

Article

# Blind Dates and Arranged Marriages: Longitudinal Processes of Network Orchestration

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## Abstract

Using longitudinal qualitative and network data capturing five years of evolution of an interorganizational network, this paper explores network orchestration – the process of assembling and developing an interorganizational network. In particular, we analyze shifts in the network orchestrator's actions and the network's structure and composition. We find that an orchestrator builds the capacity to assemble a network over time through the accumulation of resources and specialized expertise. However, as the network develops, an orchestrator faces an evolving set of dilemmas arising from the need to demonstrate value for various members and audiences. To resolve these dilemmas, orchestrators may shift their actions, moving from initially encouraging serendipitous encounters between network members ("blind dates") to increasingly selecting members and more closely influencing their interactions ("arranging marriages"). We discuss implications of our findings for a processual understanding of orchestrated network assembly and growth.

## Keywords

assembly, industrial symbiosis, network management, process, network evolution

“[Working with NISP is] a blind date really, hoping to see that something happens. Sometimes it does and sometimes it doesn't.”

Firm manager commenting on network assembly activities of the National Industrial Symbiosis Programme (NISP)

Interorganizational networks confer multiple benefits to their members, including access to knowledge, technologies, financial resources, and enhanced learning (Ahuja, 2000; Beckman &

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Haunschild, 2002; Powell, Koput, & Smith-Doerr, 1996). While many networks emerge as organizational “actors make choices about who to connect with, [and] what to transact ... without guidance from any central network agent” (Kilduff & Tsai, 2003, p. 90), other networks are intentionally “orchestrated” or “engineered” by an organizational actor who recruits network members and shapes their interactions (Dhanaraj & Parkhe, 2006; Doz, Olk, & Ring, 2000; Human & Provan, 2000; Möller & Svahn, 2009). We have some understanding of how orchestrators build networks, but limited insight into how these activities unfold over time (Capaldo, 2007; Provan, Fish, & Sydow, 2007). Importantly, we lack understanding of how an orchestrator addresses key dilemmas surrounding network assembly and development, perhaps by adjusting its actions.

As the opening quote suggests, the value of ties in a new, orchestrated interorganizational network can be uncertain for potential participants, posing two distinct dilemmas for the orchestrator. First, the orchestrator must establish the legitimacy of the network’s activities with a wide audience, while also attracting potential members who will create ties. Second, the orchestrator must invest time, energy and other resources in encouraging serendipitous interactions that may lead to ties (“blind dates”) while balancing its efforts to selectively enable certain ties to come to fruition (“arranged marriages”). Our research question explores how orchestrators manage these dilemmas, asking: what actions do orchestrators engage in to build a new interorganizational network, and how do these actions shape and respond to the evolving network over time?

We study a case of a novel interorganizational activity, industrial symbiosis, which highlights these dilemmas, enabling us to build theory on how network orchestration actions unfold. Industrial symbiosis (IS) is the “physical exchange of materials, energy, water, and by-products” by geographically proximate facilities (Chertow, 2000, p. 314). The benefits of industrial symbiosis to firms reflect the popular saying “one man’s trash is another man’s treasure” and include lowered “raw” materials costs for the receiving firm and reduced waste disposal costs or increased revenues (from by-product sale) for the providing firm. However, these gains are often difficult to realize in practice (Chertow & Lombardi, 2005), with the result that very few emergent, self-organizing IS networks exist worldwide (Chertow, 2007; Gibbs, Deutz, & Proctor, 2005).

We trace the development of an industrial symbiosis network of UK firms, probing its orchestration by an organization, the National Industrial Symbiosis Programme (NISP), for five years following its inception. We integrate qualitative analysis of interview and observational data with structural analysis of the developing network. This enables us to explore the actions of the network orchestrator, how these actions were adjusted in response to the two dilemmas noted above, and with what consequences for the network’s evolution. Our analysis revealed that, as the orchestrator shifted its actions, taking a more active hand in engaging specific members over time, a third dilemma arose around the degree to which the orchestrator could pursue novel projects versus those that were readily repeatable.

Our findings have several implications for the literature on network assembly and development. First, by paying “concerted attention to process” (Parkhe, Wasserman, & Ralston, 2006, p. 563) we answer a call for an elaborated understanding of what orchestrators actually do, and how their actions evolve as the network grows (Kale & Singh, 2007; Möller & Svahn, 2009). Our findings demonstrate that orchestration, like brokerage (Lingo & O’Mahony, 2010), should be understood as a set of evolving actions, not a static structural position. Shifts in action can be triggered endogenously as an orchestrator works to address emergent dilemmas, rather than be triggered by episodic events (Human & Provan, 2000; Madhavan, Koka, & Prescott, 1998) or evolving resource needs (Hite & Hesterly, 2001). Second, while prior work asserts that network orchestrators learn from experience, this process has not been observed over time (Kale & Singh, 2007; Simonin, 1997). By paying attention to how a new orchestrator builds a new network, we uncover how it builds and leverages accumulated information and expertise. Finally, our findings have

implications for understanding the resilience of closely managed networks, building on work that highlights the need for orchestrators to balance investments in existing partners with those in more diverse ones (Capaldo, 2007). Because the robustness of orchestrated networks rests less on the embeddedness of network actors, and more on the orchestrator's actions and capabilities (Dyer & Nobeoka, 2000; Human & Provan, 2000; Järvensivu & Möller, 2009; Provan & Kenis, 2008), a fine-grained understanding of network orchestration is of scholarly and practical importance.

## Network Orchestration and Network Evolution

Many robust interorganizational networks are formed serendipitously, without the presence of a central network agent (Håkansson & Ford, 2002; Kilduff & Tsai, 2003). These networks emerge because actors anticipate specific benefits including access to new information, opportunities, or partners (Human & Provan, 2000; Mizruchi & Stearns, 2001). Such "emergent" interorganizational networks tend to build upon pre-existing ties and are argued to outperform, and even outlive, those more instrumentally assembled (Gulati & Gargiulo, 1999; Saxenian, 1994; Uzzi, 1996).

Recent attention to supply chain networks (Capaldo, 2007; Dyer & Nobeoka, 2000; Lorenzoni & Lipparini, 1999), research consortia and innovation networks (Dhanaraj & Parkhe, 2006; Doz et al., 2000; Möller & Svahn, 2009), entrepreneurial networks (Hite & Hesterly, 2001), and business support organizations (Human & Provan, 2000) demonstrate that intentionally assembled interorganizational networks are also pervasive and can be robust and long-lived. When network-level, collective gains are sought, organizations seek to assemble or "orchestrate" networks and manage their growth (Agrawal & Cockburn, 2003; Burt, 2000; Dhanaraj & Parkhe, 2006; Doz et al., 2000; Human & Provan, 2000). As Dhanaraj and Parkhe assert, network "orchestration" involves "deliberate, purposeful actions ... to create value ... and extract value ... from the network" (2006, p. 659). Entities involved in such activity have been referred to as network entrepreneurs (Burt, 2000), hub firms (Dhanaraj & Parkhe, 2006), lead organizations (Provan & Kenis, 2008), champions or triggering entities (Doz et al., 2000), network administrative organizations (Human & Provan, 2000), and anchor tenants (Agrawal & Cockburn, 2003; Powell, Packalen, & Whittington, 2012). We adopt the term "orchestrator" because it does not presume a particular form for the assembling entity (e.g., either firm or public organization) and it accommodates a range of network assembly activities. As well, the verb form 'orchestration' directs our attention to the underlying processes (Johnson, Langley, Melin, & Whittington, 2007).

### Network orchestration activities

Network orchestrators have been described as "act[ing] as a broker to plan and coordinate the activities of the network as a whole" (Kilduff & Tsai, 2003, p. 89). In addition to performing structural brokerage roles (Burt, 1992), bringing together previously unconnected actors (Dhanaraj & Parkhe, 2006; Doz et al., 2000; Human & Provan, 2000), network orchestrators can act as relational brokers (Obstfeld, 2005) or gatekeepers (Foster, Borgatti, & Jones, 2011) to unite ideas, resources and people around a collective goal (Capaldo, 2007; Lingo & O'Mahony, 2010).

Orchestrators are not only brokers, however, because they must also attend to creating value for the entire network and its activities (Dyer & Nobeoka, 2000; Provan & Kenis, 2008), not simply for dyads. They can influence the network by developing common goals, spurring actor interest and engagement, and/or defining norms of action (Dietz, Ostrom, & Stern, 2003; Powell, White, Koput, & Owen-Smith, 2005). At times, creating network value can be fraught with uncertainty, as when a network is established for novel activities that themselves offer uncertain value for

prospective members. In such circumstances, orchestrators need to frame the value of the network for diverse audiences, and attract, manage, and learn from network participants as the network grows (Capaldo, 2007; Hite & Hesterly, 2001; Human & Provan, 2000; Möller & Svahn, 2009).

### *Network orchestration dilemmas*

Prior work suggests two specific dilemmas faced by network orchestrators who seek to build a network around a new set of activities. First, the orchestrator must build broad-based interest in and support for the envisioned network's activities. Establishing the legitimacy of a new set of organizational activities, and the surrounding labels and categories, is critical to their viability (Khair & Wadhwani, 2010; Navis & Glynn, 2010; Wry, Lounsbury, & Glynn, 2011). Sometimes labeled "moral legitimacy" (Suchman, 1995), this is established when external audiences affirm that particular actions are "the right things to do", typically because they accord with widely held social values (Hsu & Hannan, 2005; Rao, 1994). When network assembly is desired to foster *novel* organizational activity, network orchestrators must engage in sensemaking for external audiences who have little or no prior understanding of the activity and its "rightness" (Möller & Rajala, 2007). Thus, early in a network's life, an orchestrator is likely to spend considerable time and resources communicating with a large and somewhat diverse audience about the network's activities and their collective promise. Because we cannot presume new activities will initially be regarded as "morally" legitimate, we use the term "broad legitimacy" to refer to what orchestrators initially seek from these larger audiences. Such a focus, however, almost certainly takes time and resources away from getting specific projects started by directly engaging potential network participants. "Pragmatic legitimacy" (Suchman, 1995) derives from the utility of an activity for a particular set of constituents; if a large number of potential participants adopt a new activity, this is a strong signal of its practical value (Kennedy, 2008). A tradeoff therefore exists between efforts to build broad legitimacy among a diverse audience versus generating "proof" of the value of a new activity by demonstrating its application in specific circumstances by specific firms. We term this dilemma *broad versus pragmatic legitimacy*.

