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Article

Coordination of Industrial Symbiosis through Anchoring

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Abstract: This paper aims to contribute to understanding the dynamics of industrial symbiosis. More specifically, we focus on the dynamics of anchoring as they can be observed in the Chinese context of eco-industrial development. We define anchoring as those activities that (typically local) actors perform to create local physical and institutional conditions conducive to the emergence and further development of industrial symbiosis in a specific regional industrial system. We argue that, in the study of industrial symbiosis dynamics, it is conceptually more useful to focus on anchoring as an activity, rather than anchor tenants as actors. Based on a systematic literature review, we distinguish two types of anchoring activities: institutional and physical. We analyze anchoring dynamics in the case of Qijiang Industrial Symbiosis (Chongqing Municipality) in China. We have identified the physical and institutional anchoring activities, the actors responsible for these activities, and how different anchoring activities build on each other over time. Our case study shows that the attempt to bring about industrial symbiosis in the Qijiang industrial park can be described in a richer way than just ‘governmental planning’.

Keywords: industrial symbiosis; anchoring; dynamics; China

1. Introduction

In a recent publication, Boons et al. introduced a process-oriented research agenda for comparative research on industrial symbiosis dynamics [1]. Their agenda builds on, among other things, a tentative typology of seven typical sequences of events through which the emergence and development of industrial symbiosis may occur across the world. The authors invite scholars in the field to put the implications of this typology to empirical tests, in order to further refine and expand on it. In addition, the authors raise the challenge of identifying the contextual conditions (e.g., institutional, economic, geospatial, and technical) under which certain dynamics are most likely to be triggered, as well as the outcomes (environmental and others) to which different dynamics lead.

In this paper, we seek to contribute to this research agenda, with a particular focus on the dynamics of anchoring as they can be observed in the Chinese context of eco-industrial development. In the context of industrial symbiosis, we define anchoring as those activities that (typically local) actors perform to create local physical and institutional conditions conducive to the emergence and further development of industrial symbiosis in a specific regional industrial system (A regional industrial system is “a more or less stable collection of firms located in proximity to one another, where firms in principle can develop social and material/energy connections as a result of that proximity” [2] (p. 907). In the literature on economic geography, regional industrial systems are generally referred

to as clusters [3,4]). The aim of the activities is to draw new companies to the regional industrial system to engage in symbiotic exchanges with (typically larger) companies that are usually already established in the system.

Boons et al. do not identify anchoring as an independent dynamic, but discuss dynamics that involve anchor tenants (i.e., one or two larger industries that provide a critical mass for the development of industrial symbiosis in an industrial park) as a special case of a dynamic they coined self-organization [1]. Self-organization involves symbiotic activities (i.e., connecting flows among industrial actors through the use of secondary material, water, and energy resources, and/or utility and service sharing) that result from the self-motivated strategies of industrial actors, in the absence of the ambition to develop a network of symbiotic exchanges [1] (p. 7). In this article, we do not aim for more proof of the relevance of anchoring for the development of Industrial Symbiosis, because that has been shown sufficiently in other research studies as our literature review demonstrates.

The central aim of our paper is to make the case that anchoring is not necessarily a special case of self-organization, and that anchoring can be understood as an industrial symbiosis dynamic in itself, where the development of industrial symbiosis may also be an explicit motivation that underlies anchoring activities. We achieve this aim through several steps. First, we report on a systematic review of the literature on anchor tenants in industrial symbiosis. Based on this review, we propose that in the study of industrial symbiosis dynamics, it is conceptually more useful to focus on anchoring as an activity, rather than anchor tenants as actors, because activity is itself inherently dynamic [5]. A focus on anchoring as activity, for example, allows for the possibility that different actors engage in and/or cease anchoring activities at different points in time. In the process, we also critically engage with the distinction between physical and institutional anchors (or anchoring), which was introduced by Bürstrom and Korhonen [6], and which has since been taken up by other scholars in the field [7,8]. We then present findings from an empirical study of the Qijiang Industrial Symbiosis in China, revealing (1) the institutional and physical anchoring activities that have been performed in the case; (2) which actors were responsible for these activities; and (3) how different anchoring activities build on each other over time. Our case study also reveals that the identified anchoring activities can be understood as parts of a deliberate attempt to bring about industrial symbiosis in the Qijiang industrial park, but that this deliberate attempt can be described in a richer way than just ‘governmental planning’.

In the next section we discuss our overall research design, outlining the approaches that we used in the literature review. In Section 3, we introduce our empirical case study site. In Section 4 we present the conceptual basis for our work, building primarily on the literature review that we performed. In this section we offer our definitions of (physical and institutional) anchoring activities, and we develop a categorization of these activities that we use as a basis for our empirical investigation of anchoring activities in the case of the Qijiang industrial symbiosis. We then present the results of our case study in Section 5, followed by an analysis in Section 6, and Section 7 is the conclusion.

2. Methods

Our study consists of two main parts. First, we performed a systematic review of the literature relevant to anchoring in industrial symbiosis. The approach that we used is summarized in Section 2.1, with additional information included in Appendixes A and B. Second, we performed an empirical case study of the Qijiang Industrial Symbiosis in China. The approach that we used for our case study is discussed in Section 2.2, and the data that will be presented are qualitative and related to the literature review and observations.

2.1. Literature Review

We performed a literature review in Scopus and Web of Science, based on an iterative process for identifying keywords and selecting relevant papers. The search strings that we used, and other details about our literature study, can be found in Appendix A. We started with a list of keywords

derived from a review of industrial symbiosis literature performed earlier by Chertow and Park [9]. This resulted in a list of 931 publications (The concept of anchors also appears in other bodies of literature, but the focus of our review is specifically on the literature on industrial symbiosis). To assess the quality of the search results, we initially coded 50 randomly selected abstracts, distinguishing between relevant and irrelevant papers for our purposes. Based on an inspection of the contents of these 50 abstracts, we developed additional keywords that we used to further specify our literature search, focusing on papers that dealt with governance, and filtering out papers unrelated to industrial symbiosis. Our new searches resulted in 666 potentially relevant publications. We coded all of these abstracts, identifying those publications that dealt explicitly with industrial symbiosis and that were based on empirical studies, and excluding entirely quantitative assessments (these typically offer little detail about underlying governance activities). We identified 257 relevant publications. 55 of these were left out due to restricted access or language restrictions, which left us with a selection of 202 publications. From these we identified 45 publications that deal with anchoring or anchor tenants in some part of the publication, by searching all publications for any mention of the word “anchor” or variations thereof (e.g., anchoring, anchors). These publications were imported in the MaxQDA software for Qualitative Data Analysis. A bibliography of the studies that were assigned at least one code can be found in Appendix A. In the process of coding, we paid attention to the following main themes (also our main coding categories):

- (1) Actors: The types of organizations that are identified as anchors.
- (2) Activities: The activities that anchors are said to perform.

For both categories, we identified several subcategories, identifying different types of actors (e.g., public and private), and different categories of activities (these are used in our conceptual discussion). After we finished our coding of these studies, we wrote an interpretive report of the results to summarize and deepen our findings. The report is also an important basis of the conceptual discussion of this paper.

