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Organizational Perspectives of Industrial Symbiosis: A Review and Synthesis

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Abstract

Industrial symbiosis (IS) is a collaborative environmental action whereby firms share or exchange by-products, materials, energy, or waste as a way to economically reduce aggregate environmental impact. Research in IS has flourished over the past two decades, and the time is ripe for a coherent review of organizational perspectives on the topic, particularly since the practice of IS is rife with difficulties often attributed to "social" factors. We review the organizational perspectives found in IS literature using a two-dimensional framework considering the antecedents, consequences, lubricants, and limiters of IS assessed through institutional, network/system, organizational, and individual levels of analysis. Our framework highlights what organizational perspectives have been adopted so far and also points to avenues of future scholarship of this unique phenomenon.

Keywords

industrial symbiosis, environmental strategy, interfirm strategy, collective strategy, organizational theory, literature review, low-carbon economy, circular economy, social networks

A chemical firm creates carbon dioxide (CO_2) and low-grade steam heat as a by-product from ammonia production. While not useful to the firm, these resources are not without value. Nearby, a vegetable grower looking to build a new greenhouse is stymied by heating costs. Working together, these firms capture and redirect the excess CO_2 and steam heat to the vegetable grower. Doing so reduces the chemical firm's CO_2 emissions by 12.5 metric tons a year and provides enough heat to support a new 38-acre greenhouse. The symbiotic engagement preemptively addresses potential regulatory constraints, creates 80 new full-time jobs, and provides for domestically sourced tomatoes year-round in the United Kingdom. This is industrial symbiosis (IS).

More formally, IS occurs when firms collaborate in the exchange, sharing, and/or reprocessing of excess materials, energy/utilities, water, and by-products from one firm into the production feedstock of another with the underlying goal of economically reducing their aggregate environmental impacts (Chertow, 2000). IS research lies within the broader domain of industrial ecology—the

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study of optimizing material and energy flows in industrial, societal, and ecological systems more broadly (White, 1994). It is a global phenomenon (Van Beers, Corder, Bossilkov, & Van Berkel, 2007) and the environmental and economic potential of IS has caught the attention of policy makers as an important strategy for low-carbon development (European Commission, 2011; Organisation for Economic Co-operation and Development, 2010). Scholars, too, have taken an interest. IS research has flourished for several decades in environmental science and industrial ecology literatures (Ehrenfeld & Gertler, 1997; Van Beers et al., 2007; Q. Zhu, Lowe, Wei, & Barnes, 2007).

The above definition of IS is used most often in the literature. More recently, scholars have expanded this definition to also include intangible resource exchanges such as knowledge, experience, information, excess organizational capacity, and other slack resources (Lombardi & Laybourn, 2012). In its nascence, IS research focused on descriptive, successful cases such as the oft-cited Kalundborg industrial estate (Ehrenfeld & Gertler, 1997), or normative suggestions on how to develop IS (Boons & Baas, 1997). Studies speculated on the potential of IS to address ecological issues of industrial activity (Ayres, 1996; Cote, 1997; Shrivastava, 1995) and tended to be practitioner oriented rather than rooted in strong theoretical grounding (Yu, Davis, & Dijkema, 2014). The 1998 launch of the *Journal of Industrial Ecology* and the Gordon Research Conference on Industrial Ecology propelled scholarly conversations situating IS more clearly at the intersection of technical and societal issues concerning the environment (Lifset, 1998a, 1998b). Yet, as researchers were increasingly confronted with thwarted IS efforts, even when technically solutions were viable, the focus shifted toward more social, nontechnical aspects of IS such as relationships, trust, communication, coordination, and learning, among others. IS scholars thus progressively drew on organizational theories like social networks, institutional theory, and environmental strategy.

The IS literature is still fragmented theoretically and has developed separately from corporate environmental strategy where the focus is mostly on intra- rather than interfirm action (Etzion, 2007; Wassmer, Paquin, & Sharma, 2014). Given its potential to inform environmental strategy and organizational theory, it is a good time to consider the IS literature from an organizational angle and set an agenda for future research (Andrews, 2001; Ehrenfeld, 2000, 2004; Hoffman, 2003; Korhonen, Huisingh, & Chiu, 2004).

In this article, we provide a comprehensive overview of organizational perspectives used in the IS literature. Our goal is not to propose an overarching organizational *theory* of IS but rather to offer a *framework* identifying relevant paths for future research. We adopt a framework typically used in review papers (Wassmer et al., 2014), looking at the drivers, outcomes, and influencing factors associated with IS, that we refer to as antecedents, consequences, lubricants, and limiters. We organize these at four levels of analysis at which IS operates (Andrews, 2001; Boons, Spekkink, & Mouzakitis, 2011): the institutional, network (or systems), organizational, and individual levels. This framework captures theoretical perspectives that are currently used in the literature and identifies obvious theoretical gaps to develop IS as a field of scholarly study and also spur thinking on collective strategies more broadly (e.g., Bresser, 1988; Vangen & Huxham, 2012), and interfirm environmental management specifically (Boles, 1998). It also paves a path for future work on the social, rather than technical, dynamics of IS development (Gibbs, 2003; Heeres, Vermeulen, & de Walle, 2004; Sinding, 2000). As a unique interorganizational, network-based set of actions, IS research may also extend theories of (social) networks. Finally, as a multilevel phenomenon, studying IS may further contribute to integrating macro- with micro-level perspectives more generally.

Methodology

We took a systematic approach in searching the relevant literature, modeled after other recent reviews (Parmigiani & Howard-Grenville, 2011; Wassmer et al., 2014). We limited our search to

articles published in and after 1989 when Frosch and Gallopoulos's (1989) seminal article, "Strategies for Manufacturing" published in *Scientific American*, popularized the concept of IS. We searched Web of Science and Google Scholar using a two-dimensional search term matrix combining "industrial symbiosis," "industrial ecology," "industrial ecosystem," and "by-product exchange" with "collab*," "coordinat*," "organiz*," "network," "social," "institution*," "policy," "govern*," "strategy," "trust," "manag*," and "supply chain" in article titles, abstracts, and/or keywords. After an initial pass, we realized a number of important articles were missing and thus searched articles by key authors in the field and also key journals for published and in-press articles. This resulted in 249 articles, which we culled to 121 relevant articles.[1] Although Frosch and Gallopoulos's article was published in 1989, we found that *organizational* approaches to IS really took off only in 1995, and over half of the articles here were published after 2007, showing the recent rise of a social science orientation here.

We systematically analyzed the articles, adopting a two-stage content analysis technique using the software NVivo 10. First, we set up a coding system by analyzing the top-cited articles in the field. We compared notes and developed a list of relevant codes for analyzing the rest of the articles. We then trained two research assistants (RAs) to code articles using these codes while giving them the freedom to add codes where relevant. We met with the RAs regularly to check work and clarify questions. We used Cohen's kappa ($\kappa = 0.81$, agreement of 99.5%) to test inter-rater reliability between the RAs with eight highly cited articles (representing 9.8% of Phase 1 codes) giving us confidence in the coding system. The first coding stage resulted in 3,761 coded sections of text, with just over 200 unique nodes (categories).

For the second stage of the content analysis, we developed an organizing structure of these nodes. We collapsed/merged similar concepts into the same categories and organized relevant concepts into subnodes of overarching categories, dropping nodes not relevant to organizational theory. We agreed on a basic structure that identified *antecedents*, *consequences*, *lubricants* (stimulators), and *limiters* (barriers) of IS from an organizational perspective, and then teased apart antecedents and lubricants for conceptual understanding, though in practice they often go hand in hand. For our purposes, antecedents were based on those factors generally considered necessary for IS to happen in the first place. We also teased apart lubricants and limiters, even though both may be considered "contingent" influences. For our purposes, lubricants were those factors generally seen as helping IS grow over time, while limiters generally inhibited it. We discuss this more below. Table 1 shows the organization of the content analysis.

Description of Coded Data

Antecedents had the second highest number of codes overall, with 308 coded sections of text across 14 subcategories. The most often mentioned were colocation, government regulation, specific organizational roles such as anchor and scavenger firms, the necessity of a diverse actor base, and the importance of a common vision or alignment of norms/beliefs among the organizations and individuals. This emphasis on antecedents was not surprising given scholarly and policy-making interest around understanding the drivers of IS.

Consequences were least discussed with 124 coded sections and nine subcategories. The lack of emphasis here is partly because technical- or engineering-oriented studies (that did not also consider social factors) were excluded from our study. Popular themes were innovation, co-benefits of environmental and economic performance, learning, resilience, and lock-in effects.

The majority of themes concerned *lubricants*, or positive influences, with 449 coded sections of text across 12 subcategories, with 6 main subcategories: intermediaries, trust, knowledge creation, embeddedness, culture, social and network ties, and communication. Subcategories were highly interrelated. For example, trust was cross-coded 53 times with almost every other lubricant, and most frequently cross-coded with intermediaries and embeddedness; though also with

Table 1. Phase 2 Coding Results: Antecedents, Consequences, Lubricants, and Limiters of Industrial Symbiosis.