A second dilemma may arise somewhat later in a network's development. This emerges as uncertainty around the value of a novel activity is reduced, and organizations begin to seek participation. Potential network members are motivated to participate because they anticipate at least one way of deriving value. At times, value flows from serendipitous opportunities to connect with others, opening firms to new information or possibilities from diverse, heterogeneous ties (Baum, Shipilov, & Rowley, 2003; Capaldo, 2007; Gulati, 1999). At other times, value flows from targeted and directed connections arranged by an orchestrator possessing specific access or information (Capaldo, 2007; Doz et al., 2000; Dyer & Nobeoka, 2000). We can think of the earlier form of value as that associated with a "blind date" and the latter, an "arranged marriage". The orchestrator must balance effort put towards enabling each type of value-creating activity. This is a similar tradeoff to that found in the brokerage literature (Foster et al., 2011; Lingo & O'Mahony, 2010). Brokers sometimes manage these potentially competing activities by shifting their emphasis from one to another over time (Lingo & O'Mahony, 2010). Network assembly research calls for more attention to how orchestrators actually manage these tradeoffs over time (Capaldo, 2007) and with what impact on the value created at the network level and for individual members (Kale & Singh, 2007; Madhavan et al., 1998). We label this second dilemma *enabling serendipity versus directing ties*.

By probing the detailed actions of an orchestrator attempting to build a new network, and the evolving network itself, we can shed light on how orchestrators manage these dilemmas, and the consequences of their actions for the network's growth.

## Research Setting and Methods

We focus on the actions and impacts of the National Industrial Symbiosis Programme (NISP) as it orchestrated the development of regional industrial symbiosis (IS) networks in the UK from 2005 to 2009. Launched in April 2005, NISP is the first national-level IS program in the world. NISP's goal is to "encourage government and industry of the benefit of industrial symbiosis as a key policy tool in helping the UK to achieve a sustainable economy" (NISP, 2006). Most of NISP's funding comes from UK government funds set aside to support organizations – such as NISP – which help firms find ways to remain economically competitive under increasingly stringent UK and EU environmental regulations (DEFRA, 2005/08). NISP's performance metrics are tied not to specific IS projects but rather to its ability to create aggregate environmental and economic benefits (e.g. diverting landfill waste, reducing energy consumption) through IS projects. NISP's services are free to firms and a wide variety of firms participate, ranging from those with a handful of employees specializing in treating a particular type of waste to UK units of multinationals in industries such as automotive, cement, and pharmaceuticals.

Though national in scope, NISP operated as a contingent of 12 semi-autonomous regional offices across the UK. Within each region, NISP staff worked directly with organizations to identify wastes and by-products for potential IS projects. Though regionally-oriented, NISP staff regularly communicated across regions to share experiences and facilitate IS projects that crossed regional boundaries.

This is a good setting to study network orchestration as the mechanisms of network assembly are likely more transparently observable when ties are formed around unfamiliar practices (such as IS) than more traditional practices such as supply chain relationships. However, many of the same considerations underlie the creation of an IS network, namely the draw of new information and new partners coupled with pragmatic challenges of coming together around new opportunities. As well, the tension between NISP's need to meet network-level goals while also addressing individual firms' desire for value creation may make more explicit some of the underlying dilemmas involved in assembling networks (Doz et al., 2000; Human & Provan, 2000).

### *Study approach and data collection*

For this study we take an embedded case design approach (Yin, 2009) to inductively study NISP's actions and impacts as a network orchestrator assembling interorganizational networks, and to analyze the evolution of one of the regional networks NISP assembled. This approach makes sense as it offers rich data to explore the understudied process of network orchestration (Halinen & Törnroos, 2005; Parkhe et al., 2006), adding more generally to process theory building (Langley, 1999). As well, by assembling data from multiple sources and time periods, we have sought to minimize concerns of validity and generalizability often attributed to single case studies (Eisenhardt, 1989; Yin, 2009). See Table 1 for a summary of data collected and its use in our analysis.

Beginning in 2005, we studied how NISP engaged firms to develop IS projects and assemble regional IS networks in four regions where NISP was already established – East Midlands, West Midlands, Northeast, and Northwest.<sup>1</sup> To better understand NISP's impacts, we interviewed a matched theoretical sampling (Patton, 2001) of firms based on industry, firm size, and level of engagement with NISP in the East Midlands (10 firms) and West Midlands (12 firms). We focused on the East and West Midlands as they have similar industry make-up. Finally, to explore the impacts of NISP's actions as a network orchestrator, we analyzed the structural evolution of the West Midlands IS network from 2005 through 2009. We chose the West Midlands region for two

**Table 1.** Collected data and use in analysis.

Data Types (Dates)	Amount & Sources	Use in Analysis
<b><i>NISP Interviews</i></b> (Dec 2005–May 2009) Semi-structured interviews with 20 NISP staff from 4 regions (West Midlands, East Midlands, Northeast, Northwest) & national HQ (Dec 2005–July 2006)  Follow-up interviews with 13 NISP staff in 3 regions (West Midlands, East Midlands, Northeast) & national HQ (Apr–May 2009)	354 pages interview transcripts; 67 pages post interview-related notes and summaries	Explore how NISP generated interest in IS as a novel action, engaged firms to initiate IS projects, and assembled regional IS networks In follow-up interviews, affirm continued use or change of actions and probe changes in context and outcomes
<b><i>Firm Interviews</i></b> (Feb–June 2006) Semi-structured interviews of staff from 12 firms in West Midlands and 10 firms in East Midlands regions; each interview included 1–4 interviewees	568 pages interview transcripts	Gather firms' perspectives of NISP, their own activities, and the opportunity and challenges surrounding IS development
<b><i>NISP Observations</i></b> (Dec 2005–May 2009) Field observations including internal management and strategy meetings; site visits and IS project meetings; NISP sponsored public workshops, conferences, and meetings; and internal staff operations  Informal conversations with 35 additional staff across all regions, totalling over half of NISP's total staff	442 pages observational notes and summaries from 37 days in field	Additional details of how NISP engaged firms to develop new IS projects and how NISP staff strategically understand their actions for supporting IS development
<b><i>Archival IS Project Data</i></b> IS project data on all NISP-involved IS projects from West Midlands from 2005–2009; included project progress over time, resources exchanged, firms involved, and project impacts	Details on 436 IS projects and 333 firms	Structure and evolution of West Midlands IS network; affirm and elaborate on interviewee's statements about NISP's changing actions and network impacts

reasons. First, as NISP was founded and headquartered in the West Midlands, it is the longest running and most mature of NISP's regional efforts. Second, prior work suggests there was little or no prior IS activity in the region (Mirata, 2004), so it is likely that NISP developed the network from scratch.

***NISP interviews.*** From December 2005 to June 2006, we conducted semi-structured interviews with 20 NISP staff across the four NISP regions and with national headquarters staff. We were primarily interested in how NISP engaged firms to develop new IS projects and the impacts of those actions on the development of regional IS networks. We probed interviewees' roles in and perceptions of NISP and explored how they engaged firms and supported IS development within and across regions. These interviews lasted one to two hours and were digitally recorded and transcribed.

From these interviews, the first author developed ongoing relationships through repeated visits into the field and ongoing correspondence with staff. As well, the first author formally re-interviewed staff from three of these regions (East Midlands, West Midlands, and Northeast) and national headquarters in April–May 2009. In these follow-up interviews, we focused on



understanding how NISP perceived their changing actions and impacts on the networks. These interviews also helped affirm and refine our ongoing analysis.

*Firm interviews.* During the summer of 2006, we conducted semi-structured interviews with representatives of 22 firms involved with NISP in two regions. We interviewed between one and four managers in each firm, with interviews lasting between 45 minutes and two hours and often including facility tours. With two exceptions, we digitally recorded and transcribed all interviews. These exceptions – a heavy manufacturer and a tobacco firm – allowed us to take detailed handwritten notes. These interviews provided insight into the firms' interactions and engagement with NISP around IS projects, and included their perspectives of the value of NISP and IS more broadly.

*NISP observations.* From 2005–2009, we spent a total of 37 days observing and shadowing NISP staff. Our goal was to learn first-hand how NISP staff engaged firms in developing IS projects and to what effect. The first author also attended NISP's annual all-staff retreat and training events for three years. We took notes during and after all activities to capture what was done and said, and our impressions of any changes from prior interviews or observations.

*Archival IS project data.* To better understand the impacts of NISP's actions, we analyzed the structural evolution of the NISP-facilitated West Midlands IS network from the beginning of 2005 (when data was first formally collected) to the end of 2009. This network included all IS projects that NISP helped to directly facilitate or otherwise became involved with. We extracted data on these projects from NISP's internal project tracking database. This included data on firms – name, location, industry, size, and prior IS experience; IS projects – the resource exchanged, resource composition (quantity, quality, purity, etc.), firms involved, project development over time; and economic and environmental impacts of each project. Project development was tracked using NISP's internal scale (from 1 to 5) where 1, 2, and 3 represented projects "in-development", meaning firms were negotiating the technical, material, and/or contractual aspects of a project (e.g. material composition & processing, logistics, or economics of the exchange), and 4 and 5 represented "active" projects, where materials were being exchanged between firms. As NISP's data tracking system had been externally audited and verified for its government funders (NISP & Databuild, 2006), we were comfortable using their data and measures of IS project status and impact.