The main product of our literature review is a list of anchoring activities (see Appendix C), that we categorized in 2 types of physical anchoring activities: (1) contributing to synergies; and (2) creating network and physical infrastructure, and in five types of institutional anchoring activities: (1) stimulating social interactions; (2) recruitment; (3) knowledge support; (4) spearheading projects; and (5) political and managerial support.

2.2. Selection of Case Study and Data Collection

The literature review showed that existing empirical studies on industrial symbiosis in China focused on large-scale national level industrial parks in the eastern coastal regions, such as in Suzhou, Tianjin, and Shandong [10–14]. Out of the 1568 national and provincial-level industrial parks across the country [15], a significant number of industrial parks are located in central and western China, and they are mainly provincial level ones rather than national level ones. Although such provincial industrial parks are widely spread in central and western China, few studies have explored these cases. For this reason, we selected the provincial level park Qijiang Industrial Symbiosis (hereinafter referred to as QJIS) as the case. QJIS is located in the south of the Qijiang District, Chongqing Municipality in western China.

Data collection was based on document analysis and in-depth interviews. The document analysis of websites, newspapers, reports, and government policies was used to create an overview of the development, management, and institutional context of QJIS. From July 2015 to August 2016, three field trips and 20 interviews with relevant stakeholders were conducted, including interviews with 5 governmental officials, 8 staff members of the Administrative Commission, 3 managers at the tenant company of Qineng, 2 managers at the anchor company of Huicheng, and 2 researchers involved in the development of QJIS. These interviews were used to analyze the development process of QJIS, with a focus on anchoring activities performed by different actors. During the interviews, the

interviewees were asked to identify and give details of the activities performed by actors to attract and/or keep companies in that area in different phases of the industrial symbiosis development (preparation phase, development phase, and operation phase). Interviewees were also asked to explain the context of these activities, and the stakeholders engaging in these activities.

2.3. Analysis

Following Boons et al. [1], we analyzed anchoring dynamics in the case of Qijiang as sequences of events. We identified the sequences of anchoring activities in the Qijiang case. For identifying different anchoring activities, we distinguished between the preparation phase, development phase, and the operational phase of industrial symbiosis in Qijiang.

After identifying the anchoring activities that occurred in the case of Qijiang, we summarized the activities in a narrative table and an accompanying narrative graph. The approach used in this step is inspired by the work of Abell [16,17], and serves to elucidate (i) the sequencing of anchoring activities; (ii) how earlier anchoring activities lead into later anchoring activities; and (iii) how these activities are divided among the different actors involved. The narrative table offers a chronologically ordered overview of the different types of activities that occurred. In the narrative graph, the activities are visualized as nodes (ordered in time from left to right), and the relations between the activities as arcs. The vertical layout of activities in the narrative graph reveals the distribution of activities among the different actors.

The narrative table and graph allow us to investigate more closely the order in which the activities occurred (also taking into account who performed the activities), and how these activities build on each other, thus allowing for a more in-depth assessment of the sequential patterns in anchoring activities in the case of Qijiang.

3. Case: Qijiang Industrial Symbiosis Park

3.1. Background

In China, Economic and Technology Development Zones were built in 1980s, which were largely located in coastal areas, such as Shanghai, Tianjin, and Guangzhou. These Economic and Technology Development Zones were the predecessors of industrial symbiosis initiatives. [18]. Since 2003, in order to regulate and promote industrial symbiosis, various laws and policies have been introduced by the Chinese central government [19]. For example, the 'Provisional Guideline for Planning Demonstration Eco-industrial Parks' and the 'Provisional Guideline for Planning National Demonstration Circular Economy Zone' were introduced in 2003, the 'Measures for the Administration of National Eco-industrial Demonstration Parks' in 2007, and the 'Circular Economy Promotion Law' in 2009.

3.2. Qijiang Industrial Symbiosis

QJIS was established in 2006 (Figure 1). The total area of QJIS is 33.5 km². There are three industrial sub-zones in QJIS: Beidu Aluminum and Copper Industrial Zone, Qiaohe Energy Saving Building Materials Industrial Zone, and Fuhuan Coal and Electrochemical Industrial Zone.

Our analysis focuses on the Beidu Industrial Zone of QJIS, which has 30 companies with an area of 10.09 km². The Beidu Zone is the base of the Chongqing Aluminum and Copper Comprehensive Industry. Chongqing Qineng Electricity & Aluminum Co., Ltd. (hereinafter referred to as Qineng) is the anchor company of the Beidu Zone and there are 18 tenant companies of Qineng. Qineng supplies its molten aluminum to downstream companies, such as the Huicheng Company, Yuancheng Company, and Xindian Company. These tenant companies focus on processing of aluminum, extending towards the downstream light metal industry (development direction). Their products include lightweight and safe materials such as aluminum for automobiles and rails.

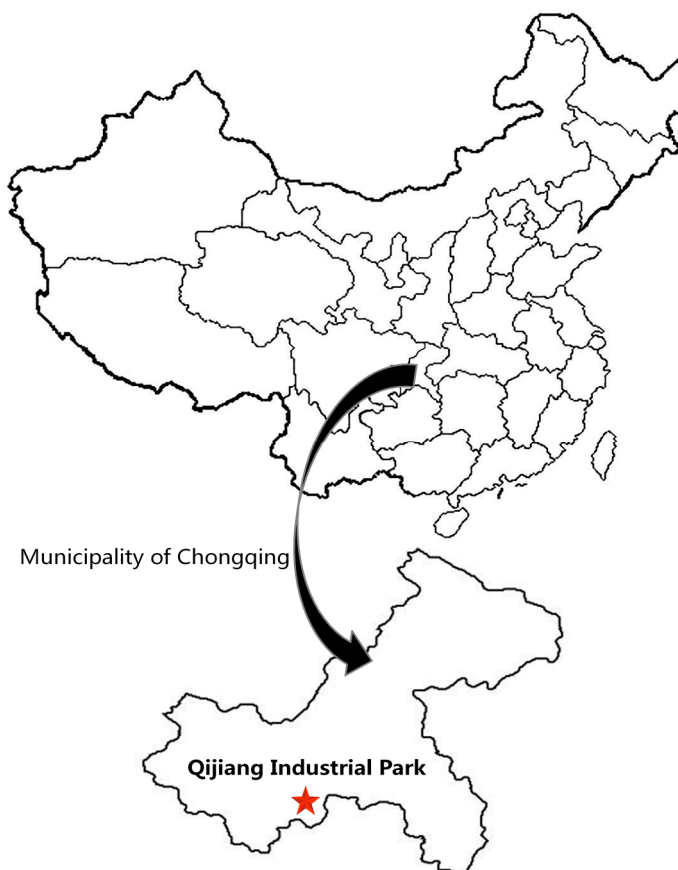


Figure 1. Location of the Qijiang Industrial Symbiosis Park.

Besides companies, the office building of the Administrative Commission of QJIS is also physically located in the industrial park. The Administrative Commission (AC), as an agent of the government, plays a vital role in the coordination of industrial symbiosis in China [12,13]. The Administrative Commission of QJIS, founded by the Qijiang government in 2006, consists of 13 departments taking charge of activities such as recruiting companies, planning formulation, infrastructure construction, R&D, social issues, and company service.