Categories and subcategories	No. of sources (articles)	No. of references (codes)
Antecedents		
Colocation, proximity	31	63
Government regulation	30	54
Anchors, scavengers, and other roles	24	47
Diversity of actors involvement	20	35
Common strategic vision, beliefs, and alignment	17	21
Economic reasons	12	21
Resources or skills	10	13
Environmental reasons	8	10
Identifying by-product exchanges, complementarities	9	10
Awareness, education	8	8
Prior, small scale success	7	8
Contractual agreements	3	4
Identify advantages for each party	3	4
Institutional pressure-stakeholders	4	4
Other	6	6
Limiters		
Power, status, asymmetries	10	14
Too much diversity	11	14
Exit of player, personnel, or change in flows	8	13
Cost, risk	10	11
Environmental regulation too restrictive	9	10
Lack of trust	7	9
Create dependency	7	7
Unaligned interests or goals	6	7
Inadequate monitoring (governance)	2	5
Other	55	59
Consequences		
Innovation	21	28
Co-benefits: environment and economic	20	25
Learning	15	24
Resilience	10	14
Lock-in, domino effect	7	10
Social capital	2	7
Interconnectedness	6	6
New norms or worldview	4	4
Public benefit	3	3
Other	4	4
Lubricants		
Intermediaries, coordinators and champions	42	110
Trust, openness	33	78
Knowledge creation or sharing	22	40
Embeddedness	12	39
Culture or mind-set	22	33
Social and network ties	11	30
Communication	20	29
Monitoring, governance	17	23
Stakeholder involvement	10	20
Cooperation	11	15
Institutional capacity, diffusion	9	15
Commitment, willingness to change	6	7
Other	5	9

social and network ties, intermediaries, embeddedness, and knowledge creation and sharing. Intermediaries was second most cross-coded, with 25 cross-links, followed by social and network ties (22 links), embeddedness (20 links), and knowledge creation (19 links). Among these,

Table 2. Current Organizational Theory Perspectives in Industrial Symbiosis and Future Research Directions.

Level of analysis	Institutional	Network (industrial symbiosis system)	Organizational	Individual
Antecedents	Institutional theory (regulatory pressure)	I/O economics: geographic clustering Network actors (roles, diversity)	Organizational structure (local autonomy)	Championing
Consequences		Network structure (embeddedness) Collective benefits: economic, ecologic, innovation, learning	Firm-level benefits: economic, ecologic, innovation, learning	
Lubricants	Institutional theory (shared norms)	Network actors (roles) Network structure (embeddedness and ties)	Organizational structure (local autonomy)	Social capital, championing
Limiters		Network actors (power imbalances, diversity) Resource dependence	Economics cost/benefit (perceived costs and risks)	

embeddedness was frequently cross-coded with social and network ties, with knowledge creation often linked to intermediaries. This high interconnectedness of subcategories was not seen elsewhere, underscoring the close link of many lubricants concepts. That lubricants dominated the organizational discussion is not surprising as the vast majority of work here focuses on network analysis/theory and related concepts and is highly relevant to IS collaborations.

Limiters were often only discussed in vague terms, with 149 coded sections across 26 subcategories and, while spread across a variety of subcategories, were typically referenced only briefly. Limiters were often considered the antithesis of lubricants or drivers, suggesting limiters may be a "lack" or "too much" of constructs that were otherwise IS lubricants. However, these points tended to be speculative with little supporting empirical work. The top five limiter subcategories included power asymmetry, too much diversity, the exit of a key player or material flow, perceived cost or risk, and restrictive environmental regulation.

In Table 2 we organized the main theories referenced in the literature, identified above, into a two-dimensional framework of antecedents, consequences, lubricants, and limiters at different levels of analysis from macro to micro: institutional, network (system), organizational, and individual. This shows what has been emphasized so far and identifies areas of future research.

Organizational Theories in Industrial Symbiosis

Institutional Level Theories in IS

Government involvement in IS was the foremost topic at the institutional level of analysis. The IS literature explored the roles of (a) government policy and (b) governmental agencies in initiating and supporting IS development, though there was some debate over usefulness of government policy versus a free market approach. Desrochers (2001) argues a free market approach encourages marketable goods and innovation and is based on in-house knowledge and solutions that are more useful than the fragmented and inconsistent conditions of government policies. Boons (2012) counters governments need not be "of the five-year plan, coercive, socialist kind" (p. 108), suggesting that government involvement can be nuanced and adapt to local contexts as

in the case of regional programs in the United Kingdom (Paquin & Howard-Grenville, 2012) and IS parks as part of China's Circular Economy policy (Shi, Chertow, & Song, 2010). Most researchers agree that government involvement is needed to create the right institutional conditions for IS to stimulate firms to find strategic uses for their by-products (Boons & Spekkink, 2012), match and coordinate industrial activity between firms (von Malmborg, 2004, 2006), and break down sectorial boundaries around cross-industry participation (Liu, Ma, & Zhang, 2012).

Government involvement can create regulatory pressure for IS through direct policy, and normative pressure through voluntary instruments and setting expectations (e.g., Boons et al., 2011). Given that institutional settings differ substantially across contexts, we expect different policies and interventions to have differing effects across national or local levels (Costa & Ferrão, 2010; Panyathanakun, Tantayanon, Tingsabhat, & Charrnondusit, 2013). Yet more research is needed to understand the role of institutional drivers, such as government policy and engagement, supporting IS (Doménech & Davies, 2011), and conditions that create barriers—for example, strict command-and-control policies (Ehrenfeld & Gertler, 1997). Recent work on green innovation has shown that stringency of environmental regulation moderates the relationship with financial performance (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013). Future studies will likely shed greater light on which types of policies—for example, tax relief for material exchanges, taxation of transport and fuel, limiting end-of-pipe emissions—may stimulate or inhibit IS.

Prior research also indicates that establishing positive feedback loops between government, industry, and stakeholders can support IS development (Alfaro & Miller, 2014; Costa & Ferrão, 2010) through clarifying local context and expectations (Ashton, 2011), building local support and accountability (Behera, Kim, Lee, Suh, & Park, 2012), supporting joint solutions (Park, Rene, Choi, & Chiu, 2008), and mitigating "not-in-my-backyard" attitudes (Costa & Ferrão, 2010). Yet more can be done here too. Drawing on institutional and stakeholder theories, for instance, scholars could investigate relationships between firms and government agencies involved in IS. First, when and how do managers find government agencies helpful? Prior work suggests that there may be normative, country-level differences (Gibbs & Deutz, 2007). If so, what elements of those relationships are helpful? Is it the ability of agencies to connect firms to each other; the resources, knowledge, and skills of the people working within those agencies; their knowledge of environmental issues and policies, and so on? And how might these elements of governmental action differentially influence how IS develops (von Malmborg, 2004, 2006). This type of work could connect institutional theories with resource-based view, knowledge-based view, and environmental management literature more generally.

Second, how do managers perceive and react to particular government policies and other institutional influences (e.g., Oliver, 1991)? How do policy makers perceive firms' receptiveness to IS initiatives? How do organizations translate polices into practice? What is the role of experiential knowledge (Jiao & Boons, 2014)? What are the impacts of policies such as tax relief for material exchanges, transport and fuel taxes, or end-of-pipe emissions constraints on IS (Lehtoranta, Nissinen, Mattila, & Melanen, 2011)? How might effective policies be adapted in different national, regional, and local contexts, or are there some common themes across contexts? Third, under what types of institutional conditions do companies voluntarily engage in IS and how would reporting on by-product exchanges, toxic release inventories (e.g., Konar & Cohen, 1997), or IS partners influence firm involvement?

These questions may be studied via a number of organizational lenses. Institutional change and institutional entrepreneurship lend insight into the role of individual organizations or a group of actors seeking to influence institutional norms. In analyzing how firms can set such wheels in motion, we may gain a better understanding of how IS can develop organically. Another important institutional theory concept is legitimacy. The impact of regulatory pressure is likely mitigated by legitimacy if a government agency acts as a collaborator with firms

(Gibbs & Deutz, 2007), or by the legitimacy of IS as a viable action for firms (Paquin & Howard-Grenville, 2013). Scholars can also look at the roles of other normative sources of pressure, such as diffusion of environmental norms more broadly, and at how this may encourage firms to consider IS. Similarly, cultural-cognitive pressures are likely to be important but have not been studied. A shared belief on handling waste and environmental concerns may spur IS activities in some contexts. That belief may be generated in a top-down manner by government, and also through a bottom-up social movement. Moreover, institutional pressures may affect how much attention firms pay to these issues. Models of the attention-based view of the firm could provide insights into the macro- to micro dynamics of government policy or other institutional forces.

In short, institutional perspectives can bring much to IS. Likewise, IS can potentially contribute to the institutional literature by lending a unique perspective as it is explicitly collaborative in nature with a collective goal, whereas other types of institutional actions studied have been primarily self-serving to the actors seeking the change (Greenwood & Suddaby, 2006) or providing symbolic value to the adopters (King, Lenox, & Terlaak, 2005). Thus, institutional studies on IS may shed light on diffusion and adaptation of practices and action.

Finally, stakeholder theory is relevant to IS, as a source of both external pressure and potential collaboration. A few articles in our review briefly noted stakeholder support as a necessary condition for the development of IS (Chertow, 2000; Panyathanakun et al., 2013; Tudor, Adam, & Bates, 2007; Zhang & Wang, 2014). Yet stakeholders can differ substantially in their objectives, creating conflicts for firms (Levanen & Hukkinen, 2013). Theoretical work on stakeholder identification and salience may offer a useful springboard for future research on how IS firms can manage such conflicts (Hart & Sharma, 2004; Mitchell, Agle, & Wood, 1997).

Network Level Theories in IS

The richest contributions made toward organizational theory in the IS literature are without doubt at the network-level of analysis, as every IS system is a network of relationships and exchanges. Issues such as individual actor roles within networks have been looked at both as antecedents and lubricants. Network diversity appears both as an antecedent and limiter. Network embeddedness has been studied as a lubricant and consequence. Network ties and resource flows are seen as lubricants while network position is seen as a possible limiter. A number of other theoretical angles have also been pursued at the network level. Foremost is work drawing on industrial organization economics such as colocation. In addition, studies have explored theories of knowledge, learning, and identity. Network performance as an outcome is sometimes considered but has not yet been overtly connected to organizational theories.