### *Qualitative analysis*

We focused on elucidating how NISP engaged firms and the impacts of its actions on developing new IS projects and supporting the resulting network. We uploaded all our qualitative data to ATLAS.ti (a computer assisted qualitative data analysis software, Muhr, 2004) to support our analysis efforts. We began by emergently coding these data, attending to what NISP did – coded as "actions" – and with what effects – coded as "perceptions" – according to both NISP staff and firms. We began to see a number of themes emerge that were similar to actions identified in the literature on network orchestration (e.g. recruitment) yet also which differed (e.g. recruiting was not pursued primarily through one approach – selective or open – but through both). We elaborated and refined these themes to capture specific actions, eventually grouping these into the main categories of action (*engagement*, *connection*, and *co-development*) as we began to see patterns. For example, a NISP staff member's statement that "it has been most successful going through the chamber of commerce and linking into the CBI (a business support group) ... [to access]

production managers” was coded with the theme *using existing contacts to make new ones* and eventually grouped with other themes within the category of action labeled *engagement*.

We worked back and forth between these coded actions and the network analysis as we sought to understand how these actions triggered and were shaped by changes in the network’s structure. We coded for challenges or difficulties interviewees raised when they spoke of developing IS projects, as well as their perceptions of how actions overcame or addressed these. Through this process, we developed an understanding of the dilemmas NISP faced, the actions taken to address these dilemmas, and their consequences. By considering shifts in the network structure, in conjunction with interviewee accounts over time, we found that the network evolved through three conceptually distinct phases, described below. We next coded NISP staff interviews conducted in 2009, looking for evidence of the original actions as well as any shifts in them. These analyses triggered further queries of the network data. For example, when NISP staff mentioned in 2009 that they used certain firms for “repeat business” to source construction-related waste (a significant contributor to landfill diversion goals because of its weight), we explored trends in construction projects and tonnage over time.

### Network analysis

Drawing on archival project data, we mapped the evolving West Midlands IS network, with firms as nodes and IS projects as ties connecting firms together. As IS involves two or more firms collaborating to exchange specific by-products, it lends itself to network analysis (Ashton, 2008). Our data captured the initiation and development of each NISP-involved IS project quarterly from 2005 through 2009. Using these data, we created a series of network “snapshots” for analysis in UCINET (Borgatti, Everett, & Freeman, 2002). Each tie is valued (using NISP’s internal tracking scale described above) and each period is a cumulative snapshot of all IS projects in the network at that time. We used these data to track both the changing structure of the network and the changing project progress (measured by tie value) over time. Because existing network-level change models assume a fixed rather than dynamic number of actors in the network (such as a classroom of students or industry of firms; Snijders, 2004), they are ill-suited for studying a growing network (Provan et al., 2007; Wasserman & Faust, 1994). Following others (Madhavan et al., 1998), we therefore calculated a number of descriptive network and actor-level measures and traced their changes over time. An important point to note, which we address in our findings, is that over time NISP itself became an active exchange partner in the network.

**Network-level measures.** We tracked the evolving network by size (number of firms and IS projects), firm engagement, structural change, and changing resource composition from 2005 to 2009. We measured *network growth* as the number of firms and projects in the whole network and core component of the network. The core component is defined as the largest subset of interconnected nodes within a network (Scott, 2000). In our case, the whole network encompasses all NISP-involved IS projects and firms in the region, while the core is comprised of all interconnected firms and projects. We focused our analysis primarily on the core component because the large majority of activity in this network occurred in the core (83–92% of IS projects and 69–79% of firms during the study period) and unconnected dyads tended to become connected to the core over time.

We measured *network structure* as the network centralization index derived from firms’ individual eigenvector centralities. Network centralization index measures the “the tendency of a single point [firm] to be more central than all other points [firms] in the network” (Freeman, 1978, p. 227). High values suggest a few actors are highly central with the rest much less so, while low values suggest actors are more equally involved in the network. While network centralization



index was developed to compare the structure of binary, not valued, networks (Borgatti et al., 2002; Kang, 2007), tracking the changing network centralization over time provides insight into a network's evolving structure (Madhavan et al., 1998).

While there are several measures of centrality to choose from, we chose eigenvector centrality (Bonacich, 1972) because it measures connectedness to, and therefore accounts for influence and information flows from, both direct and indirect connections between firms (Borgatti, 2005). This is relevant to understanding IS development, because, typical of many innovation processes (Carlile, 2004; Hargadon & Sutton, 1997), there are high information and novelty barriers to overcome and firms might be influenced by those to whom they are only distantly connected (Chertow, 2000; Paquin & Howard-Grenville, 2009). And, while eigenvector centrality calculates centrality only for firms in the core component of a network, this is suitable for our analysis because the large majority of activity occurred in the core component.

We measured *network composition* – project and firm characteristics within the network – in multiple ways. First, we captured changing mean project status (tie value) through ratios of “in development” (tie value 1 to 3) and “active” (tie value 4 and 5) projects. Second, we captured changing firm engagement through ratios of “active” projects per firm and total projects per firm. Last, we captured changing project composition (i.e. the types of projects undertaken in the network) by tracking two key types of projects, *expertise* and *construction*. For construction projects, we also tracked the impact of these projects in terms of landfill diverted from construction compared to all projects.

**Actor-level measures.** To capture changing firm-level engagement within the network, we calculated eigenvector centrality for each firm in the core component. We qualitatively compared changes in individual firm's positions within the core component (based on their eigenvector centrality measures) over time to assess movement among the most central firms. We also quantitatively compared these changes using Mann-Whitney and Kruskal-Wallis tests (as non-parametric versions of t-tests and ANOVAs respectively; Kinnear & Gray, 2010; Woodbury, 2002). Given that centrality measures a firm's engagement and position in the network, we view “changes in the relative centrality of firms [as] important indicators of structural change” (Madhavan et al., 1998, p. 442).

## Findings: Network Orchestration Actions, Outcomes, and Evolution

The developing IS network moved through three phases – 1) early assembly, 2) capturing value, and 3) strategic growth – each characterized by distinct orchestration dilemmas, approaches, and outcomes. As the network developed, NISP had to first manage the dilemma of establishing broad versus pragmatic legitimacy, and then increasingly manage the second dilemma of enabling serendipity versus directing ties. A third dilemma emerged from our analysis, and arose later in the network's development. We termed this the *replication versus reinvigoration* dilemma. It arose after the orchestrator had amassed considerable expertise that it could leverage to identify and quickly execute repeatable IS projects, but had to balance this activity against seeking more novel projects with novel partners. An outgrowth of the second dilemma, this third one also raised the question of how open or closed a network should be to new members as it grows and develops. We found that NISP engaged in three main categories of action, *engagement*, *connection*, and *co-development*, to orchestrate the network. Table 2 shows the relative emphasis on each set of actions that changed over time, both shaping and responding to the emerging dilemmas. It also summarizes the orchestrator's key dilemmas in each phase, their available resources, participants' perceptions of the value of network participation, and outcomes in terms of network structure and qualitative experiences that triggered shifts to the next phase.

**Table 2.** Orchestrator's actions and network outcomes by developmental network phase\*.

	Phase 1: Early Assembly	Phase 2: Capturing Value	Phase 3: Strategic Growth
Orchestrator's key dilemmas by phase	Establishing broad legitimacy (of the idea of IS, with external audiences) versus pragmatic legitimacy (by engaging potential members around particular IS projects)	Enabling serendipity (between potential members) versus directing ties (around specific resource exchanges with targeted members)	Replication (of high value IS projects) versus reinvigoration (of network via bringing in new members)
<b>Orchestrator's Approach and Resources</b>			
Main actions	<b>Engagement</b> <ul style="list-style-type: none"> <li>- <b>developing strategic view of the region</b></li> <li>- <b>using existing contacts to make new ones</b></li> <li>- <b>facilitating interaction spaces</b></li> </ul>	<b>Connection</b> <ul style="list-style-type: none"> <li>- <b>strategically introducing relevant firms</b></li> <li>- <b>deepening involvement with firms/projects</b></li> </ul> <b>Engagement</b> <ul style="list-style-type: none"> <li>- specific actions shown left largely continue; <i>reduced frequency of interaction spaces</i></li> </ul>	<b>Co-Development</b> <ul style="list-style-type: none"> <li>- <b>increasing regional capacity for IS; novel projects</b></li> </ul> <b>Connection</b> <ul style="list-style-type: none"> <li>- <b>replicate high value IS projects</b></li> <li>- strategically introducing relevant firms</li> <li>- deepening involvement with firms/projects</li> </ul> <b>Engagement</b> <ul style="list-style-type: none"> <li>- <i>specific actions evolve: less frequent use of facilitating interaction spaces; shift in nature of taking strategic view of needs of region</i></li> </ul>
Resources available to leverage for network assembly	Broad base of potential partners	<b>Unique information</b> (resource database) <b>Reputation for successful brokerage</b> Broad base of potential partners	<b>Expertise in brokering IS projects and ability to redeploy this efficiently</b> Unique information (resource database) Reputation for successful brokerage Broad base of potential partners
<b>Network Value</b>			
Perception of network value by participants	Gain novel ideas for by-product re-use Find potential partners for exchanges Gain new information from distant others	<b>Credibility of collective/orchestrator</b> Gain novel ideas for by-product re-use Find potential partners for exchanges Gain new information from distant others	<b>Repeat business/business development</b> Credibility of collective/orchestrator Gain novel ideas for by-product re-use Find potential partners for exchanges <del>Gain new information from distant others</del>
<b>Outcomes</b>			
Changes in network structure	Network rapidly forms Relatively high proportion of ties 'in- development'	Firms re-engage (project/firm increases) Increase in proportion of 'active' ties Decreasing network centralization	Increasingly selective re-engagement in projects Firms re-engage (projects/firm increases) Plateauing proportion of "active" ties Decreasing network centralization
Results that trigger shift to next phase	Interest from potential participants outstrips orchestrator's resources Projects require greater than anticipated orchestrator resources & time	Accumulation of orchestrator's resources and expertise Mutual selection (by participants and orchestrator) to network	?? Stagnation/lack of renewal in network ties ("pipeline" of new firms/projects drying up)

\***Bold** entries indicate new actions during phase; *Italics* indicate alterations of previous actions;

~~Strikethrough~~ indicates actions that were stopped or significantly curtailed; ?? indicates speculation about future changes.