4. Conceptual Framework: Anchors and Anchoring in Industrial Symbiosis

Chertow [20] is one of the first to explicitly discuss the role of so-called anchor tenants in the development of industrial symbiosis. She describes anchor tenants as follows: “Just as shopping malls are built around several large department stores that anchor the commercial development within, one or two large industries can provide the same critical mass for an eco-industrial park” [20] (p. 333). This critical mass typically refers to the large material and energy flows that the presence of large industrial companies entails, and the opportunities for other companies to connect to these flows in a symbiotic manner. The general purpose of anchoring is thus to draw new companies to a specific location.

In the industrial symbiosis literature, various types of companies that can provide critical mass have been identified. In our literature review, we kept track of the organizations that were identified as anchors in the empirical studies. The results of this are shown in Table 1. As Chertow’s definition suggests, and as Table 1 shows, most often companies (most of all power plants) are understood to play the role of anchor [20]. However, the list also shows that, in some studies, public organizations and business associations are identified as anchors as well. This has to do with a further elaboration of the concept of anchors that was introduced by Büström and Korhonen [6], and which has since been adopted by others [7,8]. Büström and Korhonen make a distinction between physical anchors and

institutional anchors [6]. Physical anchors are those actors that provide the critical mass for industrial symbiosis through the large material and energy flows that they create in an area. The concept of institutional anchors is most clearly explained by Martin and Eklund:

“Anchor tenants do not have to be physical anchor tenants [...]. They may also take the form of institutional anchor tenants which aim to provide systems with information, social and economic infrastructure, decision making forums and institutional and political support. This could be handled by the municipality, or another actor, for the promotion of better environmental performance through industrial symbiosis and synergies between industries thus adding further industries and economic welfare and an environmental image for the community” [8] (p. 1749).

Table 1. Overview of actors that have been mentioned as anchors in 45 reviewed studies.

Private Organizations		Public Organizations	
Organization type	Count	Organization type	Count
Power plant	17	Public authority	6
Combined heat and power plant	5	Public Utilities	1
Pulp and paper mill	3		
Chemical plant	3		
Business association	3		
Food processing facility	2		
Wallboard manufacturer	1		
Pharmaceutical plant	1		
Oil Refinery	1		
Electronic equipment plant	1		
Resource recovery plant	1		
Brewery	1		
Waste transfer station	1		
Waste incinerator	1		

Thus, institutional anchors do not provide critical mass for industrial symbiosis in terms of material and energy flows, but they play an anchoring role by creating social and institutional conditions that are conducive to the emergence and development of industrial symbiosis. Such social and institutional conditions are typically (but not exclusively) created by public organizations. Actors associated with institutional anchoring activities have also been referred to in other terms, such as ‘organizing teams’ [21], ‘coordinating bodies’ [22], ‘champions’ [23], and ‘network orchestrators’ [24,25].

Based on our review of studies that discuss the role of anchors, we found that the distinction between physical anchors and institutional anchors is empirically hard to uphold. Actors identified as physical and institutional anchors engage in different anchoring activities at different points in time. The literature review shows that both physical and institutional anchoring activities can be performed by one and the same actor. For this reason, we focus on anchoring as a type of activity, rather than anchors as a type of actor. Consequently, we distinguish between physical anchoring and institutional anchoring as two subtypes of anchoring activities. Furthermore, focusing on anchoring as an activity fits better with the conceptualization of industrial symbiosis as a process [1] and the aim to analyze dynamics in the governance of industrial symbiosis. After all, it creates room to identify which actors perform and shift their activities over time, and how these are related. Following the framework of Boons et al. [1], we suggest that the kinds of anchoring activities that actors perform are influenced by the particular context in which they transpire (e.g., the social, institutional, technical, and/or physical context), and that different activities lead to different (intermediate) outcomes (e.g., evolution of the network of linkages, and environmental and economic performance). Occasionally, the context may also be shaped by the outcomes of anchoring activities, for example when actors implement new policies and/or regulations. We illustrate these ideas in Figure 2. The focus of our work is

specifically on activities, and given that our empirical study (Section 5) is based on one case, we cannot draw strong conclusions on the relationships between context, anchoring activities, and outcomes. However, in our discussion we reflect briefly on these relationships, and how they might be addressed in future research.

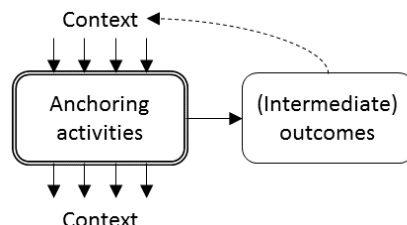


Figure 2. Anchoring activities and their link to context and outcomes. The focus of our study is on activities.

Contributing to synergies is the kind of activity that has traditionally been associated with larger industrial companies that are able to provide the critical mass for industrial symbiosis development through resource flows, utilities, and services that they make available in their region. This in itself often exerts an attractive force on other companies that see economic and environmental benefits in being located near the original companies. It is by far the most discussed anchoring activity that we encountered. Another way in which actors can create physical conditions conducive to industrial symbiosis development is through the development of physical infrastructures that others can make use of, such as pipeline infrastructures developed to transport raw materials, or other on-site transport facilities, including railway structures and connections.

Although physical anchoring activities are discussed most often in the industrial symbiosis literature that we studied, the institutional anchoring activities that we found are much greater in diversity (see Table 2). Of these activities, the one that was mentioned most often concerns the stimulation of interaction between stakeholders. Many authors assume that creating a healthy ‘social infrastructure’ is just as important as the physical infrastructure. Facilitating the development of such a social infrastructure, for example by setting up forums, organizing events where actors can meet, or by stimulating actors to participate in joint programs, was the institutional anchoring activity that we encountered most often in the literature. Another activity often seen as essential here is to feed the social process around industrial symbiosis development with knowledge and expertise, which is another institutional anchoring activity that was mentioned. For example, some authors mentioned that anchors may gather and make available the knowledge that is relevant to industrial symbiosis (e.g., available inputs and outputs, chemical properties of waste/by-products), and set up, or serve as educational platforms, where actors can meet to learn from each other. Simply bringing various actors in an area together in joint platforms may help to bundle knowledge that is already available, but fragmented.

Providing political and managerial support primarily takes the form of implementing laws and regulations. This may, for example, take the form of implementing waste management laws and/or policies to incentivize by-product exchanges, or lifting regulatory restrictions on how certain waste materials may be processed. Political support may also be of a more symbolic nature, and here authors tend to emphasize the importance of continued political support for industrial symbiosis for upholding the momentum of projects. To some extent, this symbolic aspect also exists for managerial support, although managerial support can also take more concrete forms, such as when managers act as key contact persons for stakeholders, and take responsibility for the optimal coordination and cooperation among those involved in industrial symbiosis projects.

Table 2. Overview of anchoring activities.