Network Actors: Roles, Power, and Diversity. The roles of particular actors in the IS system has been a prominent and early theme. For instance, Chertow's (2000) work described the anchor-tenant model as a fruitful antecedent as anchor firms provide large and constant flows of by-products that can form the core of exchanges (Wang, Zhang, & Wang, 2009), as well as building an infrastructure for future potential exchanges among others (Costa & Ferrão, 2010). Typical anchors include power plants, resource recovery plants, and organizations from industries including agriculture, chemicals, brewing, heavy manufacturing, pulp, saw mills, and even brownfield sites with consistent by-product throughput (Chertow, 2000; Chertow & Ehrenfeld, 2012; Dong, Gu, Fujita, Hayashi, & Gao, 2014; Korhonen & Snakin, 2005; Lambert & Boons, 2002). Similarly, scavengers—firms whose core business is dependent on others' wastes—can function as resource collectors that repair, reuse, remanufacture, and recycle materials, thus closing the environmental loop (Geng & Côté, 2002). Scavengers are central to reducing slack and redundancy in the IS system (Cote & Hall, 1995; Geng & Côté, 2002).

Actors such as anchors and scavengers may inform resource dependence theories by assessing power and influence among actors in an IS system (Ehrenfeld & Chertow, 2002; Korhonen, 2005b). Anchors are the central providers of resources, while scavengers ensure resources are used efficiently. Yet, despite likely power asymmetries that arise from these roles, resource dependence is rarely discussed in the IS literature. Nevertheless, these imbalances exist and result in suboptimal resource solutions (Boons, 1998) and uneven benefits to individual actors (Ashton & Bain, 2012; Chertow & Lombardi, 2005; Martin, Svensson, & Eklund, 2014; Paquin & Howard-Grenville, 2009) and can inhibit IS development (Ashton, 2011; Korhonen, 2004b).

The resource dependence relationship becomes abundantly clear when a "resource-rich" actor leaves the network. Such departures create ripple effects across the entire system and may be detrimental to small IS networks (Lehtoranta et al., 2011; Tudor et al., 2007), affecting resource flow and supply, as well as productivity (Chopra & Khanna, 2012) and coordination of activities (Hewes & Lyons, 2008). The role of actors' power over resources is therefore an important area for future research (Korhonen, 2005a). While contractual agreements may be one way to control for such dependencies (Williamson & Meyer, 2012), they also raise transaction costs, which may inhibit new exchanges. Understanding under what conditions power asymmetry may support or inhibit IS and how this can be managed may offer practical insight into strategic actors exiting an IS system (Chertow, 2007; Chopra & Khanna, 2012).

To develop IS, scholars have often argued a diversity of actors is necessary to ensure that opportunities for exchanges exist (Chertow, 2000) by having an array of resource inputs and outputs, technologies, and processes (Jensen, Basson, Hellawell, & Leach, 2012), as well as a diversity of values, worldviews, interests, and preferences (Korhonen, 2005b), and a broader potential knowledge base to foster innovation and learning among firms (Boons & Berends, 2001; Korhonen, 2001b; Lombardi & Laybourn, 2012). For these reasons, diversity is considered key to creating value (Romero & Ruiz, 2013). Diversity is an important mechanism to create stability and resilience within the resource-dependent system (Lombardi, Lyons, Shi, & Agarwal, 2012), as a diverse system is more likely to have others actor to fill gaps created when an actor leaves the system (Korhonen, 2005a). J. M. Zhu and Ruth (2013) identified a number of interorganizational dependencies relevant to IS systems: supply of by-products that are not core concerns of the involved firms, specialized assets developed for particular IS exchanges, and powerful organizations to support particular exchanges.

Drawing insight from resource dependence theories to inform network diversity may prove insightful, since IS systems rely on the exchange of both tangible and intangible resources. Ensuring that such resource flows are stable helps manage uncertainty. Thus, three factors—the importance of the resource, the discretion over the resource's allocation and use, and the extent to which there are few alternatives—can inform IS networks (Pfeffer & Salancik, 1978). While lack of diversity can create overdependence, excessive diversity can prove too complex. Hence, both power imbalances and mutual dependence may affect IS system success (Casciaro & Piskorski, 2005) and could inform seemingly contradictory perspectives on the influence of diversity in IS (Paquin, Tilleman, & Howard-Grenville, 2014).

The unique phenomenon of IS as a network of industrial activity furthermore has the potential to inform resource dependence theory from a network perspective. For instance, what network features or mechanisms can help reduce uncertainty and dependence on external resources? Much has been written in the IS literature about resilience as well as lock-in consequences of the network structure. Resilience is a notion borrowed from ecology a way to describe a system that can absorb disruptions without fundamentally changing its properties (Chopra & Khanna, 2012). Resilient systems, therefore, are more stable (i.e., less uncertain). An important distinction made by IS scholars is the difference between "robustness" (stability) and "resilience" (ability to handle shock) of IS networks (Schiller, Penn, & Basson, 2014; Schiller, Penn, Druckman, Basson, & Royston, 2014). Schiller et al. (2014) focus on five social dimensions of networks, those

characterizing dyadic and triadic relationships, to ensure "multiplex" approaches to any analysis of resilience and robustness. These types of relationships have (as far as we are aware) not been explicitly considered in resource dependence perspectives.

Similarly, looking at lock-in effects can offer insight to resource dependence. Lock-in is typically considered an outcome of an institutional process (e.g., path dependence), though it can also be explored from a resource dependence perspective. Does lock-in occur due to institutional barriers, resource barriers, or both? This is important to understand as lock-in prevents actors from adopting new technologies since others may depend on waste flows from existing processes or old technologies (Gregson et al., 2012; Jacobsen, 2007; Korhonen, 2004a, b; Posch, Agarwal, & Strachan, 2011; Wolf, Eklund, & Söderström, 2007). Thus, lock-in may form a systemic power imbalance and resource inefficiency, hindering subsequent changes supporting environmental progress (Jacobsen, 2007).

IS actors such as anchors also play an important coordinating role for the entire system (e.g., Korhonen, 2001b, 2005b). Other types of intermediaries include municipalities, business association, or brokers, as well as NGOs (nongovernmental organizations), steering committees or advisory boards, regional programs, and so on. These latter actors emphasize interorganizational cooperation and communication flows (Vernay, Mulder, Kamp, & de Bruijn, 2013, p. 198) rather than physical flows. A critical network function of intermediaries is generating awareness of IS exchanges (Doménech & Davies, 2011; Harris & Pritchard, 2004; Jiao & Boons, 2014; Yu, de Jong, & Dijkema, 2014) and functioning as a connecting hub (Ashton, 2008; Ashton & Bain, 2012; Behera et al., 2012; Boons & Janssen, 2004; Boons & Spekkink, 2012; Chertow, 2007; Chertow & Ehrenfeld, 2012; Costa & Ferrão, 2010; Doménech & Davies, 2011; Grant, Seager, Massard, & Nies, 2010; Jiao & Boons, 2014; Korhonen, 2001a; Panyathanakun et al., 2013; Paquin & Howard-Grenville, 2012). Often such intermediaries are the IS system experts (Ashton, 2011; Costa & Ferrão, 2010; Doménech & Davies, 2011; Grant et al., 2010; Korhonen, Von Malmborg, Strachan, & Ehrenfeld, 2004; Yu, de Jong, et al., 2014) engaging in deeper reflective learning on their own environmental actions and impacts (Baas & Huisingh, 2008; Doménech & Davies, 2011).

Intermediaries serve two critical purposes. First, they create trust among actors in the IS system through repeated engagement (Ashton, 2008; Chertow & Ehrenfeld, 2012) by means of ongoing dialogue with other firms (Baas & Huisingh, 2008; Hewes & Lyons, 2008), thus supporting the success of the system (Baas & Huisingh, 2008; Paquin & Howard-Grenville, 2012). Since actors in IS exchanges typically have little or no prior history of working together, trust through an intermediary ensures that (1) firms are more likely to consider the exchange in the first place (Paquin & Howard-Grenville, 2009); (2) the process of collaborating is shortened, saving time and costs that would otherwise be incurred through contracting (Doménech & Davies, 2011); and (3) opportunistic, free-riding behavior is reduced (Baas & Huisingh, 2008; Lombardi et al., 2012). Trust supports the creation and deepening of relationship between IS firms, allowing more complex network arrangements to arise (Hewes & Lyons, 2008). Second, intermediaries spur institutionalization by developing shared norms of action (Ashton, 2008), which reduces cognitive barriers and "mental distance" between actors (Yu, de Jong, et al., 2014). Moreover, successful intermediaries gain legitimacy for the entire IS system, allowing them to negotiate legal barriers and regulations and act as a bridge between government agencies and the private sector (Behera et al., 2012; Boons & Spekkink, 2012; Chertow, 2007; Costa & Ferrão, 2010; Korhonen, 2001a; Panyathanakun et al., 2013).

The roles of IS actors can be studied further. Specifically, how do powerful actors guide strategic vision and shape a common identity in systems (Baas & Huisingh, 2008; Chertow, 2007)? How do organizations monitor the activities of their collaborators? How is a vision shaped within an IS network? We already know that creating a common vision and beliefs is considered crucial (Behera et al., 2012; Boons, 2008; Korhonen, 2001a; Liu et al., 2012; Mathews & Tan, 2011), but

it is rarely a focal study topic. Yet a shared vision can establish a common identity and culture among IS actors (Panyathanakun et al., 2013; Park et al., 2008; Posch et al., 2011). Studying visioning could therefore inform theories about organizational (or network) identity, as a mechanism of institutionalization and legitimization. While a few articles mention strategic visioning to support goal alignment in IS (Boons & Spekkink, 2012; Costa & Ferrão, 2010) and increase institutional capacity among diverse stakeholders (Boons et al., 2011; Spekkink, 2013), exactly how strategic visioning contributes and through what mechanisms it guides, motivates, and empowers IS actors remain an area open to research.