### *Phase 1: Early assembly*

In the earliest phase of network assembly NISP sought to build something from essentially nothing. Not only were there no IS ties between potential network participants, but IS was a new and unfamiliar activity. Industrial symbiosis therefore needed to be established as practical and valuable to firm participants and of interest to audiences more broadly committed to the collective goal of creating economic value by reducing waste to landfill. As noted, this posed the dilemma of establishing both broad and pragmatic legitimacy.

*Engagement actions.* In this phase, NISP primarily undertook actions we labeled engagement because NISP staff sought to involve various audiences, introducing them to the concept of IS and its potential, and conveying its value. Specifically, we define engagement as those actions that deliberately expose potential participants and other relevant audiences to the nascent network and its potential value, and that position the orchestrator as an authority on the exchanges or ties (in this case, IS exchanges) central to the network. We found three specific types of engagement activities in this phase of early network development: i) developing a strategic view of the region, ii) using pre-existing individual and organizational contacts to attract potential participants, and iii) facilitating “interaction spaces” where potential participants could meet and share information. As shown in Table 2, engagement actions occurred in all phases, but were enacted in slightly altered forms as the network developed.

*Developing a strategic view of the region.* In order to gain pragmatic legitimacy, NISP needed to identify and attract firms who could benefit from and demonstrate the practical value of IS exchanges. To do this, NISP staff sought to assemble specific information on a region’s industrial make-up, waste flows, impending regulation, and other knowledge that could help them identify potential participants. One regional coordinator spoke of developing a regional “profile” identifying “industries, so we have ‘X’ number of construction companies and [know] who they are”. This included accessing government records of waste types and flows, which, the interviewee noted, “showed [which companies] we wanted to get on board very quickly”. Another coordinator noted her “strategy is to basically build the membership around certain industry sectors and geographically”, adding that she worked to identify companies and sectors with large volumes of waste because NISP’s performance was measured partly in tonnage of waste diverted from landfill. She observed, “you can do a lot of very interesting work, but if it’s 23 tonnes, it’s not going to do a lot to add up to your 100,000 tonnes [target]”. NISP staff also noted which companies would be impacted by impending regulatory changes, such as new restrictions on the land filling of certain waste types. One explained:

There have been a number of changes with the environmental legislation over the last six to nine months, with everything from farm waste to electronics. So ... you start looking at those legislative drivers and see who is going to be affected.

Finally, NISP sought to recruit large firms well respected for their environmental practices, and involve them in regional Program Advisory Groups (PAGs). Building this broader legitimacy was important even if these firms did not themselves engage in IS (they often did not). One regional coordinator spoke of having “target companies” noting:

For instance, it was very important at first that we get [Auto Co.] on board because they are a very big employer in the area. We went out and ... sought out the correct person in their organization to come and join NISP.

*Using existing contacts to make new ones.* NISP also worked through other organizations to build awareness of IS as an activity that might support their aims, thereby establishing its broader legitimacy, and to reach firms who might directly engage in IS. NISP staff worked with respected organizations (e.g. trade associations, PAG members) to identify and contact potential firms. As one staff member stated, we “wanted to get to know the trade associations [and] then use [them] and their networks to basically send out our message”. This approach cast a relatively wide net to attract potential members and also took account of where NISP might find firms already receptive to the idea of industrial symbiosis. For example, one interviewee reported learning of NISP through participation in a waste-related government-university partnership, recalling “we were involved before NISP with the [partnership] ... we were looking to see if others could offer us silver-bearing materials, or ... could offer us other opportunities”. Another interviewee had been contacted by NISP because of his involvement with the ceramic industry’s waste exchange program. NISP appealed to him as “a new exchange resource, backed by funding and [because] they do training sessions”, so he concluded “we need to be part of this”.

NISP staff also worked closely with UK Environment Agency staff to build awareness of IS. Again, this legitimating channel was tapped to help recruit potential firms. For example, one NISP manager said, “when [regulators] go into the industries they say ‘I think that this [IS] could work for your company, here is the guy you can talk to’”.

This activity illustrates that building broad legitimacy was not always at odds with building pragmatic legitimacy with potential members. In fact, the use of respected organizations as channels for engagement could drive broad legitimacy and facilitate pragmatic legitimacy. However, engaging various audiences did produce tradeoffs in how resources were allocated, and the dilemma became more pronounced later in the network’s development, as discussed below, because awareness drove greater demand from potential participants than NISP could pragmatically meet.

*Facilitating interaction spaces.* Finally, a primary activity NISP undertook during this phase was to host Quick Wins workshops. These provided physical spaces for direct interaction, an important element in building relational ties between network members (Dyer & Nobeoka, 2000; Human & Provan, 2000). We label these more generally as *interaction spaces*, noting later their additional importance in enabling an orchestrator to gather information that it could subsequently leverage. Quick Wins workshops were designed to educate potential firm participants about IS and enable them to interact with each other and NISP staff members. A fast-paced, energetic, and short introduction opened each workshop, giving an overview of NISP and IS, with successful projects highlighted for their economic and environmental benefits. Often a member of a PAG company or Environment Agency representatives were on hand to testify to the benefits of IS for achieving broader environmental goals. The remainder of the workshop centered on small group facilitated information exchanges which detailed individual firms’ wastes. As one firm participant described:

Essentially ... you sit at a table with a document and go through with everyone, saying “this is what I’ve got and this is what I want”. Say for example me, I say I’ve got transport. We move something from the North to the South Midlands and [the trucks are] full one way and empty the next way. So we need to utilize this empty space, and we say “does anyone else [want] transport?”

This example also illustrates the wide range of assets NISP considered as resources, beyond manufacturing waste or by-product. Described to us colloquially as “industry speed dating”, these interactions often generated a large number of potential IS projects. One firm interviewee stated, “we were all thinking we will never get anything out of this, but then 132 [potential

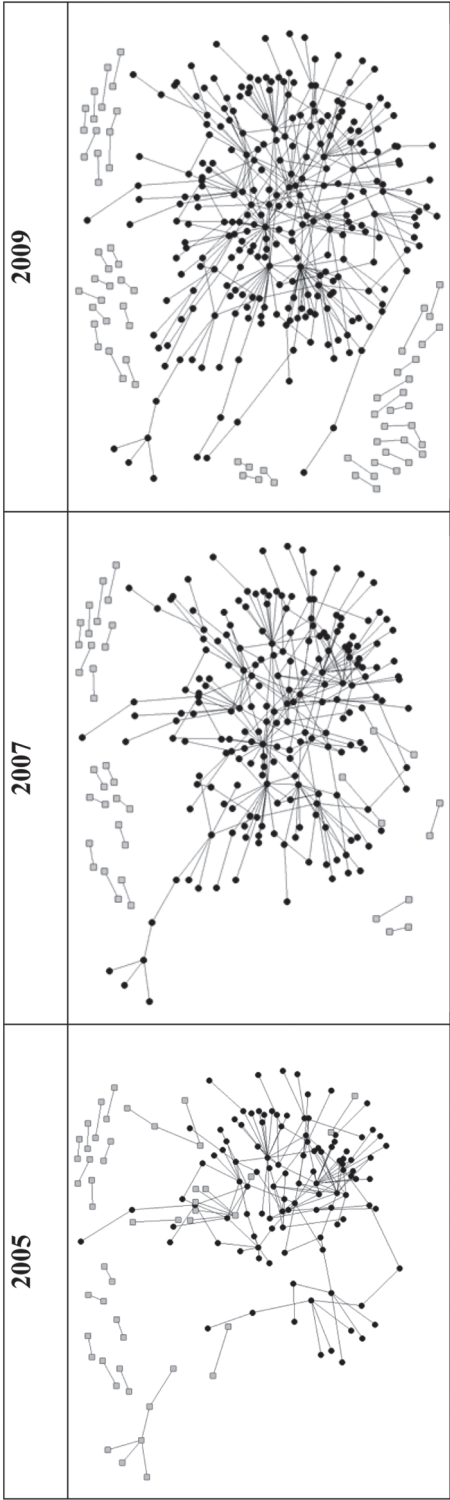
projects] came out of the workshop ... when we didn't think there would be any". Many others expressed similar views, suggesting that such events were effective in capturing participants' interest in the network's potential.

**Outcomes of engagement actions.** Together, these actions resulted in a quickly emerging and rapidly growing network. Table 3 summarizes the network's growth from 2005 to 2009, including descriptive measures for the whole network and the core component and a breakdown of "in-development" and "active" projects in the core component. Recall that in-development projects are those where firms are still negotiating various aspects of a project, while active projects are those where firms are exchanging resources. Figure 1 provides visual snapshots of the network in 2005, 2007, and 2009.