Physical Anchoring	Institutional Anchoring
Contributing to synergies:	Stimulating social interactions:
- Create opportunities for by-product and utility synergies - Provide (share) utilities and services	- Facilitate interaction between stakeholders - Maintain close contact with relevant stakeholders
	Knowledge support:
	- Provide knowledge and expertise - Provide platforms for education - Make inventories and databases of inputs and outputs
Creating infrastructure	Political and managerial support:
- Provide physical infrastructures	- Provide political support - Implement supporting laws and regulations - Provide managerial support
	Recruitment:
	- Recruit new companies for establishment - Set beneficial prices (e.g., land or energy prices) - Promote the area
	Spearheading projects:
	- Act as an owner of industrial symbiosis projects - Be a role model

Note: see table in Appendix B for literature sources.

Other institutional anchoring activities we encountered are active recruitment of new companies, and spearheading projects, by taking ownership of a project or acting as a role model for others in the industrial symbiosis development. The active recruitment of companies, where acquisition activities are designed to specifically target new potential symbiosis partners, can be seen as an addition to the more passive attractive force exerted by physical anchoring activities, and the implementation of laws and regulations that provide a positive bedding for industrial symbiosis. In this context, several authors also emphasize that companies that are already established in the area are often able to identify other companies that might serve as possible partners [18,23,24]. As with political and managerial support, spearheading projects and acting as a role model is primarily of a symbolic nature, showing to others that there is someone who is willing to take initiative.

Now that we have provided a brief overview of anchoring activities encountered in the industrial symbiosis literature, we use this as a basis for our own empirical investigation of the case of Qijiang, which is the topic of the next section.

5. Anchoring in the Qijiang Case

In this section, we present the anchoring activities as identified in the QJIS case. We categorize these activities based on the three phases of industrial symbiosis development: (1) preparation; (2) development; (3) operation. Our empirical data reveals 10 anchoring activities in the three phases of the QJIS. In the preparation phase, the anchoring activities are (1) providing a local institutional setting; (2) expropriating land for the industrial symbiosis construction; and (3) providing physical infrastructure. In the development phase the anchoring activities are (4) implementing preferential policies to attract companies; (5) recruiting companies to industrial symbiosis; and (6) facilitating companies' settlement in industrial symbiosis. In the operation phase, the anchoring activities include

(7) providing by-product and utility synergies; (8) providing daily managerial support for companies; (9) seeking funding for scaling up industrial symbiosis; and (10) promoting research and development.

5.1. Preparation Phase of QJIS

This phase involves three anchoring activities. First, providing a local institutional setting, second, the expropriation of land and, third, providing physical infrastructure.

(1) Providing Institutional Setting Locally

In an authoritarian state like China, national laws and policies provide a solid institutional context for the emergence of industrial symbiosis [15]. Based on the central government's guidelines, provincial and municipal governments make tremendous efforts to promote the industrial symbioses in their region. Industrial symbioses have been booming across the country, and its number reached 1568 in 2011 [18]. Among them, these are 43 industrial symbioses in the Chongqing Municipality, which are located in different administrative districts and counties of Chongqing. In 2009, the Chongqing Municipal Government specifically introduced the Opinions of Chongqing Municipal Government about Further Accelerating Development of Characteristic Industrial symbiosis in Chongqing, which provides a solid institutional setting for Industrial symbiosis in the Chongqing municipality. Based on this policy from the Chongqing municipal government, the county and district government introduced policies correspondingly to promote the development of Industrial symbiosis in their administrative areas.

(2) Expropriating Land for the Industrial Symbiosis Construction

According to the Land Administrative Law, land in urban China is state owned, and land in rural and suburban China is collectively owned. Only state-owned land can be used for urban and industrial construction (Table 3). If any new construction is planned on collectively owned land, the first step is the transfer of land ownership from the rural collective to the state through expropriation. Between 2001 and 2011, construction land expanded by 17,600 km², and 90 percent of the newly developed urban land was acquired by the state through the expropriation of rural land [26] (p. 271). Most industrial symbioses projects are located in suburban areas. Therefore, land expropriation by the government is an important activity for IS development.

Table 3. Land Ownership and Property Rights in China.

	Rural Land	Urban Land
Ownership	Owned by rural collective	State owned, represented by municipal government
Permissible Use	Agriculture, villager's homestead, village public facilities, and village enterprises	Industrial, commercial, residential, administrative, urban public facilities, urban infrastructure, etc.
Land Use Rights	Permanent with the village and (in case of homestead) villagers, leasing out permitted	Provided through public land leasing, with a period of 70 years for residential land, 50 years for commercial land, and 40 years for industrial land

Compensation and relocation are the two most important issues during land expropriation. The government normally offers compensation to rural households in the form of money, including compensation for the land and the housing on it. Relocation housing is built nearby the expropriated rural communities, and then provided to these households. Demolition will be done for all the rural housing in one neighborhood after each household has signed the demolition agreement. With the expansion of QJIS, there have been three rounds of land expropriation, which were in 2008, 2011, and 2015, respectively. In 2008 for example, 400 rural houses were demolished.

As for QJIS, the rate of signing the land expropriation and housing demolition agreements has been up to 99%. The Qijiang government established a team specialized in coordinating and resolving disputes raised by land expropriation. This team has issued over 1000 brochures, organized two lectures by experts, and four visits of the relevant officials have been made to the communities. This anchoring activity also involved local officials dealing with issues raised by the residents in new communities of relocated housing, in this case relating to property management, farmers' markets, and damaged environmental facilities.

(3) Providing Physical Infrastructure

Providing physical infrastructure is the next anchoring activity. Firstly, the office building of the Administrative Commission was constructed. This physical infrastructure can be regarded as a physical enabler for institutional anchoring by the Administrative Commission. In QJIS, its Administrative Commission office building was constructed in 2006 under the coordination of the Qijiang district government. Secondly, the construction of road, water pipe, electricity, natural gas, communications, sewerage, green space, etc., was performed. Up to 2014, 39.5 km of roads with facilities were constructed under the coordination of the Administrative Commission in QJIS, which was financed by the Qijiang district government and the Administrative Commission.

5.2. Development Phase of QJIS

Three activities are identified in this phase: (1) implementing preferential policies to attract companies; (2) recruiting companies to industrial symbiosis; and (3) facilitating companies' settlement in industrial symbiosis.

(1) Implementing Preferential Policies to Attract Companies

Based on the principles and guidelines of the municipal policies, in 2012 the Qijiang District Government introduced Several Preferential Policies of Companies' Entering Qijiang Industrial Parks for Establishing Business, put into practice by the Administrative Commission of QJIS. Due to the economic incentives, preferential policies on land lease and tax reduction are regarded as the key institutional factors attracting companies to settle in industrial symbiosis [15,27].

As for land lease, there were different types of adjusted land lease prices in QJIS. For companies with a turnover of 200–300 million yuan (1 Yuan = 0.147 US Dollar), 300–400 million yuan, 400–500 million yuan, and over 500 million yuan, the land lease fee can be deduced respectively by 2000 yuan/mu (1 Mu = 0.067 Hectare), 3000 yuan/mu, 4000 yuan/mu, and 5000 yuan/mu, with a maximum of 20,000 yuan/mu.

As for tax reduction, every industrial company newly established in QJIS is eligible for an exemption from the district-level part of the Corporate Income Tax during the first three years and for a reduction of 50% of that part in the fourth and fifth years. In addition, every newly established company pays only 50% of the Added Value Tax/Business Tax in the first three years (Table 4).