Network Structures: Social Ties and Embeddedness. Social ties are an integral part of network structures. It is through such ties that actors within IS systems engage one another and develop embeddedness, shared norms or cultures, and "social capital" more generally (Ashton & Bain, 2012). Within IS, formal and informal ties are often considered necessary (Ashton, 2008) and can lay the foundation for formal IS exchanges (Boons & Janssen, 2004). Social ties are crucial to the knowledge transfer necessary for IS exchanges between firms (Baas & Huisingh, 2008). They facilitate communication and information sharing (Behera et al., 2012; Shi et al., 2010), stimulate cooperation among managers and firms while minimizing transaction costs, and help develop shared norms (Ashton, 2008; Chertow & Ehrenfeld, 2012; Harris & Pritchard, 2004).

Most of the research has focused on how interpersonal relationships help firms engage directly (Ashton, 2008) and through intermediaries (Posch et al., 2011) to develop exchanges. As intermediaries are centrally located within IS networks, they can be efficient at brokering communications and developing trust among firms (Mirata, 2004; Paquin & Howard-Grenville, 2009, 2013). Thus, intermediaries may be a key lubricant to stimulate IS engagement (Posch et al., 2011). Ties with external stakeholders are also important for external support (de Araujo, Pintao, & Rosa, 2011). Importantly, firms within IS systems may be required to wear multiple hats simultaneously as both anchors and intermediaries (Paquin, Busch, & Tilleman, 2015). The network literature can provide insight on the impact of different types of brokers and what actions they may undertake to support network growth and evolution toward network-level outcomes. In addition, the unique roles that arise in IS networks may provide deeper understanding of how different types of actors affect the network structure.

When ties are established to such an extent that actors can influence other's behaviors and share common norms, the network is considered to be embedded. Embeddedness arises as an institutionalization process through repeated interactions. While social ties may exist early on in IS development, embeddedness tends to develop only over time (Chertow & Ehrenfeld, 2012; Doménech & Davies, 2011; Paquin & Howard-Grenville, 2012). Embeddedness in networks can be related to network position (structural), power distribution (political), shared norms and trust (cultural/relational), and shared mental modes (cognitive; Zukin & Dimaggio, 1990) that overlap with many of concepts coded in our review including "short mental distance," "openness," "communication," and "trust" (Ashton & Bain, 2012) and identified as mechanisms of embeddedness (Doménech & Davies, 2011). Embeddedness is related to the type of IS system: in self-organized IS systems, cultural embeddedness may necessarily precede structural embeddedness, while in facilitated IS systems, structural embeddedness is more important given the role of intermediaries in developing exchanges (Paquin & Howard-Grenville, 2012).

Closely related to embeddedness is the concept of culture. Scholars generally agree that a culture of cooperation, influenced by short mental distance and common values and beliefs, is helpful here. For instance, actors sharing common attitudes toward waste have greater cultural and cognitive overlap (Ashton & Bain, 2012). Yet more can be done. For example, how do actors in IS systems frame their IS-relevant activities? How are these frames or perspectives received by individual firms? What is the process of developing a common culture of IS engagement? What is the role of key firm-level actors (e.g., intermediaries, coordinating organizations, anchor

firms, scavengers) and individual-level actors (e.g., champions) in this process? What is the role of network position in developing cultural or cognitive embeddedness and vice versa in IS development? Also, the challenges of diverse actors within an IS system need to be considered when developing a common culture in the face of conflicting interests, values, and preferences (Boons & Spekkink, 2012; Korhonen, 2001a, 2004a, b; Korhonen & Snakin, 2005; Korhonen, Von Malmborg, et al., 2004).

Another research area speaks to the notion of network governance. Intermediaries are thought to play an important governance role in IS systems (Doménech & Davies, 2011; Posch et al., 2011). Since IS systems are usually self-governed (Boons & Janssen, 2004), scholars agree that some form of oversight and control is necessary for actor accountability. While appropriate monitoring may contribute to positive feedback loops within an IS system (Costa & Ferrão, 2010), little research has explored the types of governance best suited to IS. Since IS systems have no clear principal or agent relationships, governance issues that arise may be more like principal-principal conflicts. Power imbalances within the network structure also likely influence governance structures. Many IS systems have steering or advisory boards, suggesting that "network governance" or "participatory governance" may be effective (Baas & Huisingh, 2008; Doménech & Davies, 2009), though it is unclear what influence such bodies have over others in the system. In other words, how are relationships governed when contractual agreements are minimized and much is based on trust? Is this simply a system of peer sanctions and rewards? Ownership issues are likely also an important area (Boons & Baas, 1997; Korhonen, 2005a). Similarly, what is the impact of various firm and network-level incentive structures in developing IS?

Colocation and Proximity. IS research has strong roots in the geographic clustering or economic agglomeration literature from industrial organization economics (Chertow, 2000; Chertow, Ashton, & Espinosa, 2008; Desrochers, 2001; Desrochers & Leppala, 2010). Locational advantages that benefit IS clusters may include concentrations of firms and skilled labor, economies of scale by suppliers, knowledge spillovers, lower transportation costs, local tax and regulatory incentives, infrastructure/utility sharing, and more (Desrochers, 2001; Desrochers & Leppala, 2010). There are some notable differences, however, with IS. IS clusters tend to involve building new relationships rather than relying on existing ones (Deutz & Gibbs, 2008), especially when IS is planned. IS clusters often involve environmental as well as economic benefits (Chertow et al., 2008), though exchanges are sometimes complex (Desrochers & Leppala, 2010) and often develop around non-core aspects of the businesses (Deutz & Gibbs, 2008).

Physical proximity is important both to IS emergence and its subsequent development (Chertow & Ehrenfeld, 2012). However, the impact of physical proximity is under debate. Some argue proximity is not critical for IS as knowledge flows, supply chains, and technology already occur on a global scale (Gregson et al., 2012; Lombardi & Laybourn, 2012). Others contend proximity supports the social and cognitive linkages that encourage material exchanges through trust and knowledge spillovers (Baas & Huisingh, 2008) and take time to build (Boons et al., 2011; Chertow, 2000; Paquin & Howard-Grenville, 2012). Other benefits arise via utility-sharing services and reducing transportation emissions (Armstrong & Tranby, 2002; Chertow, 2000). Empirically, managers tend to have more and better connections to other IS actors when they are nearby (Ashton & Bain, 2012) and IS exchanges tend to favor close distances (Jensen, Basson, Hellawell, Bailey, & Leach, 2011; Q. Zhu & Cote, 2004).

Given the complexity of IS clustering, which includes physical exchanges as well as social and cognitive linkages, Desrochers and Leppala (2010) have specifically called for revitalization of geographic clustering perspectives. Future research could draw on notions of social and culture embeddedness, as discussed above, and also expand the concept to include spatial and temporal embeddedness as mechanisms to support IS development (Boons & Howard-Grenville, 2009).

Collective Benefits: Economic, Environmental, Innovation, and Learning

At a network or systems level of analysis, outcomes such as innovation, learning, and performance are key topics of interest. For instance, embeddedness can heighten learning and innovation while decreasing transaction costs, and increase flexibility (Doménech & Davies, 2011). Intermediaries can act as "knowledge banks" or "knowledge brokers" to identify and transfer explicit and tacit knowledge throughout the system (Korhonen, Von Malmborg, et al., 2004; von Malmborg, 2004) and encourage actors to reflect on what has been learnt (Baas & Huisingh, 2008). Thus, systemic innovation arises from the interaction of actors within the system (Vernay et al., 2013). Different types of learning also arise, including network-level learning of firms that reach out across traditional organizational boundaries (Baas & Huisingh, 2008; Korhonen, 2001b) and triple-loop learning through developing new underlying processes and methodologies to support IS (Harris & Pritchard, 2004).

Economic and environmental benefits of IS have been widely studied from engineering and materials exchange perspectives but less so from social perspectives (e.g., Chertow & Lombardi, 2005; Jacobsen, 2006). Thus, room exists to explore these links, particularly given environmental management scholars' obsession with connecting environmental and economic performance (Albertini, 2013; Margolis, Elfenbein, & Walsh, 2009; Orlitzky, Schmidt, & Rynes, 2003). Organizational perspectives on IS concur that such benefits arise due to minimizing transaction costs by sharing water, energy, transport, and other inputs, infrastructures, and services (Ashton & Bain, 2012; Chertow & Ehrenfeld, 2012; Chertow & Miyata, 2011; Gregson et al., 2012; Lehtoranta et al., 2011). Studies taking an explicit organizational approach from a resource-based view support this and find that prior experience in IS is an important mitigating factor (Paquin et al., 2014; Paquin et al., 2015).

IS also serves as a platform for exploration and exploitation (Alfaro & Miller, 2014) for firms to develop customized solutions (Doménech & Davies, 2011; Grant et al., 2010). Such innovations tend to happen through the exchanges themselves (Ashton, 2008; Baas & Huisingh, 2008; Boons, Montalvo, Quist, & Wagner, 2013; Doménech & Davies, 2011; Lombardi & Laybourn, 2012); may be incremental, radical, or architectural (Boons et al., 2013); and can create interorganizational (Mirata & Emtairah, 2005) and institutional changes (Liu et al., 2012).