NISP's engagement actions contributed to rapid growth in membership that culminated in a sizeable network in place by 2005. In three years<sup>2</sup> the network had grown from essentially no members and activity to 162 member firms participating in 174 IS projects. Further, 2005 shows both a relatively larger proportion of in-development projects and a higher percentage of activity outside the core component of the network, as compared to later years. These trends support our qualitative observations that the orchestrator's early focus on engagement served to attract firms interested in exploring the potential of IS, and that a large number of potential projects had been identified between such firms. However, many of these potential projects, about two-thirds, had not yet developed into active IS projects.

**Table 3.** West Midlands industrial symbiosis network over time.

	2005	2006	2007	2008	2009
<b>Network Growth</b>					
<b>Whole Network</b>					
Number of Firms	162	180	243	309	333
Number of IS Projects	174	207	308	401	436
<b>Core Component or 'Core'</b>					
Number of Firms ( <i>1-yr change</i> )	111	136 (22%)	203 (50%)	239 (18%)	264 (10%)
Number of IS Projects					
Total ( <i>1-yr-change</i> )	144	181 (26%)	280 (55%)	364 (30%)	399 (10%)
In-development ( <i>1-yr-change</i> )	96	105 (9%)	174 (66%)	198 (14%)	220 (11%)
Active ( <i>1-yr-change</i> )	48	76 (58%)	106 (39%)	166 (57%)	179 (8%)
<b>Network Composition</b>					
<b>Proportion of core to whole network</b>					
Firms	0.69	0.75	0.83	0.77	0.79
IS Projects (all)	0.83	0.87	0.91	0.91	0.92
<b>Proportion of active IS projects to (core only)</b>					
In-development IS projects	0.50	0.72	0.61	0.84	0.81
All IS projects	0.33	0.42	0.38	0.46	0.45
<b>Mean IS projects per firm (core only)</b>					
Active projects	0.86	1.12	1.04	1.40	1.36
All projects	2.59	2.66	2.76	3.04	3.02
<b>Network Structure</b>					
<b>Centralization Index (core only)</b>	1.03	0.95	0.95	0.88	0.92



**Figure 1.** West Midlands industrial symbiosis network in 2005, 2007 and 2009.

Notes:

1) Nodes: *Black Circles*: firms in the core component of the network; *Grey Squares*: firms not connected to the core component.

2) These snapshots show:

- (a) A large and increasing amount of activity occurring in the core component of the network over time.
- (b) The core component expanding mostly through new firms joining the network, but to some extent also by connecting previously unconnected components through new projects.



*Perception of network value by participants.* Firm interviewees reported a number of reasons for participating in the network. As shown in Table 2, they valued gaining novel ideas for by-product re-use, finding potential partners for exchanges, and gaining new information from distant others. In the first case, firms might discover a new use for a by-product or waste, but not yet identify a potential partner for it. Many interviewees mentioned learning of surprising re-uses for material through NISP. One manager learned “that road sweepings [grit collected from street sweeping] could be used as a partial raw material”, adding that “it sounds silly but it was actually fact. There was silica in the road sweep that we could use ... that is the kind of thing we need to look into”.

Finding potential IS partners added value in a different way, for a firm might have already known of a potential re-use opportunity yet lack the connections to make it viable. One interviewee recalled NISP “helped me with contacts with the reprocessing of car batteries, and they have also helped me locate reprocessors of catalytic converters”. In many cases, such as this one described by a food producer, a new idea and new partner came together:

One of the products we have is yogurt washings and one of the companies wanted something like that to cool the drill head from drilling [for oil production] ... they needed something liquid to pour over the drill head to keep it cool and the yogurt washings we have is basically what they needed.

Firms’ recognition of NISP’s value in identifying partners and projects suggests the orchestrator was fulfilling a structural brokerage role, acting as a “conduit for access to information” (Lingo & O’Mahony, 2010, p. 49). As one firm interviewee noted:

They [NISP] have the time and energy to get around and talk to a huge cross section of companies ... It’s quite easy for them, from the outside looking in ... They are able to come up with ideas that we wouldn’t have thought of, and then they introduce us to other companies that we might never have crossed swords with.

For many, the nascent network, and especially the interaction spaces, offered a third source of value, the potential to gain information from those not in a firm’s typical network. One interviewee said “the biggest benefit, possibly immeasurable ... is the conversations you have with people that you wouldn’t normally be caught with”. Another noted:

You go along to these events and meet up either with someone in your own industry, [or] more importantly, you meet people on the cutting edge of technology – new systems, new methods ... You say, “Let’s see what you’ve got. Let’s see if it’s applicable to our industry.”

Many firms expressed openness to engaging with the network, even if they did not see immediate exchange opportunities, precisely because it might reveal such serendipitous ideas.

These responses from firms, and the engagement of a range of other champions (Environment Agency staff, PAG members), suggest that by the end of this phase NISP’s orchestration activities had considerably reduced uncertainty around the potential value of IS as an activity. This helped legitimate IS as a viable new solution to waste management and associated environmental challenges. However, this broad based legitimacy and the excitement it generated among firms soon began to hamper NISP’s ability to deliver on facilitating specific projects, potentially damaging the pragmatic legitimacy of IS because of difficulties or delays in “showing how it worked”. Others have documented the challenges facing orchestrators who, in demonstrating external legitimacy, can fall short in helping their members capture value from network participation (Human

& Provan, 2000). In our case, NISP became aware of this challenge and adjusted its actions to address it.

### Phase 2: Capturing value

Two shifts in activity marked the network's transition from early assembly to a second phase we label "capturing value". First, interest from potential participants had outstripped NISP's resources. One NISP regional coordinator noted that his staff was "having a hard time handling all of the phone calls"; and a staff member recalled, "we stopped doing so much publicity". Offering the example of a Quick Wins workshop where 104 potential IS projects were identified, another explained:

We have to go through the process of quantifying the relative importance of those 104 ... Even if we get down to 10 [potential projects], the investment that it will take for the regional team ... will be great.

Recognizing the potential damage this unmet interest could have to NISP's pragmatic legitimacy with firms, he added, "the danger I see for NISP... is promises".

Second, as NISP staff worked with firms on IS projects they discovered that many required greater time and effort than anticipated. Quick Wins workshops, while generative of many opportunities, often left both NISP and firm participants feeling more needed to be done to develop successful IS projects. One regional coordinator explained, "The workshop is quite a cold activity if you don't have time to engage and understand someone's business". Thus, NISP began to move from casting a wide net to deepening its relationships with and support of particular firms and projects. This revealed a second dilemma, enabling serendipitous encounters (that lead to the excitement and multiple projects identified by members, as noted above) versus directing the formation of specific ties. The latter was needed to demonstrate pragmatic legitimacy, but the former was potentially a necessary precursor. In this phase, NISP did not abandon its original engagement actions; rather it shifted emphasis to new actions focused on creating *connections*.

*Connection actions.* We define *connection* actions as those that bring together relevant organizations to develop specific network ties. Our analysis revealed two main *connection* actions: i) strategically introducing relevant firms and ii) deepening involvement with firms and/or projects.

*Strategically introducing relevant firms.* NISP's workshops and other engagement actions had provided it with valuable information and contacts, which it began to use to strategically develop potential IS exchanges. Information, including firm details and resource needs, was captured in NISP's project management database. Equally important, however, was staff members' developing specialized knowledge gained from earlier workshop engagements. NISP staff used this knowledge and growing contact list to make strategic introductions, especially for projects considered "low hanging fruit". Such projects were fairly straightforward, requiring little additional material reprocessing or technical knowledge that could otherwise complicate firms' ability to work together. One NISP regional coordinator related how his staff used Quick Wins workshops to identify partners for one such project:

For instance there is a waste company not too far away ... They have a biogas program, and they are trying to source all kinds of organic materials ... So we take that to the workshop and we find more organic materials for them ... [We found one company with] 20,000 tonnes of food pulps that are currently going to landfill and it was [easy] to get them together.

Some firms were particularly interested in such opportunities and looked to NISP for partners. One firm interviewee suggested the importance of NISP's strategic perspective when he observed that "I have a great interest in getting rid of something, so I go to NISP". Another, a brick maker, explained how NISP helped find waste clay for use in his process when it alerted him to a site that would be extracting 160 thousand tonnes of clay to build a cod fishery. He reflected, "I see [NISP] as being a sort of dating agency to some extent", able to make quick and straightforward connections.

*Deepening involvement with firms and projects.* Beyond making quick yet strategic introductions between potential IS partners, NISP worked in this phase to more directly support the development of particular ties. Despite their appeal, many low hanging fruit projects fell through because complications arose as firms attempted to work out project details. One NISP staff member discussed a failed project that involved reusing de-ionized water produced by one firm for another firm in the same industrial park. He noted:

[The project] appeared at the outset to be very simple ... but the technicalities of it and the commercial issues did not go well. [The receiving firm] start[ed] getting into issues of continuity of supply, [they] did not want to commit to taking the water completely from [the other firm] ... [The firms] actually made ... a simple opportunity much more problematic.

NISP staff sought to mitigate such challenges by deepening their relationships with firms that held promise for significant or repeat IS projects. They did this through site visits and one-on-one meetings with firm staff. Site visits gave NISP staff members a more nuanced understanding of the business and improved their confidence in the firm as an IS partner. As one regional coordinator noted:

Often what they are giving you on paper [waste data] may not match what is really going on. So [you need] to gain confidence of the people you are talking to for them to give you an accurate description rather than the "corporate" view.

Such interactions helped build trust between NISP staff and firm participants, enabling staff to better direct the exchange's development. One regional coordinator spoke of needing trust "so you can sit behind a company and act as a sounding board for them". NISP staff felt that demonstrating an understanding of the business and bringing forth their holistic expertise around IS was more important to building trust than an in-depth knowledge of a firm's technical area. One staff member observed:

I haven't actually encountered any occasion where it was vital where I had a full [technical] understanding of say ... plastics manufacturing ... It's really forming those relationships that last and having the ability to capture someone's enthusiasm.