Table 4. Categories of Taxes and Proportion of Taxes Retained.

	Central Government	Chongqing Municipality	Qijiang District
Corporate Income Tax	60%	N/A	40% ¹
Added Value Tax	75%	N/A	25% ²
Business Tax	N/A	40%	60% ²
Individual Income Tax	60%	16%	24%
Others	N/A	N/A	100%

¹ Fully waived for the first three years, pay half of it for the fourth and fifth years; ² pay half of it for the first three years.

(2) Recruiting Companies to Industrial Symbiosis

Due to high competition among the different industrial symbioses, recruiting companies to industrial symbiosis is regarded as the most important activity by the Administrative Commission [15]. In practice, company recruitment covers four steps: (1) information gathering; (2) site visiting; (3) decision making; and (4) agreement signing.

In the first step, the Administrative Commission of QJIS actively participated in high-level business forums and fairs held by the National Industry Associations and the Chongqing Economy and Information Technology Commission in order to collect information about potential companies. In the second step, the Administrative Commission paid a visit to the company and presented the preferential policies of QJIS. After the company showed the interest in joining the IS, an assessment report was prepared by the Company Recruitment Department of the Administrative Commission. The third step includes three stages: (1) The Company Recruitment Department took the lead in organizing a preliminary review meeting to discuss the interested company; (2) when the project was approved at the meeting, there was an assessment of the settlement conditions, where different departments were involved to assess issues such as the Land Department that is responsible for the land lease issue. After an agreement was reached on the relevant issues, these departments signed the preliminary review form for confirmation; (3) The Qijiang district government needed to approve. Afterwards, the Administrative Commission made a feasibility analysis, environmental impact assessment, investment intensity, economic benefit, and industry policy. In the fourth step, agreement signing, the representative of the company and various departments of the Administrative Commission attended the joint meeting for signing the company recruitment agreement. After that, the company would start the procedures for settlement in QJIS.

(3) Facilitating Companies' Settlement in Industrial Symbiosis

Appendix D illustrates the process through which companies have to go in the development phase. The Administrative Commission of QJIS played an important role in supporting the company in going through the entrance procedures at each stage through intensive interaction with different bureaus of the Qijiang district government.

5.3. Operation Phase of QJIS

After completing the settlement procedures, the company started to operate. Four anchoring activities have been identified in this phase: (1) providing by-product and utility synergies; (2) providing daily managerial support for companies; (3) seeking funding for scaling up industrial symbiosis; (4) promoting research and development.

(1) Providing By-Product and Utility Synergies

Qineng, founded in October 2008, is the major anchor company in QJIS, and there are 18 tenant companies. Qineng is composed of four divisions: an aluminum plant, a self-owned thermal power plant, railway, and electricity. The entire project was constructed in two phases, of which the first phase was completed in 2013. Up to the end of August 2016, Qineng has realized the virgin aluminum output of 215,800 tons and the generating capacity of 3.4 billion kwh. Except for the electric power consumed by the aluminum plant itself, it has the annual surplus electric quantity of about 1 billion kwh. This surplus electric quantity is supplied to other companies in the industrial symbiosis. Qineng sets up long-term cooperative relations with its tenant companies and directly supplies its molten aluminum to downstream companies, which not only saves transportation costs but also saves economic costs to cool aluminum and to melt aluminum. In terms of synergies, the opportunities provided by Qineng are thus primarily utility synergies.

(2) Providing Daily Managerial Support for Companies

After companies start to operate, providing daily managerial support to companies is the major activity for the Administrative Commission. For example, the legal department offers legal assistance, the safety and environment department manages safety, the labor department deals with workers' social protection, and the company service department provides (shares) utilities and services, etc.

(3) Seeking Funding for Scaling Up Industrial Symbiosis

The Administrative Commission of QJIS plays an important role in seeking funding. First, it established contact with various financial organizations including the China Merchants Bank, China Minsheng Bank, Foreign Economic and Trade, and Dongxing Securities. Second, it aims to obtain low-cost and long-term policy bank financing, and a focus has been placed on applying to the Agricultural Development Bank for projects of water conservation, construction of small towns, and land reclamation. In 2015, the Administrative Commission submitted an application to the Agricultural Development Bank for a 6.2 billion yuan loan with the maximum period of 20 years. In total, until 2016, the Administrative Commission has raised 4.6 billion yuan, among which 3.4 billion yuan was used to repay the capital and interest, 230 million yuan was used as the fund for land expropriation and demolition, 270 million yuan was used for historical construction payments in arrears, and 80 million yuan was used to support the local community.

(4) Promoting Research and Development

In order to promote the efficient management of industrial symbiosis, the Administrative Commission of QJIS has collaborated with technology consultant companies and universities, such as Tsinghua University and Chongqing University. The joint research and development focuses on energy management, information management, safety management, traffic management, and environment management of QJIS.

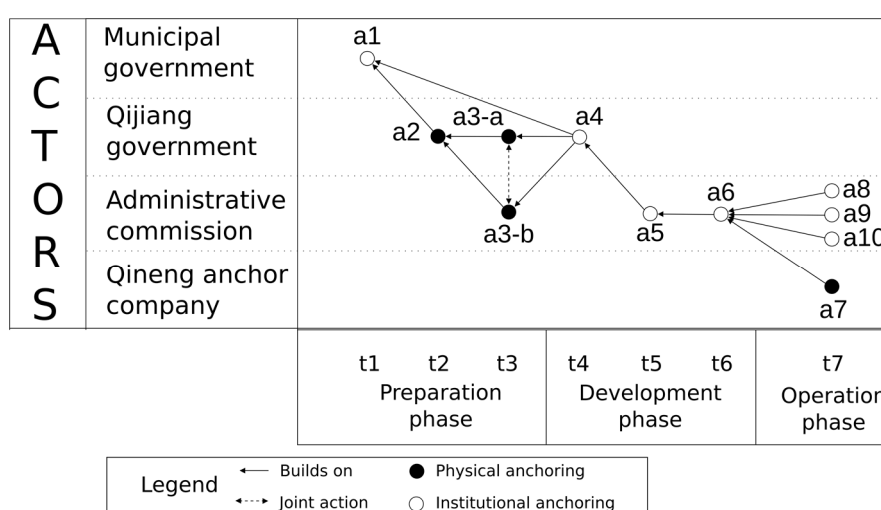
6. The Coordination of Anchoring Activities

Our observations regarding the case of Qijiang reveal that the various anchoring activities are clearly related to each other as part of a broader strategy to stimulate the development of industrial symbiosis in the area. Coordination of anchoring activities thus takes shape as a coherent set of very deliberate, top-down, efforts. In line with Paquin and Howard-Grenville [25], we refer to this particular type of coordination as *orchestration*, as to distinguish it from more serendipitous types of coordination. To bring this orchestration of the activities to the foreground, we summarized and visualized how the anchoring activities build on each other in Table 5 and Figure 3. We visualize the linkages as pointing 'backwards in time', to emphasize how activities build on activities that were performed earlier. Our understanding of the links between actions corresponds with Schatzki's [28] notion of *chains of action*.