Innovation goes hand in hand with learning (Doménech & Davies, 2011; Hewes & Lyons, 2008; Hudson, 2005; Mirata & Emtairah, 2005), especially complex forms of learning necessary for more radical innovations (Baas & Huisingh, 2008; Hudson, 2005). Yet this often requires firms undergo a cyclical process of awareness, cooperation, and internalization of IS as an interfirm action for competitive advantage and managing change (Harris & Pritchard, 2004). Doing so means breaking from established routines to allow collective learning and new problem solving to take place (Baas & Huisingh, 2008; Boons, 1998; Boons & Berends, 2001; Boons et al., 2011; Boons & Spekkink, 2012).

In essence, assessing IS outcomes—whether economic, environmental, innovation, or learning—has to do with how firms create collective value. Lavie (2006) proposed an extended model of the resource-based view that includes relational rents earned by firms through network resources that come from specific assets firms dedicate to alliance relationships and governance structures that support collective action. From a single firm's point of view, relational assets through networking may provide bargaining power and reduce uncertainty and instability in the business environment. As an explicitly collaborative value creating action, IS offers a unique platform to empirically test many of these ideas. Future work can explore the nature of the *relationships*, rather than resources, in the network. As IS consists of more than a simple collection of dyadic ties, work can study affiliation networks involving firms connected to events rather than solely through paired firm connections (Lavie, 2006). Studying IS may also lend insight into other collective value creation concepts such as multiplex ties, tie redundancy, homophily, and heterogeneous ego networks.

Organizational-Level Theories in IS

Comparatively little work on IS has been done at an organizational-level perspective. Work in this direction emphasizes obstacles—reasons why firms do not engage in IS—typically adopting an economic cost–benefit or a risk management argument. For instance, firms may choose to forego IS exchanges if there are higher (financial) payback options elsewhere (Ashton, 2011; Chertow, 2000; Chertow & Miyata, 2011). As well, the upfront investment required to develop a particular IS exchange (Mathews & Tan, 2011; Vernay et al., 2013), or set up new institutional coordination mechanisms (Shrivastava, 1995), may create hurdles to development. Concerns over creating dependency to others (Desrochers, 2001; Miller & Mukherji, 2010), or the novelty of IS (Paquin & Howard-Grenville, 2012), are also prevalent. Thus, firms seek to avoid partners perceived as unreliable (opportunistic), having low-quality outputs, or having incompetent management (Doménech & Davies, 2009; Levanen & Hukkinen, 2013).

Needless to say, much can be done to explore the organizational level of analysis, especially regarding decisions firms make to engage in IS. Within the context of environmental strategy, future IS research may provide insight into developing greener supply chains (Bansal & McKnight, 2009), collaboratively enhancing firms' competitiveness (Lombardi & Laybourn, 2012), and supporting low-carbon economic development (Laybourn & Lombardi, 2012). Yet little work explicitly addresses whether, how, and what types of value are created at the firm level through IS engagement (counterexamples, Chertow & Lombardi, 2005; Paquin et al., 2015). By contrast, environmental management has looked extensively at institutional-, firm-, and individual-level factors that determine environmental performance. Future IS work can leverage this work by hypothesizing about the impacts of regional and firm-level factors and exchanges on firms (Ehrenfeld, 2009). The environmental capabilities literature (Hart, 1995; Sharma & Vredenburg, 1998) may prove useful to assess how firms conceive of IS as a way of developing internal value and expertise, including managing by-products and wastes as potentially valuable resources (Aragon-Correa & Sharma, 2003; Baker & Nelson, 2005) and the types of environmental capabilities that may develop (Walls, Phan, & Berrone, 2011). For instance, simply starting an IS exchange can help firms build skills for subsequent, more elaborate exchanges (Paquin et al., 2014; Paquin & Howard-Grenville, 2013). In addition, assessing individual firm's environmental capabilities may provide clues as to why some firms benefit from IS more than others (Chertow & Lombardi, 2005; Paquin et al., 2015). Conversely, environmental strategy scholars may benefit from exploring IS to better understand how firms create collective value when they look beyond their own boundaries seeking new approaches to competitiveness (Wassmer et al., 2014). Thus, IS research may provide insight into how individual firms can engage in environmental, collaborative, and network-based strategic action more broadly (Capaldo, 2007; Vangen & Huxham, 2012; Wassmer et al., 2014).

Other important issues involve understanding intraorganizational influences on IS engagement. One limitation to IS engagement involving subsidiaries may involve insufficient autonomy for entering into local exchanges (Ashton, 2008; Boons & Janssen, 2004; Fichtner, Tietze-Stöckinger, Frank, & Rentz, 2005). This points to the importance of organizational structures such as decentralization/centralization of parent–subsidiary set ups and headquarters location, with a lack of local roots making companies less attractive exchange partners. Internal resistance to adapting organizational routines is another factor (Armstrong & Tranby, 2002; Chertow, 2000). These issues have not been studied in detail and applying lenses such as processes of organizational change and structural inertia may provide further insight.

Finally, it is important to understand how individual firms manage uncertainty and resource dependence within IS systems. To what extent do firms bind themselves to particular exchanges? Do they protect core production processes and knowledge, or do they commit everything? Does

the level of involvement lead to differential outcomes and benefits? Why do firms leave IS exchanges? Such organizational-level questions and many others, such as when and how these factors may support or inhibit IS activity, are still relatively understudied though likely important for understanding firms' action within IS systems, and their overall success.

One way to think about future organizational-level IS research may be through a boundaries approach. Santos and Eisenhardt (2005) identify four ways in which firms conceive boundaries that, by extension, may be applied to IS systems: (1) efficiency boundaries based on minimizing transaction costs, (2) power boundaries that maximize strategic control over resources and dependencies, (3) competence boundaries that maximize the value of organizational resources and evolve them in congruence with market opportunities, and (4) identity boundaries that maintain internal coherence to align activities. This approach raises interesting questions for IS. First, how are relationships across organizational boundaries governed? Trust is considered key to minimizing IS contracting and monitoring costs but needs more empirical study. Second, what types of power dynamics take place within IS? What kinds of power do organizations such as anchors, intermediaries, or others wield and how are they acquired? How do organizations gain strategic significance within an IS system? Do coalitions form within a system to lobby for their interests? Or does a more overt culture of collectivity hold sway instead? Third, what is the role of network resources? It is clear that collective capabilities are being built, but how are they captured and understood by firms in the system? And how do such resources translate into a competitive advantage for individual actors and simultaneously the IS system as a whole? Finally, how does IS identity develop? What are the sense-making processes that bring firms toward a more collective mind-set? What is the role of conscious mechanisms, such as adopting explicit mental models, versus unconscious mechanisms of conforming to an implicitly understood image or blueprint? By understanding how organizational boundaries become *blurred*, we might get insight into how collective action is shaped.

Individual-Level Theories in IS

Individual-level theories are not prominent in the IS literature. A key construct that is considered, however, is that of championing. Champions are key individuals within IS systems with the ability and energy to push for and broaden IS participation among firms (Baas & Huisingh, 2008; Hewes & Lyons, 2008; Mirata, 2004) and to support managing specific exchanges (Behera et al., 2012). They tend to be boundary spanners who diffuse new IS beliefs across the system (Chertow & Ehrenfeld, 2012) and are critical when firms are first learning about IS. Nevertheless, champions' enthusiasm for IS has to diffuse quickly to others in the community if exchanges are to succeed (Hewes & Lyons, 2008).

Other individual-level influences involve building social capital throughout the network via social ties and repeated interactions, as informal relationships are often an important lubricant (Hewes & Lyons, 2008). For example, pub meet-ups have been identified as a critical factor for Kalundborg's success (Boons & Janssen, 2004). Such repeated human interactions form the basis for creating a common culture and relational and cognitive structures (Ashton & Bain, 2012). In this sense, social capital built within an IS cluster may differ from traditional industrial clusters where goals are not necessarily shared or compatible, and where culture is industry based (Inkpen & Tsang, 2005). This suggests that knowledge transfer in IS clusters may operate under different conditions since shared vision and collective goals of IS networks rely more on relational trust than commercial transactions (Inkpen & Tsang, 2005). It would be interesting to uncover whether individuals in IS networks experience the usual benefits of social capital such as access to broader, relevant, and timely information; increased influence and control; and a reduced need for formal oversight (Adler & Kwon, 2002). In short, what is the influence of social capital on developing a common culture and identity among IS firms?

Largely missing at an individual level is the role of individuals with relevant IS skill sets and experience, as well as their values and preferences, as antecedents to IS. Future work can draw on concepts of institutional entrepreneurship and institutional work. Similarly, issues such as individual motivation, preferences, value orientations, and cognition as drivers for corporate environmental action may prove fruitful avenues of research. For instance, value orientations of powerful individuals within organizations can drive corporate environmental action (Andersson & Bateman, 2000; Bansal & Roth, 2000; Cordano & Frieze, 2000; Delmas & Toffel, 2008; Sharma, 2000), including through developing cooperative supply chain management (Sharfman, Shaft, & Anex, 2009) and corporate social entrepreneurship (Hemingway, 2005). Studying leadership characteristics that aid IS development can inform a growing body of work in this area of environmental management (Chin, Hambrick, & Treviño, 2013; Egri & Herman, 2000; Lewis, Walls, & Dowell, 2013; Waldman & Siegel, 2008).