A NISP executive observed that "as trust develops ... more and more potential resources will come up", adding, "projects that start up one way often end up being quite different". The value of these deeper and longer-term relationships was only realized through effort. As a NISP staffer explained, "larger synergies don't tend to drop out by one visit, you need to put in a lot of time and effort, follow up meetings and bringing in other members, so it takes longer to nurture". Effort spent here, however, necessarily competed with effort required to run Quick Wins workshops and otherwise enable serendipitous encounters between firms.

*Outcomes of connection actions.* Evidence of NISP's emphasis on connection showed up in the evolving network structure in a number of ways. As shown in Table 3, the proportion of "active" projects to all projects steadily increased (33% in 2005 to 38% in 2007), showing that potential projects were increasingly moving to completion. This occurred on top of a large increase in the total number of projects during this time (174 projects in 2005 to 308 in 2007). This increasing proportion of active projects might reflect the fact that fully developing an IS project takes time, with many "in-development" projects in 2005 reaching fruition by 2007. However, the increase in average projects per firm over the same time period supports our observations that NISP was deepening its relationships with certain firms through additional projects.

The downward trend of the network centralization index (Table 3) suggests that firms in the network tended to develop new ties with dissimilar others (in this case, those with differing amounts of IS experience). This trend is *opposite* to that seen in emergent networks where network centralization tends to increase over time as the same few actors receive a disproportionate share of network involvement and value (e.g. "rich get richer" or "the Matthew effect", Merton, 1968; Provan et al., 2007). In addition, the percentage of firms in the core component grew. Together these trends suggest that NISP is strategically introducing firms to each other based on match potential (not necessarily position in the network), and also connecting some of the network's outlying small clusters (see Figure 1) to the network's core. The most dramatic evidence of NISP's increasingly directed orchestration actions comes from observing the large amount of "churn", or turnover, of the network's most central members.

Table 4 shows this churn by illustrating that *none* of the 20 most active firms in 2005 remained so as the network grew. Put differently, none of the most central firms in 2006 were so in 2005. Ten of the 20 most central firms were brand new to the network in 2006. By 2007, 10 of the 20 most central firms were among the top 20 in 2006, and five others were new to the network. This significant turnover supports our observation that the increasing proportion of active ties over this period was at least partly a result of NISP selectively connecting new firms, and not simply the natural maturation of projects already in-development.

*Perception of network value by participants.* Firms saw many of the same benefits to network participation as they saw in the first phase, and NISP's more hands-on approach was recognized by some as a way to realize these benefits. One firm interviewee noted that NISP had to "break down the barriers of 'Hi, I'm [Dave], what can I do for you?'" and learn "what business these people are in". Another observed that NISP had to "evolve" in order to help firms bring projects to fruition, noting:

[NISP] has to keep things going. There's been too much of "I'll introduce you" then you have to see what goes on. There's very little chasing that goes on.

Of course, with such interest generated in the earlier phase, NISP could not deepen its relationships with all firms. Some who did not directly or quickly benefit from NISP's connection actions were frustrated. One firm member spoke of giving all their resource data to NISP and then wondering what had become of it. He observed in 2006 that "I haven't had email or a phone call ... there was a black hole or something".

Despite these critiques, NISP was very successful at meeting its aggregate environmental goals (NISP & Databuild, 2006) and garnering public recognition (House of Commons, 2010). In turn, this broad legitimacy increased the pragmatic value of network participation for firms and firms noted the reputational benefits of working with NISP. Somewhat ironically, NISP's actions to

**Table 4.** Top 20 most active firms in West Midlands IS network and prior year rankings.

Rank	2005	2006 (2005 Rank)	2007 (2005, 2006 Rank)	2008 (2005, 2006, 2007 Rank)	2009 (2005, 2006, 2007, 2008 Rank)
1	A	NISP (76)	NISP (76,1)	NISP (76,1,1)	NISP (76,1,1,1)
2	B	HG (na)	DH (na,3)	AJ (36,75,5)	AJ (36,75,5,2)
3	C	DH (na)	HG (na,2)	CD (82,4,4)	CD (82,4,4,3)
4	D	CD (82)	CD (82,4)	DH (na,3,2)	DH (na,3,2,4)
5	E	DP (na)	AJ (36,75)	AT (46,74,6)	AR (44,56,19,10)
6	F	CA (79)	AT (46,74)	EE (na,na,40)	HG (na,2,3,7)
7	G	CG (85)	DJ (na,29)	HG (na,2,3)	AT (46,74,6,5)
8	H	CH (86)	CA (79,6)	DZ (na,95,29)	EE (na,na,40,6)
9	I	CE (83)	GY (na,130)	DJ (na,29,7)	GU (na,na,na,26)
10	J	CU (99)	CG (85,7)	AR (44,56,19)	DZ (na,95,29,8)
11	K	DV (na)	CH (86,8)	DI (na,121,31)	GV (na,na,na,61)
12	L	DU (na)	DL (na,na)	EL (na,na,56)	DJ (na,29,7,9)
13	M	DW (na)	DM (na,na)	IL (na,na,na)	EL (na,na,56,12)
14	N	DX (na)	DN (na,na)	CA (79,6,8)	DI (na,121,31,11)
15	O	DY (na)	DO (na,na)	GO (na,na,195)	CB (80,19,43,29)
16	P	DQ (na)	CE (83,9)	DK (na,na,na)	CE (83,9,16,28)
17	Q	ED (na)	DP (na,5)	GY (na,130,9)	CA (79,6,8,14)
18	R	BH (60)	DQ (na,16)	CG (85,7,10)	GW (na,na,na,25)
19	S	CB (80)	AR (44,56)	CH (86,8,11)	GO (na,na,195,15)
20	T	CM (91)	DR (na,na)	DL (na,na,12)	DK (na,na,na,16)

**Notes:**

a) Except for NISP, all firms have been coded to obscure their identity.

b) Prior year rankings marked with "na" means the firm was not in the network.

c) The dotted lines visually trace individual firms as they shift position within the top 20 firms from year to year.

address the dilemma of enabling serendipity versus directing ties appeared to solve, for a time, the earlier dilemma of establishing broad versus pragmatic legitimacy. However, NISP's choice of directing ties through making connections led to a further shift, suggesting that an orchestrator's actions endogenously propel network evolution, and not without unforeseen consequences.

### Phase 3: Strategic growth

We observed a second shift in NISP's orchestration actions, and consequent changes in the network structure, resulting in a third phase of network development, *strategic growth*. In this phase, beginning in late 2007, the network's growth slowed while the nature of the IS projects shifted somewhat. NISP staff spent much less time openly recruiting members to the network and increasingly sought to deepen and sustain their relationships with select firms. As this proceeded, a third orchestration dilemma of replicating versus reinvigorating ties was posed.

Several factors occasioned these shifts. First, NISP's accumulated expertise resulted in a movement away from engagement actions. Leveraging their experience NISP staff began to, in their words, "work smarter" by identifying and cultivating repeat partners and/or replicable projects. This shift in perspective was likely accelerated by 2008 and 2009 funding cuts that, because of

NISP's earlier success in exceeding its performance targets, were not tied to commensurate reductions in targets. In fact, performance targets increased. NISP was also increasingly called on for its expertise in identifying resource solutions, and began to develop more projects to provide regional infrastructure for problematic wastes. Second, as "low hanging fruit" or relatively straightforward IS projects were progressively implemented, more complex and time-consuming projects remained. In 2009, a regional coordinator noted, "our work tends to be more focused on the more difficult things ... foundry sands, hazardous wastes and other nasty stuff". This meant looking to other industries and infrastructure opportunities. Another observed that her team was looking at "plastics, alternative energy systems like anaerobic digestion, things like textiles", adding, "we've started to look at the more novel things rather than moving sand and gravel about". The latter referred to an increasingly common way for NISP to reliably meet landfill targets through involvement in construction projects.

As a result of these factors, and in order to sustain interest from participant firms while delivering on collective goals, NISP altered its main orchestration actions in several ways. First, it reduced most of its *engagement* actions and shifted how it enacted the action of *taking a strategic view of the region*. Second, it expanded its *connection* actions to include explicit efforts to identify and replicate high value IS projects and/or work repeatedly with specific partners. Finally, it engaged in a new category of action, *co-development*, which typically moved beyond single IS exchanges or partners and sought to increase firm or regional capacity for handling a particular waste.

*Shifts in earlier actions and emergence of co-development actions.* NISP significantly shifted its *engagement* actions, most notably by pulling back considerably on the frequency of Quick Wins workshops. As one regional coordinator noted in 2009:

We've had to reduce the amount of workshops that we are able to run in a region because they are very labor intensive. We then couldn't grow the network to the same degree as we have done in the past ... That has had a knock-on effect that really goes back to the pipeline and what we are going to see going forward. Year in and year out we are seeing growth in our outputs [NISP's performance targets], but it will be interesting to see what happens next.

Having less time to spend on out-bound engagement, staff members spoke of using existing resource data, gleaned from earlier workshops and company visits, to identify new opportunities. One region was piloting an electronic survey to be sent to members asking them for updated resource information, which, on return, would populate NISP's database. The coordinator explained, "we decided to do this database thing because we haven't got as much in the pipeline as we have had historically". Simple approaches like following up when electronic newsletters went undelivered and learning who was in a new role "[kept] a contact alive within a company". This engaged interested members, albeit in a less active and serendipitous manner than earlier efforts. Similarly, the nature of *taking a strategic view of the region* shifted with the waning of low hanging fruit and the opportunity, gained through experience, to deliver replicable and /or more complex projects.

