physical flows of resources and energy (Cohen-Rosenthal, 2000; Ehrenfeld, 2000; Boons and Roome, 2001; Wall and Paquin, 2015). There are three technical terms representing how social factors impact upon an industrial symbiosis: social embeddedness, the role of champions and institutional setting. The concept of embeddedness has been imported from sociology in order to understand the phenomenon of short 'mental distance' that was first noticed by Ehrenfeld and Gertler's case study on the Kalundborg Symbiosis in Denmark (Ehrenfeld and Gertler, 1997). Mental distance refers to the degree of psychological intimacy, derived from trust, openness and communication, between firms involved with an industrial symbiosis (Ashton and Bain, 2012). As a number of studies on industrial symbioses have shown, a cooperative business culture and existing social networks can contribute to facilitating a potential industrial symbiosis network (Lowe and Evans, 1995; Ehrenfeld and Gertler, 1997; Gibbs et al., 2005; Gibbs and Deutz, 2007). Hence, the embeddedness framework has been in the limelight within the field of industrial ecology (Baas, 2008; Hewes and Lyons, 2008; Boons and Howard-Grenville, 2009; Doménech and Davies, 2011). Boons and Howard-Grenville (2009), by modifying Zukin and DiMaggio's typology (1990) on embeddedness, suggest six mechanisms through which social embeddedness affects industrial symbiosis networks: cognitive, structural, cultural, political, spatial and temporal embeddedness.

However, a proper degree of embeddedness for industrial symbiosis is not found everywhere. Facilitating networking for symbiotic relationships demands time and effort (Gibbs and Deutz, 2007; Velveva et al., 2014). It often requires the role of a coordinator who can mediate the relationship between firms in establishing and implementing industrial symbioses, so-called 'champions'. Champions can be defined as organisations or persons "who are able to bring group of actors together and motivate them to become personally involved in the construction of an EIP" (Hewes and Lyons, 2008: 1339). The coordination bodies help identify key actors at the local level, circulate knowledge about industrial symbiosis and facilitate communication between stakeholders (Ashton and Bain, 2012; Boons and Spekkink, 2012; Mirata, 2004). The industrial symbiosis literature identifies two different types of champions. First, a group of industrial ecologists use the term 'anchor tenant' to denote a firm that generates by-products useful for other neighbouring firms, identifies potential resource exchange networks and attracts other firms into an EIP (Lowe, 1997; Chertow, 2000; Gibbs and Deutz, 2005; Gibbs, 2008). The other champion is a non-firm network broker, such as a local authority, that serves as a coordinator in establishing industrial symbiosis networks (Gibbs, 2008) or building infrastructures to foster symbiosis networks (Velveva et al., 2014). The presence of this type of coordination bodies is especially instrumental in an area where anchor tenants are absent and/or inter-firm networks are relatively weak.

A goal of coordination activities carried out by champions is to establish platforms through which firms and other actors can have effective communication channels, share common purposes and undertake collaborative interactions. This underlines the importance of "having the right institutional setting in a region" (Mirata, 2004). Furthermore, given that the establishment of industrial symbiosis is often encouraged through targeted policy measures (Ronch et al., 2013), the notion of institutional setting also implies a degree of public intervention. Central and local governments can ensure favourable regulations (Yu et al., 2015; Shi et al., 2010; Wang et al., 2017), provide research funding (Gibbs, 2003), facilitate knowledge transfer (von Malmborg, 2004) and identify champions (Behera et al., 2012). Considering complicating and conflicting interests of various stakeholders involved in the eco-industrial development, the convening power of public authorities takes a pivotal position (Behera et al., 2012; Lombardi and Laybourn, 2012).

Due to the characteristics of an EIP, as a geographically concentrated inter-firm network, a growing number of industrial ecology studies draw on the agglomeration economies literature. This helps to explore the social context in which industrial symbiosis networks are formed (Lowe, 1997; Larbert and Boons, 2002; Baas and Boons, 2004; Deutz and Gibbs, 2004; Deutz and Gibbs, 2008; Gibbs, 2009; Lambardi and Laybourn, 2012; Walls and Paquin, 2015). Some authors have proposed the need for dialogue between the industrial symbiosis literature and the industrial cluster literature (Deutz and Gibbs, 2008; Chertow et al., 2008; Desrochers and Leppala, 2010; Velenturf and Jensen, 2016). For example, Deutz and Gibbs (2008: 1316) define EIPs as an "environmentally based variant of a cluster strategy" on three aspects: the role of external economies of scale, the dynamics of networking and the clustering policy approach to regional development. However, the industrial cluster literature remains relatively quiet on environmental concerns. In order to answer the call from industrial ecology, we now turn to the limited studies on environmental issues within the industrial cluster literature.

2.2. Industrial cluster and its environmental externalities

Environmental damage can be understood as a typical external diseconomy. The basis of an externality is that private costs or benefits are not balanced with social costs or benefits (Scitovsky, 1954; Schmitz, 1999; Nadvi, 1999a,b). The industrial cluster literature has traditionally viewed externalities in a positive sense, providing empirical evidence of common labour pools, specialist suppliers, knowledge spill-