A similar lacuna of the role of individuals has been lamented by institutional entrepreneurship scholars (Battilana, Leca, & Boxenbaum, 2009). IS offers a unique empirical platform in which to study this. Much of the institutional entrepreneurship literature has focused on actors' network position, particularly those spanning across embedded fields who need to develop a vision to mobilize and motivate others toward a common goal (Battilana et al., 2009). This points to underlying processes at the individual level that can inform multilevel theorizing by connecting micro- with macro-level processes—for instance, how the impacts of IS champions' actions are felt across an IS network, perhaps even supporting institutional change.

Conclusion

At the beginning of this review, we noted that interest in IS has steadily increased over the past 20 years. Given the enormous potential of IS to lower firms' and countries' environmental footprints, an organizational research approach to IS is needed to understand how environmental and economic value can be created here. IS research is increasingly explored via organizational perspectives, but it remains fragmented and the time is ripe to take stock of this work and explore future paths. In assessing what has been done to date and identifying additional organizational perspectives that are relevant to future studies on IS, our work supports prior calls for IS research to move in this direction (Ehrenfeld, 2009; Lombardi et al., 2012). Through our review, we offer a framework that shows how past IS research connects with numerous organizational perspectives to generate new insights. In addition, the unique collaborative network system that is IS provides a novel setting with which to inform and refine our understanding of these organizational theories more broadly.

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Note

1. Many of the culled articles discussed technical or engineering issues that, while valuable in their own right, were not relevant to our review. Two journals, *Journal of Cleaner Production* and *Journal of Industrial Ecology*, published the bulk of articles covered in this review.

References

Adler, P. S., & Kwon, S.-W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review, 27*, 17-40.

Aguilera-Caracuel, J., & Ortiz-de-Mandojana, N. (2013). Green innovation and financial performance: An institutional approach. *Organization & Environment, 26*, 365-385.

Albertini, E. (2013). Does environmental management improve financial performance? A meta-analytical review. *Organization & Environment, 26*, 431-457.

Alfaro, J., & Miller, S. (2014). Applying industrial symbiosis to smallholder farms. *Journal of Industrial Ecology, 18*, 145-154.

Andersson, L. M., & Bateman, T. S. (2000). Individual environmental initiative: Championing natural environmental issues in U.S. business organizations. *Academy of Management Journal, 43*, 548-570.

Andrews, C. (2001). Building a micro foundation for industrial ecology. *Journal of Industrial Ecology, 4*, 35-51.

Aragon-Correa, J. A., & Sharma, S. (2003). A contingent resource-based view of proactive corporate environmental strategy. *Academy of Management Review, 28*, 71-88.

Armstrong, C. S., & Tranby, C. E. (2002). *Eco-industrial redevelopment of LA brownfields*. Southampton, England: Wit Press.

Ashton, W. (2008). Understanding the organization of industrial ecosystems: A social network approach. *Journal of Industrial Ecology, 12*, 34-51.

Ashton, W. S. (2011). Managing performance expectations of industrial symbiosis. *Business Strategy and the Environment, 20*, 297-309.

Ashton, W. S., & Bain, A. C. (2012). Assessing the "short mental distance" in eco-industrial networks. *Journal of Industrial Ecology, 16*, 70-82.

Ayres, R. U. (1996). Creating industrial ecosystems: A viable management strategy? *International Journal of Technology Management, 12*, 608-624.

Baas, L. W., & Huisingh, D. (2008). The synergistic role of embeddedness and capabilities in industrial symbiosis: Illustration based upon 12 years of experiences in the Rotterdam Harbour and Industry Complex. *Progress in Industrial Ecology, 5*, 339-421.

Baker, T., & Nelson, R. E. (2005). Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative Science Quarterly, 50*, 329-366.

Bansal, P., & McKnight, B. (2009). Looking forward, pushing back and peering sideways: Analyzing the sustainability of industrial symbiosis. *Journal of Supply Chain Management, 45*, 26-37.

Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. *Academy of Management Journal, 43*, 717-736.

Battilana, J., Leca, B., & Boxenbaum, E. (2009). How actors change institutions: Towards a theory of institutional entrepreneurship. *Academy of Management Annals, 3*, 65-107.

Behera, S. K., Kim, J. H., Lee, S. Y., Suh, S., & Park, H. S. (2012). Evolution of "designed" industrial symbiosis networks in the Ulsan eco-industrial park: "Research and development into business" as the enabling framework. *Journal of Cleaner Production*, 29-30, 103-112.

Boles, J. M. (1998). James Rorty's social ecology: Technology, culture, and the economic base of an environmentally sustainable society. *Organization & Environment, 11*, 155-179.

Boons, F. (1998). Caught in the web: The dual nature of networks and its consequences. *Business Strategy and the Environment, 7*, 204-212.

Boons, F. (2008). Self-organization and sustainability: The emergence of a regional industrial ecology. *Emergence: Complexity & Organization, 10*, 41-48.

Boons, F. (2012). Freedom versus coercion in industrial ecology: Mind the gap! *Econ Journal Watch, 9*, 100-135.

Boons, F., & Berends, M. (2001). Stretching the boundary: The possibilities of flexibility as an organizational capability in industrial ecology. *Business Strategy and the Environment, 10*, 115-124.

Boons, F., & Howard-Grenville, J. A. (2009). *The social embeddedness of industrial ecology*. Cheltenham, England: Edward Elgar.

Boons, F., & Janssen, M. A. (2004). The myth of Kalundborg: Social dilemmas in stimulating eco-industrial parks. In J. C. J. M. Van den Bergh, & M. A. Janssen (Eds.), *Economics of industrial ecology: Materials, structural change and spatial scales* (pp. 337-355). Cambridge: MIT Press.

Boons, F., Montalvo, C., Quist, J., & Wagner, M. (2013). Sustainable innovation, business models and economic performance: An overview. *Journal of Cleaner Production, 45*, 1-8.

Boons, F., & Spekkink, W. (2012). Levels of institutional capacity and actor expectations about industrial symbiosis. *Journal of Industrial Ecology, 16*, 61-69.

Boons, F., Spekkink, W., & Mouzakitis, Y. (2011). The dynamics of industrial symbiosis: A proposal for a conceptual framework based upon a comprehensive literature review. *Journal of Cleaner Production, 19*, 905-911.

Boons, F. A. A., & Baas, L. W. (1997). Types of industrial ecology: The problem of coordination. *Journal of Cleaner Production, 5*, 79-86.

Bresser, R. K. F. (1988). Matching collective and competitive strategies. *Strategic Management Journal, 9*, 375-385.

Capaldo, A. (2007). Network structure and innovation: The leveraging of a dual network as a distinctive relational capability. *Strategic Management Journal, 28*, 585-606.

Casciaro, T., & Piskorski, M. J. (2005). Power imbalance, mutual dependence, and constraint absorption: A closer look at resource dependence theory. *Administrative Science Quarterly, 50*, 167-199.

Chertow, M., & Ehrenfeld, J. (2012). Organizing self-organizing systems. *Journal of Industrial Ecology, 16*, 13-27.

Chertow, M., & Miyata, Y. (2011). Assessing collective firm behavior: Comparing industrial symbiosis with possible alternatives for individual companies in Oahu, HI. *Business Strategy and the Environment, 20*, 266-280.

Chertow, M. R. (2000). Industrial symbiosis: Literature and taxonomy. *Annual Review of Energy and the Environment, 25*, 313-337.

Chertow, M. R. (2007). "Uncovering" industrial symbiosis. *Journal of Industrial Ecology, 11*, 11-30.

Chertow, M. R., Ashton, W. S., & Espinosa, J. C. (2008). Industrial symbiosis in Puerto Rico: Environmentally related agglomeration economies. *Regional Studies, 42*, 1299-1312.

Chertow, M. R., & Lombardi, D. R. (2005). Quantifying economic and environmental benefits of co-located firms. *Environmental Science & Technology, 39*, 6535-6541.

Chin, M. K., Hambrick, D. C., & Treviño, L. K. (2013). Political Ideologies of CEOs: The influence of executives' values on corporate social responsibility. *Administrative Science Quarterly, 58*, 197-232.

Chopra, S. S., & Khanna, V. (2012, May). *Toward a network perspective for understanding resilience and sustainability in industrial symbiotic networks*. Paper presented at the 2012 IEEE International Symposium on Sustainable Systems and Technology, Boston, MA.

Cordano, M., & Frieze, I. H. (2000). Pollution reduction preferences of U.S. environmental managers: Applying Ajzen's theory of planned behavior. *Academy of Management Journal, 43*, 627-641.

Costa, I., & Ferrão, P. (2010). A case study of industrial symbiosis development using a middle-out approach. *Journal of Cleaner Production, 18*, 984-992.

Cote, R. (1997). Industrial ecosystems. *Journal of Industrial Ecology, 1*, 9-11.

Cote, R., & Hall, J. (1995). Industrial parks as ecosystems. *Journal of Cleaner Production, 3*, 41-46.

de Araujo, J. B., Pintao, R., & Rosa, C. W. (2011). Sustainable value generation through collaborative symbiotic networks planning. In L. M. CamarinhaMatos, A. PereiraKlen, & H. Afsarmanesh (Eds.), *IFIP advances in information and communication technology: Vol. 362. Adaptation and value creating collaborative networks* (pp. 564-571). Berlin, Germany: Springer-Verlag.

Delmas, M., & Toffel, M. (2008). Organizational responses to environmental demands: Opening the black box. *Strategic Management Journal, 29*, 1027-1055.

Desrochers, P. (2001). Cities and industrial symbiosis: Some historical perspectives and policy implications. *Journal of Industrial Ecology, 5*, 29-44.

Desrochers, P., & Leppala, S. (2010). Industrial symbiosis: Old wine in recycled bottles? Some perspective from the history of economic and geographical thought. *International Regional Science Review, 33*, 338-361.