In this phase, as in the previous one, NISP staff continued *connection* actions, namely, strategically introducing relevant firms, and deepening their involvement with firms and projects. However, they expanded their connection activities by looking for replicable projects that could help them predictably deliver on their targets. Their focus on sectors with particularly heavy (in terms of tonnage) resource needs, such as the construction sector, intensified as these sectors could significantly contribute to NISP's overall landfill diversion targets. One regional coordinator noted



that she sought “returning customers ... [like] construction companies who come back to us time and time again because they are working on something new”. She explained:

The larger construction companies ... will get on the phone and tell us that they are breaking ground and are going to need so many thousand tonnes of aggregate ... We can just look on our database or make a few phone calls ... and find them something.

Another regional coordinator separately noted this was a more efficient use of time, in contrast to “working with ‘company A’ ... solv[ing] their problem and then you have to move on to another company because there is nothing else for you to help them with”. Even if they were not re-engaging with the same company, NISP staff sought the kind of IS exchanges that could be repeated with new firms. One noted:

I got engaged in ... the Cast Metal Federation. They are a trade body for ... the foundries. This [region] is an area with a high concentration of foundries; they all have the same foundry sands waste. If I can solve one, I can solve the rest of them. I can then replicate [those] sort[s] of synergies.

Finally, NISP became increasingly involved in a new and different form of activity, *co-development*. We define co-development as actions that sought to build the underlying “infrastructure” (e.g. capacities and capabilities to reprocess important resource streams) to support future network ties. Co-development was an outgrowth of NISP’s growing expertise, experience, and strategic perspective and built on its prior engagement and connection actions. For example, one NISP staff member spoke of being aware of “certain gaps in solution providers” or firms that could reprocess certain waste streams in his region, citing the lack of “quality composting facilities”. Outsiders also approached NISP with requests for co-development actions. A regional coordinator recalled when the region’s economic development organization called to say “we’ve got a company who wants to invest and build a gasification plant, can you tell us the best place and what materials are available?”

Co-development actions tended to be more resource-intensive, varied and consultative in nature than connection actions. One type of co-development activity involved NISP working to find researchers or early-stage firms to develop new techniques for reprocessing problematic wastes shared by a number of firms. It might connect these organizations with funding or other forms of support to enable technological or business development. For example, one NISP staff member worked with a firm seeking to introduce a new, lower cost, way of processing animal by-products (ABPs) for use as fertilizer, something that would be helpful to many network members. In this case, NISP helped the firm understand the strict regulations existing around the uses of ABPs.

*Outcomes of actions in strategic growth phase.* A number of changes in the network’s structure reflect these shifts in engagement and connection actions, and the emergence of co-development actions. First, the overall growth of the network slows after 2007, as reflected in declining year-over-year changes in the number of firms and projects. This is likely the result of reducing Quick Wins workshops, and a more general shift from engagement toward connection and co-development actions. Second, both the proportion of active projects to total projects and the average number of projects per firm continue to climb through 2008 (then appear to plateau), suggesting NISP was increasingly successful in bringing projects to completion. Similarly, the core component continued to grow and the network centralization index trended down, showing a sustained tendency to bring

together dissimilar firms. Together these continue to suggest NISP's active hand in bringing new firms into the network and connecting them to diverse others to develop projects.

There is also new evidence in this period that NISP has begun to more actively "pick winners" rather than simply strategically connect firms. NISP's approach of working with certain firms repeatedly (e.g. construction firms) because they could consistently help meet landfill diversion goals is reflected in an increasingly selective re-engagement pattern. Particularly striking is the increasing stability among the most central firms in the network. Recall from Table 4 that none of the top 20 firms in 2005 remained so in 2006 and 11 of the top firms in 2007 had not joined the network by 2005. By contrast, 17 of the top 20 firms in 2009 were among the top 20 firms in previous years, suggesting the network structure was stabilizing.

Supplemental quantitative analyses support our qualitative interpretation of network turnover, or churn. First, Kruskal-Wallis tests (a non-parametric version of ANOVA) comparing the centralities of the top 20 firms ( $\alpha = 0.37$ ) and the centralities of all firms in the network ( $\alpha = 0.48$ ) showed these centralities did not change significantly between 2005, 2007, and 2009. In other words, though the network grew, its overall structure did not significantly change. Second, Mann-Whitney tests (a non-parametric version of a t-test) compared the centrality rankings of the top 20 firms to their own centralities in different periods. The centrality of the top firms in 2005 differed significantly with their own centrality in 2007 ( $\alpha = 0.00$ ). The same comparison between the centralities of the top firms between 2008 and 2009 was not significant ( $\alpha = .34$ ). These comparisons show, like Table 4, that the structural position of the top firms in the network changed significantly early on but less so later. These analyses support our qualitative interpretations of the evolving network.

Following our interviewees' comments about the types of firms and projects they sought to re-engage, we also explored the nature of the firms ranked as the most central over time. We noticed that in 2009 the central firms were predominately specialty waste handlers as opposed to the manufacturing and production firms that had dominated the network earlier on. We also explored changes in construction-related IS projects. As summarized in Table 5, the ratio of active projects involving construction waste to all active projects declined from 28 percent in 2005 to 21 percent in 2009, although the number of active construction projects increased from 17 to 40. Yet, when accounting for landfill tonnage diverted, tonnage from construction-related projects increased by a factor of 5.6 between 2005 and 2009, while total tonnage from all projects increased by only a factor of 2.3. Put another way, the percentage of NISP's landfill diversions from construction-related IS projects reached 73 percent in 2009, up dramatically from 30 percent in 2005. This occurred despite the *decreasing* proportion of construction-related IS projects over time. These trends further suggest NISP had, indeed, begun to pick firms who could help it substantially contribute to its total landfill diversion goals. This no doubt left NISP staff with time and energy to engage in more complex co-development actions. Co-development actions are reflected in projects labeled as *expertise* by NISP. Table 5 also shows that, while NISP connected firms for expertise projects all along, it increasingly became involved as a direct partner in these projects over time. While the total number of expertise projects increase over time, NISP's engagement as a direct partner in these projects increases disproportionately, supporting our qualitative observations that NISP staff were increasingly seeking out and participating in more complex, and likely higher value, co-development projects.

**Perceptions of network value.** The significant shifts in the network's structure – the nature of projects undertaken and the composition of its most central members – imply the network continued to

**Table 5.** Construction and expertise projects in West Midlands.

	2005	2006	2007	2008	2009
<b>Active Construction Projects over Time</b>					
Construction projects	17	22	34	37	40
(% of all active projects)	(28%)	(27%)	(30%)	(21%)	(21%)
Landfill diverted ('000 tonnes)					
Construction projects	148.6	279.4	548.3	781.7	831.7
All projects	499.3	692.1	704.8	1093	1146.2
Proportion of construction to all projects	30%	40%	78%	72%	73%
Average Landfill diverted per construction project ('000 tonnes)	8.7	12.7	16.1	21.1	20.8
<b>All Expertise Projects over Time</b>					
Expertise projects	41	54	86	102	107
(% of all projects)	(28%)	(30%)	(31%)	(28%)	(27%)
With NISP as direct partner	9	11	32	41	44
Proportion NISP to all expertise projects	22%	20%	37%	40%	41%

offer at least some members considerable value. This was in part derived from NISP's developing expertise. One NISP staff member explained:

I think that our [member firms] are getting more involved in what we are about and that we are better at picking [IS projects] that we want to get involved with. ... [Also] businesses now trust us ... [so we] evolve and get bigger projects and more engagement.

In many ways this represents a natural and logical evolution of the network from one that was characterized initially by an "open tent" approach, engaging any interested firms, or "working with the willing", as one NISP executive put it. On the other hand, it also suggests that the choices made to address the second dilemma (enabling serendipity versus directing ties), which in this case favored increasingly directing ties, may lay the foundation for a third. As we elaborate in our discussion, NISP staff members' concerns about a drying pipeline for projects reflects a dilemma around pursuing replicable projects (leveraging connections already made) versus reinvigorating the network by seeking new members and new serendipitous opportunities.

## Discussion

Drawing on five years of qualitative and quantitative data, we explored how network orchestration actions changed as an orchestrator encountered and managed a series of dilemmas associated with building a network. Whereas previous work shows shifts in orchestration actions can be triggered by exogenous events (Human & Provan, 2000; Madhavan et al., 1998) or by the changing resource needs of the focal actor (Hite & Hesterly, 2001), we found that an orchestrator's actions also shift in response to an evolving set of dilemmas that arise out of the need to generate and manage network value. In our study, resolving one dilemma led to the emergence of others, suggesting an endogenous trajectory for the evolution of network orchestration actions. Here we discuss the implications of our findings for theory on network assembly and management, addressing calls for more research on the underlying processes and implicit tradeoffs (Capaldo, 2007; Kale & Singh,

2007; Möller & Svahn, 2009; Parkhe et al., 2006). We also delineate the boundary conditions of our theorizing.

### *Endogenous drivers of network change*

Our findings demonstrate how network orchestration actions shape network structures and outcomes, which in turn beget shifts in orchestration actions. Past work has shown that networks evolve when exogenous factors trigger responses by orchestrators or as a result of orchestrators' management choices (Capaldo, 2007; Human & Provan, 2000). We add to this literature by showing how the trajectory of an assembled network unfolds endogenously, with changes triggered as the orchestrator and members interact over time. Network orchestration choices are not one-off, taken only at the beginning of network assembly (Doz et al., 2000), but are made repeatedly as the outcomes of prior actions generate new demands and dilemmas. We capture this endogenous trajectory as a series of shifts in network orchestration actions associated with the emergence of new dilemmas. The dilemmas themselves arise as the orchestrator seeks to address the pervasive questions of value creation that arise in settings of novel network activity and/or a new network.