The Chongqing municipal government developed an institutional bedding that promotes industrial symbiosis locally (activity 1). Subsequently, the Qijiang government started to build QJIS, and expropriating land is the prime step for site construction (activity 2). After completing the land expropriation, the Qijiang government and Administrative Commission provided physical infrastructure for the QJIS (activity 3). After completing the preparation of QJIS, the Qijiang government started to implement preferential policies to attract companies (activity 4). This was followed by the actual recruitment of companies (activity 5). After successfully recruiting companies, the Administrative Commission facilitates the attracted companies' settlement in QJIS (activity 6). After the company's settlement, the Qijiang anchor company provides by-product and utility synergies during its operation (activity 7). Meanwhile, during the operation phase, the Administrative Commission provides daily managerial support for companies (activity 8), seeks funding for scaling up industrial symbiosis (activity 9), and promotes research and development (activity 10).

Table 5. Anchoring activities in the case of Qijiang Industrial Symbiosis.

Phase	Id	Order	Activity	Actor(s)	Anchoring
Preparation Phase	a1	t1	Providing institutional setting	-National government -Municipal government	Institutional
	a2	t2	Expropriating land	-Qijiang government	Physical
	a3	t3	Providing physical infrastructure	-Qijiang government -Administrative Commission	Physical
Development Phase	a4	t4	Implementing preferential policies	-Qijiang government	Institutional
	a5	t5	Recruiting companies	-Administrative Commission	Institutional
	a6	t6	Facilitating companies' settlement	-Administrative Commission	Institutional
Operation Phase	a7	t7	Providing by-product and utility synergies	-Qineng anchor company	Physical
	a8	t7	Providing Managerial Support	-Administrative Commission	Institutional
	a9	t7	Seeking funding	-Administrative Commission	Institutional
	a10	t7	Promoting R&D	-Administrative Commission	Institutional

**Figure 3.** Narrative graph of the Qijiang case. Note: The nodes indicate physical and anchoring activities, the arrows indicate which activities build on each other (also see the legend below the figure), and the layout indicates the order in which the activities occurred from left to right. The reader should also note that the actors are ordered by the jurisdictional level at which they operate from top to bottom.

It is clear that the Qijiang government and the Administrative Commission are two key actors during the process, which indicates: (1) anchoring in this case is very much about creating local circumstances conducive to the development of industrial symbiosis; (2) Lots of anchoring activities have been coordinated by institutional anchors (i.e., the Qijiang government and the Administrative Commission), instead of traditional physical anchors, which reveals that in China, industrial symbiosis is a form of government-led planned anchoring rather than self-organization; (3) the Qijiang government and the Administrative Commission engage in both physical and institutional levels of activities, which problematizes the distinction between the institutional and physical anchors in the industrial symbiosis literature [6–8].

What is also interesting to see is that as the process unfolds, the anchoring activities seem to take place at increasingly specific jurisdictional/geographical levels, starting with the municipal level, then moving on to the Qijiang government, and then moving to the level of the industrial park itself (Administrative Commission). This suggests that institutional anchoring activities performed at lower levels presuppose/depend on preparations made at higher levels. The traditional 'physical' anchoring only comes into play when an institutional infrastructure has been put into place.

7. Conclusions and Discussion

In this article, based on a case study of industrial symbiosis development in China, we have sought to explain anchoring as activities that play a vital role in the industrial symbiosis dynamics, and develop a framework to analyze the sequencing and dependence of anchoring activities.

In the beginning of this research, we conducted a thorough literature review on existing publications regarding “anchoring” or “anchor tenant” in the field of industrial symbiosis, and identified a list of anchoring activities and categorized them into physical anchoring activities (which appear in the literature most often) and institutional anchoring activities, which forms the foundation of the framework we used in the empirical part of our study. The case site is the Qijiang Industrial Symbiosis, located in the south of the Qijiang District, Chongqing Municipality in western China. During data collection, 20 in-depth interviews with relevant stakeholders were conducted, such as governmental officials, staff members of the Administrative Commission, and the managers at companies.

Based on empirical data, 10 anchoring activities were identified to be vital to the dynamics of QJIS, which include providing an institutional setting locally, expropriating land for the industrial symbiosis construction, providing physical infrastructure, implementing preferential policies to attract companies, recruiting companies to industrial symbiosis, facilitating companies’ settlement in industrial symbiosis, providing by-product and utility synergies, providing daily managerial support for companies, seeking funding for scaling up industrial symbiosis, and promoting research and development.

Boons and his colleagues identify anchoring as a special case of an industrial symbiosis dynamic that they refer to as self-organization [1]. In this dynamic, the development of symbiotic activities is described as a result of self-motivated strategies of industrial actors, where an ambition to develop a network of symbiotic exchanges is initially absent. In this dynamic, linkages are typically developed more or less autonomously, driven by a variety of motivations and incentives from the individual industrial actors. These actions may be shaped by an underlying institutional context that influences the presence of trust among the actors, the presence of social norms, and regulations and policies that provide the boundary conditions for industrial symbiosis to occur [29]. The anchor tenant approach, then, describes the special case where a core industrial anchor attracts other actors, primarily for the benefit of the core actor, and where an industrial symbiosis network is built along the value chain of the anchor companies. The article of Boons [1] highlights that this is a widespread approach in China.

Our analysis of anchoring activities in the Qijiang case contradicts some of the ideas of Boons on the anchor tenant approach. Boons et al. define the anchor tenant approach as a special case of self-organization [1]. In a Chinese context, however, it is not self-organization but top-down planning that most strongly defines the anchor tenant approach. Our analysis reveals that, from the very beginning, anchoring activities were performed with the deliberate purpose of creating conditions conducive to the development of industrial symbiosis. This does not match with the idea that anchoring is a form of self-organized dynamics that start without the ambition to develop an industrial symbiosis network. Our analysis shows that anchoring can also be a deliberate strategy towards industrial symbiosis. This may particularly be the case in the Chinese context. Our observations also suggest that industrial actors are not necessarily the only or even the most important actors in performing anchoring activities. What Boons’ article describes as ‘providing the boundary conditions for self-organization’ [29], can actually be understood as taking the concrete form of institutional anchoring activities, as (primarily governmental) actors deliberately aim to create opportunities for industrial symbiosis to develop, and draw new industrial actors to a particular area. We also find that these anchoring activities clearly build on each other, and can be understood as parts of an overarching anchoring strategy. The dynamic of anchoring in the Chinese context is thus essentially different than the dynamic of anchoring as self-organization, as the latter emphasizes autonomous actions by individual industrial actors. This leads to the conclusion that rather than treating anchoring as a special case of self-organization as Boons et al. [1] suggest, anchoring should be considered as an industrial

symbiosis dynamic in its own right, that consists of two sub-types: (1) self-organized (i.e., those discussed in [29]) and (2) orchestrated (i.e., the approach used in this article) approaches to anchoring.

With our literature review and our empirical study, we also make other contributions to the theoretical discussions on anchoring. First, our focus on activities, rather than actors, provides a useful conceptual alternative to studying the role of anchoring in the development of industrial symbiosis. This is important because, as our empirical analysis shows, the same actor may engage in institutional as well as physical types of anchoring activities, which creates problems for conceptualizations that rely on a distinction between institutional and physical anchors [6–8]. We also identified how anchoring activities can be understood to build on each other, and how this sequencing of activities can be accompanied by a type of funneling approach, where anchoring activities occur at increasingly specific jurisdictional/geographic levels.