Deutz, P., & Gibbs, D. (2008). Industrial ecology and regional development: Eco-industrial development as cluster policy. *Regional Studies, 42*, 1313-1328.

Doménech, T., & Davies, M. (2009). The social aspects of industrial symbiosis: The application of social network analysis to industrial symbiosis networks. *Progress in Industrial Ecology, 6*, 68-99.

Doménech, T., & Davies, M. (2011). The role of embeddedness in industrial symbiosis networks: Phases in the evolution of industrial symbiosis networks. *Business Strategy and the Environment, 20*, 281-296.

Dong, L., Gu, F., Fujita, T., Hayashi, Y., & Gao, J. (2014). Uncovering opportunity of low-carbon city promotion with industrial system innovation: Case study on industrial symbiosis projects in China. *Energy Policy, 65*, 388-397.

Egri, C. P., & Herman, S. (2000). Leadership in the North American environmental sector: Values, leadership styles, and contexts of environmental leaders and their organizations. *Academy of Management Journal, 43*, 571-604.

Ehrenfeld, J. (2009). A critical view on the social science contribution to industrial ecology. In F. Boons & J. Howard-Grenville (Eds.), *The social embeddedness of industrial ecology* (pp. 257-272). Cheltenham, England: Edward Elgar.

Ehrenfeld, J., & Gertler, N. (1997). Industrial ecology in practice: The evolution of interdependence at Kalundborg. *Journal of Industrial Ecology, 1*, 67-79.

Ehrenfeld, J. R. (2000). Industrial ecology paradigm shift or normal science? *American Behavioral Scientist, 44*, 229-244.

Ehrenfeld, J. R. (2004). Industrial ecology: A new field or only a metaphor. *Journal of Cleaner Production, 12*, 825-831.

Ehrenfeld, J. R., & Chertow, M. R. (2002). Industrial symbiosis: The legacy of Kalundborg. In R. U. Ayres & L. W. Ayres (Eds.), *Handbook of industrial ecology* (pp. 334-348). Cheltenham, England: Edward Elgar.

Etzion, D. (2007). Research on organizations and the natural environment, 1992-present: A review. *Journal of Management, 33*, 637-664.

European Commission. (2011). *A resource-efficient Europe: Flagship initiative of the Europe 2020 strategy*. Brussels, Belgium. Retrieved from http://ec.europa.eu/resource-efficient-europe/

Fichtner, W., Tietze-Stöckinger, I., Frank, M., & Rentz, O. (2005). Barriers of interorganisational environmental management: Two case studies on industrial symbiosis. *Progress in Industrial Ecology, 2*, 73-88.

Frosch, R. A., & Gallopoulos, N. E. (1989). Strategies for manufacturing. *Scientific American, 261*, 144-152.

Geng, Y., & Côté, R. P. (2002). Scavengers and decomposers in an eco-industrial park. *International Journal of Sustainable Development & World Ecology, 9*, 333-340.

Gibbs, D. (2003). Trust and networking in inter-firm relations: The case of eco-industrial development. *Local Economy, 18*, 222-236.

Gibbs, D., & Deutz, P. (2007). Reflections on implementing industrial ecology through eco-industrial park development. *Journal of Cleaner Production, 15*, 1683-1695.

Grant, G. B., Seager, T. P., Massard, G., & Nies, L. (2010). Information and communication technology for industrial symbiosis. *Journal of Industrial Ecology, 14*, 740-753.

Greenwood, R., & Suddaby, R. (2006). Institutional entrepreneurship in mature fields: The big five accounting firms. *Academy of Management Journal, 49*, 27-48.

Gregson, N., Crang, M., Ahamed, F. U., Akter, N., Ferdous, R., Foisal, S., & Hudson, R. (2012). Territorial agglomeration and industrial symbiosis: Sitakunda-Bhatiary, Bangladesh, as a secondary processing complex. *Economic Geography, 88*, 37-58.

Harris, S., & Pritchard, C. (2004). Industrial ecology as a learning process in business strategy. *Progress in Industrial Ecology, 1*, 89-111.

Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of Management Review, 20*, 986-1014.

Hart, S. L., & Sharma, S. (2004). Engaging fringe stakeholders for competitive imagination. *Academy of Management Executive, 18*, 7-18.

Heeres, R. R., Vermeulen, W. J. V., & de Walle, F. B. (2004). Eco-industrial park initiatives in the USA and the Netherlands: First lessons. *Journal of Cleaner Production, 12*, 985-995.

Hemingway, C.A. (2005) Personal values as a catalyst for corporate social entrepreneurship. *Journal of Business Ethics*, 60, 233-249.

Hewes, A. K., & Lyons, D. I. (2008). The humanistic side of eco-industrial parks: Champions and the role of trust. *Regional Studies, 42*, 1329-1342.

Hoffman, A. J. (2003). Linking social systems analysis to the industrial ecology framework. *Organization & Environment, 16*, 66-86.

Hudson, R. (2005). Towards sustainable economic practices, flows and spaces: Or is the necessary impossible and the impossible necessary? *Sustainable Development, 13*, 239-252.

Inkpen, A. C., & Tsang, E. W. K. (2005). Social capital, networks, and knowledge transfer. *Academy of Management Review, 30*, 146-165.

Jacobsen, N. B. (2006). Industrial symbiosis in Kalundborg, Denmark: A quantitative assessment of economic and environmental aspects. *Journal of Industrial Ecology, 10*, 239-255.

Jacobsen, N. B. (2007). Do social factors really matter when companies engage in industrial symbiosis? *Progress in Industrial Ecology, 4*, 440-462.

Jensen, P. D., Basson, L., Hellawell, E. E., Bailey, M. R., & Leach, M. (2011). Quantifying "geographic proximity": Experiences from the United Kingdom's National Industrial Symbiosis Programme. *Resources, Conservation & Recycling, 55*, 703-712.

Jensen, P. D., Basson, L., Hellawell, E. E., & Leach, M. (2012). Habitat' suitability index mapping for industrial symbiosis planning. *Journal of Industrial Ecology, 16*, 38-50.

Jiao, W., & Boons, F. (2014). Toward a research agenda for policy intervention and facilitation to enhance industrial symbiosis based on a comprehensive literature review. *Journal of Cleaner Production, 67*, 14-25.

King, A., Lenox, M., & Terlaak, A. (2005). The strategic use of decentralized institutions: Exploring certification with the ISO 14001 management standard. *Academy of Management Journal, 48*, 1091-1106.

Konar, S., & Cohen, M. A. (1997). Information as regulation: The effect of community right to know laws on toxic emissions. *Journal of Environmental Economics and Management, 32*, 109-124.

Korhonen, J. (2001a). Four ecosystem principles for an industrial ecosystem. *Journal of Cleaner Production, 9*, 253-259.

Korhonen, J. (2001b). Some suggestions for regional industrial ecosystems: Extended industrial ecology. *Eco-Management and Auditing, 8*, 57-69.

Korhonen, J. (2004a). Industrial ecology in the strategic sustainable development model: Strategic applications of industrial ecology. *Journal of Cleaner Production, 12*, 809-823.

Korhonen, J. (2004b). Theory of industrial ecology. *Progress in Industrial Ecology, 1*, 61-88.

Korhonen, J. (2005a). Industrial ecology for sustainable development: Six controversies in theory building. *Environmental Values, 14*, 83-112.

Korhonen, J. (2005b). Theory of industrial ecology: The case of the concept of diversity. *Progress in Industrial Ecology, 2*, 35-72.

Korhonen, J., Huisingh, D., & Chiu, A. S. F. (2004). Applications of industrial ecology: An overview of the special issue. *Journal of Cleaner Production, 12*, 803-807.

Korhonen, J., & Snakin, J. P. (2005). Analysing the evolution of industrial ecosystems: Concepts and application. *Ecological Economics, 52*, 169-186.

Korhonen, J., Von Malmborg, F., Strachan, P. A., & Ehrenfeld, J. R. (2004). Management and policy aspects of industrial ecology: An emerging research agenda. *Business Strategy and the Environment, 13*, 289-305.

Lambert, A. J. D., & Boons, F. A. (2002). Eco-industrial parks: Stimulating sustainable development in mixed industrial parks. *Technovation, 22*, 471-484.

Lavie, D. (2006). The competitive advantage of interconnected firms: An extension of the resource-based view. *Academy of Management Review, 31*, 638-658.

Laybourn, P., & Lombardi, D. R. (2012). Industrial symbiosis in European policy. *Journal of Industrial Ecology, 16*, 11-12.

Lehtoranta, S., Nissinen, A., Mattila, T., & Melanen, M. (2011). Industrial symbiosis and the policy instruments of sustainable consumption and production. *Journal of Cleaner Production, 19*, 1865-1875.

Levanen, J. O., & Hukkinen, J. I. (2013). A methodology for facilitating the feedback between mental models and institutional change in industrial ecosystem governance: A waste management case-study from northern Finland. *Ecological Economics, 87*, 15-23.

Lewis, B. W., Walls, J. L., & Dowell, G. W. S. (2013). Difference in degrees: CEO characteristics and firm environmental disclosure. *Strategic Management Journal, 35*, 712-722.

Lifset, R. (1998a). On becoming an industrial ecologist. *Journal of Industrial Ecology, 2*, 1-3.

Lifset, R. (1998b). Setting the boundaries? *Journal of Industrial Ecology, 2*, 1-2.

Liu, C., Ma, C., & Zhang, K. (2012). Going beyond the sectoral boundary: A key stage in the development of a regional industrial ecosystem. *Journal of Cleaner Production, 22*, 42-49.