New networks, and especially those assembled by new orchestrating entities, face an inherent challenge of establishing the legitimacy of the activity upon which the network is founded, and of conveying the value of network participation to potential members (Doz et al., 2000; Möller & Svahn, 2009; Wry et al., 2011). In answering the question "what is the value of this network?", an orchestrator faces a dilemma of investing resources on broadly conveying the nature of network activity to a wide audience of potential supporters, versus pragmatically demonstrating value by enabling successful ties between potential members. We labeled this dilemma that of *establishing broad versus pragmatic legitimacy*. Of course, the two sides of this dilemma are not simple trade-offs, because establishing pragmatic legitimacy can be one route to broad legitimacy. Conversely, broad legitimacy can attract members and help them overcome reticence to participate. Nonetheless, an orchestrator must choose how to allocate time and resources to each of these, in what proportion, and in what sequence.

Choices made at this stage influence the network's growth rate and its members' expectations about how they might extract value from the network, sowing the seeds of a second dilemma. We labeled the second dilemma *enabling serendipity versus directing ties*, because it captures a second question about network value: "what type of value, and for whom?" As members begin to see promise in network activity, they may seek to participate for different reasons. For some, the network offers opportunity for unexpected ideas, information, and potential connections. For others, it offers very specific connections to resources or partners. Both forms of value are important to the overall performance and level of innovation present in a network, which ultimately benefit both the orchestrator and members (Capaldo, 2007; Doz et al., 2000). However, orchestrators' choices at this stage also reflect their necessarily limited resources and may force them to ration one type of value creation activity at the expense of another (Lipsky, 1980). As we discuss further below, such choices lead to a third dilemma that hinges on the type of value creation envisioned for the overall network. At this point, an orchestrator must choose between replicating ties known to have value or reinvigorating network activity by bringing in new members, ideas, and potential (but uncertain) opportunities for value creation.

While the details of how an orchestrator chooses to manage each dilemma may differ, the underlying endogenous trajectory we uncovered is likely to apply in other assembled networks because every orchestrator has to convey and manage network value. Indeed, prior empirical work in a variety of settings (e.g. furnishings manufacturer networks, R&D consortia, auto manufacturing

supply chains, and SME associations respectively, Capaldo, 2007; Doz et al., 2000; Dyer & Nobeoka, 2000; Human & Provan, 2000) points to elements of these dilemmas and the actions taken to manage them. Through our longitudinal examination of network orchestration, we extend this work by showing how orchestrator actions and network structure co-evolve to shape and respond to the evolving dilemmas.

### *Learning to orchestrate: Accumulating resources and expertise*

A second main implication of our work is to document how an orchestrator learns to build a network by accumulating resources and expertise over time. This finding supports prior conceptual and empirical work showing that network participants build valuable positions through their activities (Hite & Hesterly, 2001; Powell et al., 1996), rather than the other way around (Dhanaraj & Parkhe, 2006; Lorenzoni & Lipparini, 1999). In the case of a network founded on a novel form of interorganizational activity, an orchestrator can start from essentially nothing and rapidly accumulate valuable resources (e.g. database of firms' resources, regional knowledge, contacts) and specialized expertise (e.g. experience in bringing projects to fruition). These represent both explicit and more tacit knowledge. Leveraging each of these is essential for the orchestrator to establish and maintain its central role in network assembly. Prior work on alliance formation and brokerage points to the importance of resources and expertise, but does not empirically show how an organization accumulates and leverages these over time as it builds a network. For example, cross-sectional empirical work on alliances suggests that firms learn how to assemble productive alliances by codifying knowledge and sharing internal tacit "alliance wisdom" (Kale & Singh, 2007). The possession of "collaborative know-how", which includes knowing how to identify partners and being skilled in working with them, is developed through experience (Powell et al., 1996; Simonin, 1997). The way in which such alliance formation expertise is developed over time awaits elaboration, however (Kale & Singh, 2007). Similarly, work on brokerage suggests that brokers must possess knowledge that helps them select partners and/or resources to bring together; and also develop more tacit, relational skills in order to synthesize knowledge or enable innovation (Foster et al., 2011; Lingo & O'Mahony, 2010; Obstfeld, 2005). The work on brokerage has only recently considered how brokers adjust their actions over time as they build and manage ties (Lingo & O'Mahony, 2010).

By showing empirically how a network orchestrator develops and then uses resources (explicit knowledge) and expertise (tacit "know-how") over time, our study can inform the sequencing and use of these in other settings. More importantly, it also sheds light on how these two types of knowledge are implicated in different stages in the endogenous trajectory of a developing network. Resources like information can be accumulated early in a network's development and used to relatively quickly establish an orchestrator's value. In our case, knowledge of waste resource types, quantities, and locations enabled potential connections. As the network grew, the orchestrator gained expertise in bringing exchanges to fruition, an activity more complex than it initially appeared. This type of tacit expertise was then increasingly valuable later in the network's evolution as the orchestrator sought to make direct connections and replicate high value ties. Unique to our setting, multiple regional teams were building IS networks more or less simultaneously, meaning that tacit knowledge could be shared by their frequent communication. Each regional team still needed to amass information about the industrial make-up of their region, suggesting that learning *across* networks centered on tacit knowledge, while that *within* networks centered on both explicit and tacit knowledge. Thus, expertise should not be regarded as a substitute for

information resources. Rather, orchestrators need to continue to build both explicit and tacit knowledge as the network evolves.

### *Over-engineering an orchestrated network: A cautionary tale*

Finally, our study offers a cautionary tale for network orchestrators. On the one hand, orchestrators are increasingly able to convey, deliver, and manage network value as they sequentially and accumulatively gain information (or other resources) and expertise. On the other, our study suggests that orchestrators should “be careful what they wish for”. We found that as the orchestrator became better able to identify and select participants and projects that would serve the network’s goals, it also restricted opportunities for new firms to join the network or even be exposed to its activities, thus potentially slowing future network growth. Prior work points to related forms of network dysfunction. Network inertia has been theorized to arise “not as a symptom of poorly managed interorganizational networks but as a by-product of the previously successful management of networks that generate synergies for the participating organizations” (Kim, Oh, & Swaminathan, 2006, p. 705). An “over-engineered” network (Doz et al., 2000), consisting of overly narrow membership and/or weighted towards strong ties with a relatively small group of members (Capaldo, 2007), may result when an orchestrator overly directs a network towards delivering on a common goal.

With over-engineering, a network and its orchestrator lose the benefits of a broad and diverse membership. It is too early to tell how NISP’s network will unfold, but the slowing growth and evidence that certain types of projects and partners were increasingly selected over others suggests the possibility of over-engineering. Innovation within the network may also suffer, as may the broader exposure of firms to the novel activities upon which the network is founded. Greater exposure to a novel activity, like industrial symbiosis, may be particularly warranted for collective goals, like environmental protection, where widespread learning and change is sought. Whereas the ability to manage ‘dual networks’ – those that balance a core of strong ties and active periphery of weak ties – benefits the orchestrating firm (Capaldo, 2007), such an ability may also prove essential for the long-term survival and resilience of an orchestrated network founded on collective goals.

### *Boundary conditions*

The main implications of our findings – that, i) assembled networks follow an endogenous trajectory driven by ongoing dilemmas around value creation, ii) orchestrators work their way into a valuable network position by acquiring resources and developing expertise, and iii) an over-orchestrated network may hold the seeds of its own demise – have application in other settings. Perhaps most clearly they apply in other networks which, like ours, seek to “build something from nothing” by advancing novel network activity and/or connecting participants in a new network. Environmental or social initiatives that operate within or across supply chains (Cashore, 2002; Organic Exchange, n.d.) or even between different types of organizations (Ritvala & Salmi, 2010) offer ready examples. Here uncertainty around the network activity and its value is inherently high, and the need to establish legitimacy early on is particularly pronounced (Ritvala & Salmi, 2010). Other settings might also be characterized by high initial uncertainty over network value and simultaneously high demands for interdependence. In such cases, orchestrating entities might be either private or public. For example, in the case of novel industry or technology emergence (Adner & Kapoor, 2010; Möller & Rajala, 2007) or in networks assembled by public entities with overarching collective goals (Milward, Provan, Fish, Isett, & Huang, 2010; Provan & Kenis,



2008), we would expect to see similar challenges around conveying, generating, and managing network value, giving rise to similar dilemmas. The fact that prior work hints at similar dilemmas in other, more stable or traditional environments like supply chains, alliance networks, or innovation networks (Capaldo, 2007; Doz et al., 2000; Dyer & Nobeoka, 2000; Powell et al., 1996) further suggests that our findings generalize to other assembled networks.

On the other hand, there are some characteristics of our setting that might limit the generalizability of our findings. First, the orchestrating entity had a specific collective goal (improved environmental performance) and was expected to meet explicit targets. Other entities may have more latitude in how they generate network value and on what terms they attract members (Hite & Hesterly, 2001). Future work could explore how the interaction of collective, orchestrator, and member goals shape orchestration actions. Second, industrial symbiosis networks depend on a firm's spatial proximity (it must be economically feasible to transport a "waste" resource, which varies by the value of the resource). Yet, other interorganizational networks also seem to be geographically bounded as proximity enables knowledge flow and innovation (Powell, Koput, Bowie, & Smith-Doerr, 2002). We found face-to-face interaction was important as orchestrators worked to develop and deepen connections with network members, suggesting that learning the tacit elements of the role may well depend somewhat on geographical proximity. Future research could explore whether and how geographical scale influences network orchestration activities and their evolution over time. In the end, examining the assembly and development of this network, and others, will shed further light on the underlying dilemmas that drive network evolution across a variety of conditions (Kilduff, Tsai, & Hanke, 2006).

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## Notes

1. NISP was also established in Scotland. However, due to funding and operational differences we dismissed it from this study. Between 2005 and 2007, NISP subsequently established itself in the rest of the UK, including Wales and Northern Ireland.
2. The West Midlands region began operating in 2002, but only formalized its project tracking in 2005.

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