Our empirical findings are based on a single case study, which limits our ability to analyze how the observed anchoring activities were shaped by the specific institutional and social context in which they transpired. As we previously discussed, we hypothesized that the orchestrated nature of the anchoring activities observed in our case study can be partially explained by the social and institutional context of China. Similarly, the intimate link that Boons et al. [1] create between self-organization and anchoring might be explained by reference to the contexts of the cases that inspired them. However, in order to build support for (or against) this hypothesized link between social and institutional context and the top-down versus self-organized nature of anchoring activities, further research is required. Further research on the link between the context and anchoring activities would preferably take a comparative approach, comparing sequences of anchoring activities in different institutional and social contexts. A comparative approach may help identify typical sequences of anchoring activities, and reveal how these are linked to different contexts, thereby building a more generalized understanding of anchoring as an activity.

Given that the case of Qijiang is still in a relatively early stage of development, there is relatively little we can say about the link between the observed anchoring activities and outcomes. Here, we also observe a more general need to study the link between anchoring activities and outcomes. Based on previous research, we might expect the physical anchoring activities to lead to a hub-and-spoke network of exchanges, where multiple smaller companies link to larger companies that thereby develop a relatively high degree of relationships [1,30]. However, this does not yet account for the impact that institutional anchoring activities have on the evolution of the symbiotic network, and neither does it address the environmental and economic implications of anchoring activities. Thus, additional research is also required to address the relationship between anchoring activities and outcomes.

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Author Contributions: Li Sun, Wouter Spekkink, and Eefje Cuppen designed the research; Wouter Spekkink did the literature review; Li Sun conducted the fieldwork and analyzed the data; Li Sun and Wouter Spekkink drafted the paper. Eefje Cuppen and Gijsbert Korevaar finalized the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Details of Literature Studying

We selected the keywords for our literature study using the following steps. We started with a list of keywords that we derived from a literature study of industrial symbiosis literature that was performed earlier by Chertow and Park. We translated the list of keywords to the following search strings for Scopus:

TITLE-ABS-KEY (“industrial symbiosis”) OR TITLE-ABS-KEY (“by-product exchange”) OR TITLE-ABS-KEY (“by-product synergy”) OR TITLE-ABS-KEY (“industrial ecosystem”) OR TITLE-ABS-KEY (“eco-industrial”) OR TITLE-ABS-KEY (“resource synergy”) OR TITLE-ABS-KEY

("recycling linkage") OR TITLE-ABS-KEY ("recycling network") AND (LIMIT-TO (DOCTYPE, "ar")) AND (EXCLUDE (PUBYEAR, 2016))

And for Web of Knowledge:

TS = ("industrial symbiosis" OR "by-product exchange" OR "by-product synergy" OR "industrial ecosystem" OR "eco-industrial" OR "resource synergy" OR "recycling linkage" OR "recycling network") Refined by: DOCUMENT TYPES: (ARTICLE) AND [excluding] PUBLICATION YEARS: (2016) Timespan: All years. Search language=Auto

The results from the searches in Scopus and Web of Knowledge were merged, and double entries were removed, resulting in a list of 931 publications in total. The abstracts of these publications were downloaded and collected in an XLS file. We coded 50 randomly selected abstracts to identify papers that had relevance to our purposes. Papers were found relevant if (1) they mention something about the governance of industrial symbiosis; and (2) are based on empirical studies. Coding was done by placing marks (yes/no) in two separate columns. After coding 50 abstracts, we more closely inspected the content of all the coded abstracts (those that we deemed relevant as well as the ones we deemed irrelevant to our purposes) to develop new keywords to be included in search strings. The purpose of the new keywords was to obtain more specific results (e.g., more specifically about governance, and filtering out papers unrelated to industrial symbiosis). The search strings we used are as follows. For Scopus:

(TITLE-ABS-KEY ("industrial symbiosis") OR TITLE-ABS-KEY ("by-product exchange") OR TITLE-ABS-KEY ("by-product synergy") OR TITLE-ABS-KEY ("industrial ecosystem") OR TITLE-ABS-KEY ("eco-industrial") OR TITLE-ABS-KEY ("resource synergy") OR TITLE-ABS-KEY ("recycling linkage") OR TITLE-ABS-KEY ("recycling network")) AND (TITLE-ABS-KEY (collaborat*) OR TITLE-ABS-KEY (cooperat*) OR TITLE-ABS-KEY (polic*) OR TITLE-ABS-KEY (regulat*) OR TITLE-ABS-KEY (decision mak*) OR TITLE-ABS-KEY (manag*) OR TITLE-ABS-KEY (plann*) OR TITLE-ABS-KEY (govern*) OR TITLE-ABS-KEY (legislat*) OR TITLE-ABS-KEY (partnership) OR TITLE-ABS-KEY (coordinat*)) AND (EXCLUDE (PUBYEAR, 2016)) AND (LIMIT-TO (DOCTYPE, "ar"))

For Web of Knowledge:

TS = ("industrial symbiosis" OR "by-product exchange" OR "by-product synergy" OR "industrial ecosystem" OR "eco-industrial" OR "resource synergy" OR "recycling linkage" OR "recycling network") AND TS = (collaborat* OR cooperat* OR polic* OR regulat* OR decision mak* OR manag* OR plann* OR govern* OR legislat* OR partnership OR coordinat*) Refined by: DOCUMENT TYPES: (ARTICLE) Timespan: 1900–2015. Search language = Auto

We merged the search results from the two searches, identifying 666 potentially relevant papers. We downloaded the abstracts of these publications and coded all of them to indicate (1) their relevance to industrial symbiosis (yes/no); (2) the inclusion of empirical studies (yes/no); and (3) whether or not the study concerns a quantitative economic or environmental assessment (yes/no). We decided to focus on the selection of publications that are specifically relevant for industrial symbiosis and are based on empirical studies, but are not a quantitative assessment (these typically offered little detail about governance activities per se). Based on these criteria, 257 publications were selected. We then attempted to download all of the papers, but due to restricted access or language restrictions, we finally were able to download 202 publications.

For the current paper, we decided to do a specific search within our 202 publications, identifying those that specifically deal with anchoring or anchor tenants. We achieved this by simply searching all the 202 publications for any mention of the word "anchor" or variations thereof (e.g., anchoring, anchors). In this way, we identified 45 potentially relevant studies, although some of these only mention something related to anchors or anchoring once or twice. These publications were included in our final literature review. Our approach in this is discussed in the methods section of our paper.

Appendix B. Overview of Anchoring Activities and Publications in Which These Are Observed

Table A1. Overview of Anchoring Activities and Publications in Which These Are Observed.