Lombardi, D. R., & Laybourn, P. (2012). Redefining industrial symbiosis. *Journal of Industrial Ecology, 16*, 28-37.

Lombardi, D. R., Lyons, D., Shi, H., & Agarwal, A. (2012). Industrial symbiosis. *Journal of Industrial Ecology, 16*, 2-7.

Margolis, J. D., Elfenbein, H. A., & Walsh, J. P. (2009, March). *Does it pay to be good . . . and does it matter? A meta-analysis of the relationship between corporate social and financial performance* (Working paper). Retrieved from http://ssrn.com/abstract=1866371

Martin, M., Svensson, N., & Eklund, M. (2014). Who gets the benefits? An approach for assessing the environmental performance of industrial symbiosis. *Journal of Cleaner Production*. Advance online publication. doi:10.1016/j.jclepro.2013.06.024

Mathews, J. A., & Tan, H. (2011). Progress toward a circular economy in China the drivers (and inhibitors) of eco-industrial initiative. *Journal of Industrial Ecology, 15*, 435-457.

Miller, V. V., & Mukherji, A. (2010). Music: A metaphor for industrial ecology. *Progress in Industrial Ecology, 7*, 239-256.

Mirata, M. (2004). Experiences from early stages of a National Industrial Symbiosis Programme in the UK: Determinants and coordination challenges. *Journal of Cleaner Production, 12*, 967-983.

Mirata, M., & Emtairah, T. (2005). Industrial symbiosis networks and the contribution to environmental innovation: The case of the Landskrona industrial symbiosis programme. *Journal of Cleaner Production, 13*, 993-1002.

Mitchell, R. K., Agle, B. R., & Wood, D. J. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of Management Review, 22*, 853-886.

Oliver, C. (1991). Strategic responses to institutional processes. *Academy of Management Review, 16*, 145-179.

Organisation for Economic Co-operation and Development. (2010). *Eco-innovation in industry: Enabling green growth*. Paris, France: Author.

Orlitzky, M., Schmidt, F. L., & Rynes, S. L. (2003). Corporate social and financial performance: A meta-analysis. *Organization Studies, 24*, 403-441.

Panyathanakun, V., Tantayanon, S., Tingsabhat, C., & Charrnondusit, K. (2013). Development of eco-industrial estates in Thailand: Initiatives in the northern region community-based eco-industrial estate. *Journal of Cleaner Production, 51*, 71-79.

Paquin, R. L., Busch, T., & Tilleman, S. G. (2015). Creating economic and environmental value through industrial symbiosis. *Long Range Planning*. Advance online publication. doi:10.1016/j.lrp.2013.11.002

Paquin, R. L., & Howard-Grenville, J. (2009). Facilitating regional industrial symbiosis: Network growth in the UK's National Industrial Symbiosis Programme. In F. A. Boons, & J. Howard-Grenville (Eds.), *The social embeddedness of industrial ecology* (pp. 103-128). London, England: Edward Elgar.

Paquin, R. L., & Howard-Grenville, J. (2012). The evolution of facilitated industrial symbiosis. *Journal of Industrial Ecology, 16*, 83-93.

Paquin, R. L., & Howard-Grenville, J. (2013). Blind dates and arranged marriages: Longitudinal processes of network orchestration. *Organization Studies, 34*, 1281-1304.

Paquin, R. L., Tilleman, S. G., & Howard-Grenville, J. (2014). Is there cash in that trash? *Journal of Industrial Ecology, 18*, 268-279.

Park, H. S., Rene, E. R., Choi, S. M., & Chiu, A. S. F. (2008). Strategies for sustainable development of industrial park in Ulsan, South Korea: From spontaneous evolution to systematic expansion of industrial symbiosis. *Journal of Environmental Management, 87*, 1-13.

Parmigiani, A., & Howard-Grenville, J. (2011). Routines revisited: Exploring the capabilities and practice perspectives. *Academy of Management Annals, 5*, 413-453.

Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. New York, NY: Harper & Row.

Posch, A., Agarwal, A., & Strachan, P. (2011). Managing industrial symbiosis (IS) networks. *Business Strategy and the Environment, 20*, 421-427.

Romero, E., & Ruiz, M. C. (2013). Framework for applying a complex Adaptive system approach to model the operation of eco-industrial parks. *Journal of Industrial Ecology, 17*, 731-741.

Santos, F. M., & Eisenhardt, K. M. (2005). Organizational boundaries and theories of organization. *Organization Science, 16*, 491-508.

Schiller, F., Penn, A. S., & Basson, L. (2014). Analyzing networks in industrial ecology: A review of social-material network analyses. *Journal of Cleaner Production, 76*, 1-11.

Schiller, F., Penn, A., Druckman, A., Basson, L., & Royston, K. (2014). Exploring space, exploiting opportunities. *Journal of Industrial Ecology, 18*, 792-798.

Sharfman, M. P., Shaft, T. M., & Anex, R. P. (2009). The road to cooperative supply-chain environmental management: Trust and uncertainty among pro-active firms. *Business Strategy and the Environment, 18*, 1-13.

Sharma, S. (2000). Managerial interpretations and organizational context as predictors of corporate choice of environmental strategy. *Academy of Management Journal, 43*, 681-697.

Sharma, S., & Vredenburg, H. (1998). Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategic Management Journal, 19*, 729-753.

Shi, H., Chertow, M., & Song, Y. (2010). Developing country experience with eco-industrial parks: A case study of the Tianjin economic-technological development area in China. *Journal of Cleaner Production, 18*, 191-199.

Shrivastava, P. (1995). Ecocentric management for a risk society. *Academy of Management Review, 20*, 118-137.

Sinding, K. (2000). Environmental management beyond the boundaries of the firm: definitions and constraints. *Business Strategy and the Environment, 9*, 79-91.

Spekkink, W. (2013). Institutional capacity building for industrial symbiosis in the canal zone of Zeeland in the Netherlands: A process analysis. *Journal of Cleaner Production, 52*, 342-355.

Tudor, T., Adam, E., & Bates, M. (2007). Drivers and limitations for the successful development and functioning of EIPs (eco-industrial parks): A literature review. *Ecological Economics, 61*, 199-207.

Van Beers, D., Corder, G., Bossilkov, A., & Van Berkel, R. (2007). Industrial symbiosis in the Australian minerals industry. *Journal of Industrial Ecology, 11*, 55-72.

Vangen, S., & Huxham, C. (2012). The tangled web: Unraveling the principle of common goals in collaborations. *Journal of Public Administration Research and Theory, 22*, 731-760.

Vernay, A. L., Mulder, K. F., Kamp, L. M., & de Bruijn, H. (2013). Exploring the socio-technical dynamics of systems integration: The case of sewage gas for transport in Stockholm, Sweden. *Journal of Cleaner Production, 44*, 190-199.

von Malmborg, F. (2004). Networking for knowledge transfer: Towards an understanding of local authority roles in regional industrial ecosystem management. *Business Strategy and the Environment, 13*, 334.

von Malmborg, F. (2006). Stimulating learning and innovation in networks for regional sustainable development: the role of local authorities. *Journal of Cleaner Production, 15*, 1730-1741.

Waldman, D. A., & Siegel, D. (2008). Defining the socially responsible leader. *Leadership Quarterly, 19*, 117-131.

Walls, J. L., Phan, P. H., & Berrone, P. (2011). Measuring environmental strategy: Construct development, reliability, and validity. *Business & Society, 50*, 71-115.

Wang, C., Zhang, G., & Wang, W. (2009). Research on the industrial symbiosis supporting system of eco-industrial park. *Chinese Journal of Population Resources and Environment, 7*, 61-66.

Wassmer, U., Paquin, R., & Sharma, S. (2014). The engagement of firms in environmental collaborations: Existing contributions and future directions. *Business & Society, 53*, 754-786.

White, R. (1994). Preface. In B. R. Allenby & D. J. Richards (Eds.), *The greening of industrial ecosystems* (pp. 1-19). Washington, DC: National Academy Press.

Williamson, P. J., & Meyer, A. D. (2012). Ecosystem advantage: How to successfully harness the power of partners. *California Management Review, 55*, 24-46.

Wolf, A., Eklund, M., & Söderström, M. (2007). Developing integration in a local industrial ecosystem: An explorative approach. *Business Strategy and the Environment, 16*, 442-455.

Yu, C., Davis, C., & Dijkema, G. P. J. (2014). Understanding the evolution of industrial symbiosis research. *Journal of Industrial Ecology, 18*, 280-293.

Yu, C., de Jong, M., & Dijkema, G. P. J. (2014). Process analysis of eco-industrial park development: The case of Tianjin, China. *Journal of Cleaner Production, 64*, 464-477.

Zhang, B., & Wang, Z. H. (2014). Inter-firm collaborations on carbon emission reduction within industrial chains in China: Practices, drivers and effects on firms' performances. *Energy Economics, 42*, 115-131.

Zhu, J. M., & Ruth, M. (2013). Exploring the resilience of industrial ecosystems. *Journal of Environmental Management, 122*, 65-75.

Zhu, Q., & Cote, R. P. (2004). Integrating green supply chain management into an embryonic eco-industrial development: A case study of the Guitang group. *Journal of Cleaner Production, 12*, 1025-1035.

Zhu, Q., Lowe, E. A., Wei, Y.-A., & Barnes, D. (2007). Industrial symbiosis in China: A case study of the Guitang group. *Journal of Industrial Ecology, 11*, 31-42.

Zukin, S., & Dimaggio, P. (1990). *Structures of capital: The social organization of the economy*. Cambridge, England: Cambridge University Press.

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