Activity	Type	References
Create opportunities for by-product and utility synergies	<i>P</i>	Lowe 1997; Chertow 2000; Korhonen 2002; Heeres, Vermeulen & De Walle 2004; Fichtner et al., 2005; Gibbs and Deutz 2005; Bansal and McKnight 2009; Liwarska-Bizukojc et al., 2009; Costa and Ferrão 2010a; Costa and Ferrão 2010; Chertow and Miyata 2011; Martin and Eklund 2011; Zhu and Ruth 2014; Gregson et al., 2015; Mannino et al., 2015 Lowe 1997; Lambert and Boons 2002; Eilering and Vermeulen 2004; Heeres, Vermeulen and De Walle 2004; Zhu and Ruth 2014; Park et al., 2008; Liwarska-Bizukojc et al., 2009; Costa and Ferrão 2010a; Lehtoranta et al., 2011; Martin and Eklund 2011; Yu, De Jong and Dijkema 2014; Mannino et al., 2015
Provide (share) utilities and services	<i>P</i>	Korhonen 2002; Eilering and Vermeulen 2004; Von Malmborg 2004; Bansal and McKnight 2009; Liwarska-Bizukojc et al., 2009; Costa and Ferrão 2010a; Martin and Eklund 2011
Provide physical infrastructures	<i>P</i>	Von Malmborg 2004; Liwarska-Bizukojc et al. 2009; Costa and Ferrão 2010a; Martin and Eklund 2011
Facilitate interaction between stakeholders	<i>I</i>	Heeres, Vermeulen and de Walle 2004; Von Malmborg 2004; Wolf, Eklund and Söderström 2007; Bansal and McKnight 2009; Liwarska-Bizukojc et al., 2009; Costa and Ferrão 2010a; Martin and Eklund 2011; Boons and Spekkink 2012; Veleva et al. 2015
Provide knowledge and expertise	<i>I</i>	Heeres, Vermeulen and de Walle 2004; Von Malmborg 2004; Liwarska-Bizukojc et al., 2009; Martin and Eklund 2011; Veleva et al. 2015
Maintain close contact with relevant stakeholders	<i>I</i>	Von Malmborg 2004; Liwarska-Bizukojc et al., 2009; Costa and Ferrão 2010a; Pakarinen et al., 2010; Lehtoranta et al. 2011
Provide platforms for education	<i>I</i>	Heeres, Vermeulen and de Walle 2004; Von Malmborg 2004; Boons and Spekkink 2012; Veleva et al., 2015
Implement supporting laws and regulations	<i>I</i>	Von Malmborg 2004; Martin and Eklund 2011; Boons and Spekkink 2012
Make inventories and databases of inputs and outputs	<i>I</i>	Lowe 1997; Van Leeuwen, Vermeulen and Glasbergen 2003
Provide political support	<i>I</i>	Martin and Eklund 2011; Veleva et al., 2015
Set beneficial prices	<i>I</i>	Liwarska-Bizukojc et al., 2009; Eilering and Vermeulen 2004
Promote the area	<i>I</i>	Martin and Eklund 2011
Recruit other companies for establishment	<i>I</i>	Lowe 1997; Van Leeuwen, Vermeulen and Glasbergen 2003
Act as owner of industrial symbiosis projects	<i>I</i>	Baas 2011
Provide managerial support	<i>I</i>	Veleva et al., 2015
Be a role model	<i>I</i>	Von Malmborg 2004

Appendix C. Papers Included in the Review

Baas, L. (2011). Planning and Uncovering Industrial Symbiosis: Comparing the Rotterdam and Östergötland regions. *Business Strategy and the Environment*, 20, 428-440.

Bansal, P., & McKnight, B. (2009). Looking Forward, Pushing Back and Peering Sideways: Analyzing the Sustainability of Industrial Symbiosis. *Journal of Supply Chain Management*, 45(4), 26-37.

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Heeres, R. R., Vermeulen, W. J. V., & de Walle, F. B. (2004). Eco-industrial park initiatives in the USA and the Netherlands: first lessons. *Journal of Cleaner Production*, 12(8-10), 985-995.

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Appendix D. Company's Settlement Procedures to Qijiang Industrial Symbiosis

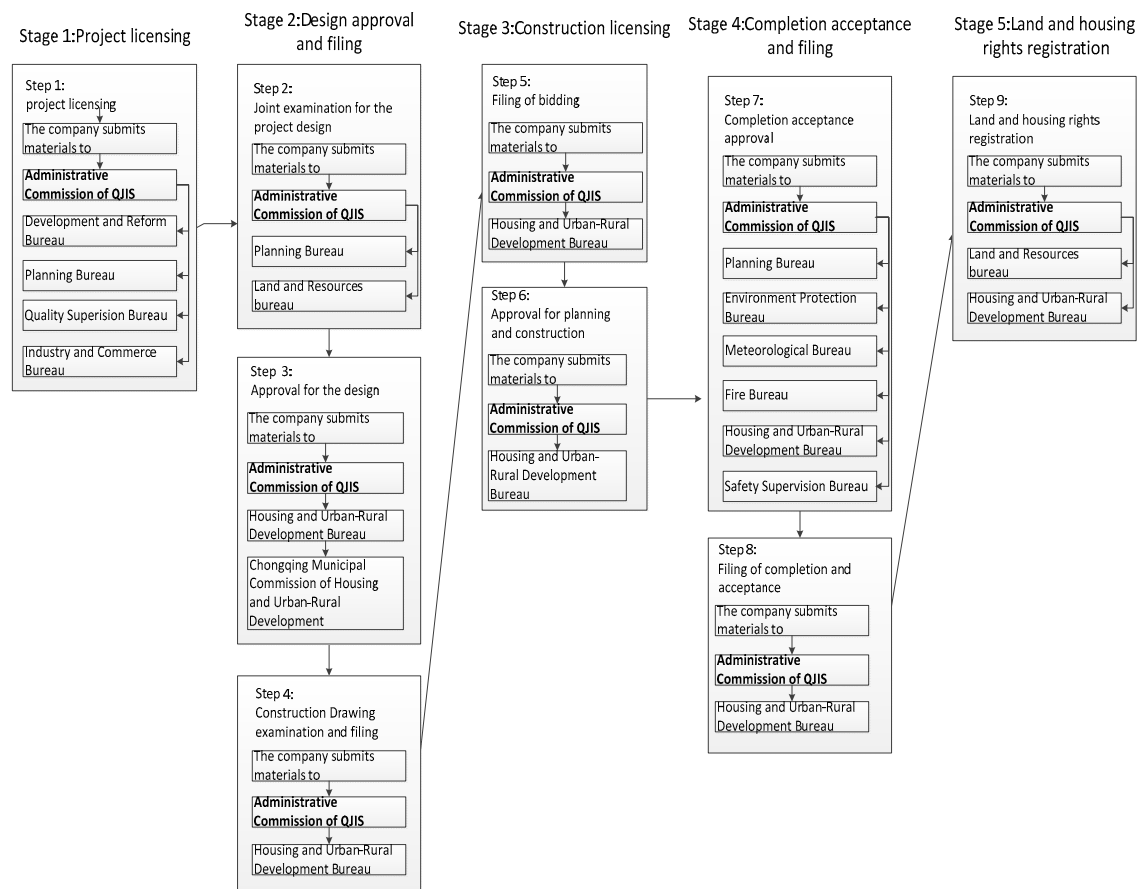


Figure A1. Company's Settlement Procedures to Qijiang Industrial Symbiosis.

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