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Durable Policy Facilitation of Sustainable Industrial Parks in China: a perspective of co-evolution of policy processes

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Abstract: For some time, China has engaged in durable governmental facilitation of the development of Sustainable Industrial Parks (SIPs). This has materialized through two policy programs: one stimulating Eco-industrial Parks (EIPs) and one advancing Circular Economy Industrial Parks (CEIPs). Given their overlapping objectives, we conceive of the interaction of these programs as a process of policy co-evolution, seeking to understand in what ways they have reinforced or dampened each other, and consequently, its effects on the diffusion of SIPs in China. Using event-based analytical tools, we show that 1) each program constituted a selection environment for the other, indicating that co-evolution took place; 2) the orchestration from powerful actors in the Circular Economy policy led to the change of types of co-evolution from the interference and potential competitions to symbiosis that brought about similar diffusion patterns of CEIPs and EIPs; 3) co-evolution was especially evident in the earlier periods of the policy processes, when policy actors strived to create a fit with broader social and physical environment; and 4) along with the established primary adaptation and shifted policy goals toward effective policy outcomes, the co-evolutionary dynamics became less intensive; and the combination of these factors eventually produced wide diffusion of SIP concept in diverse types of industrial parks.

Keywords: policy facilitation; co-evolution; policy durability; Eco-industrial Parks; Circular Economy Industrial Parks; China

1 Introduction

For a number of years, China's government has actively facilitated the development of SIPs through nationwide policy programs of EIPs and CEIPs. Positive outcomes of these policy programs have been observed (e.g. Bai et al., 2014; Tian et al., 2014; Jiao&Boons 2017), indicating the significance of governmental facilitation for developing of SIPs. Existing studies of Chinese SIP policies focus on either the CEIP policy or EIP policy, including reviews of policy progress (e.g. Shi et al., 2012; Su et al., 2013), evaluation of policy performance (e.g. Tian et al., 2014), critical analysis of policy instruments (e.g. Geng et al., 2012), and the evaluation of local SIP practices (e.g. Shi et al., 2010). These studies have generated a rich scholarly understanding of the dynamics of governmental facilitation of SIPs (Jiao&Boons 2014).

However, to gain deeper insight into the dynamics of governmental facilitation, two issues need to be addressed further. The first is how policies for long term developments such as SIP-development can be maintained over longer periods of time. The significance of governmental policy for the development of SIPs has been widely recognized (Costa et al. 2010; Geng et al. 2013; Deutz&Ioppolo 2015; Wang et al., 2017); however, we still lack insights into the ways through which policy actors continuously safeguard SIP policies against

various undermining forces and adapt to changing institutional contexts (Jiao&Boons 2017). We will use the concept of policy durability (Lockwood, 2013; Patashnik, 2008; Jiao&Boons 2017) to gain insight into this. The second issue is about how policy processes overlap and interact. Policies are complex and adaptive (Gerrits, 2008), and interactions between policy processes occur regularly (Byrne and Callaghan 2014). The resulting complexity challenges our understanding of the dynamics of governmental facilitation in general, and the durable governmental facilitation of SIPs in particular. Theoretically, co-evolving policies can compete or support each other, thus undermining or reinforcing the development of SIPs. The co-evolutionary relation was noticed in a previous study of Chinese policy facilitation of CEIP (Jiao&Boons 2017) where CEIP policy was analysed as an individual policy process with concentration on internal policy dynamics. Also, Zhang et al. (2010) observed some overlaps between the Chinese policies of CEIP and EIP. There is thus initial evidence that the two policies did not evolve independently but interacted as time passed. They share a common interest in SIP, but with a different emphasis, which created the space for their mutual influence. The co-existence of these two programs allows us to study the potential effects of co-evolution.

By addressing the aforementioned, we intend to make three contributions to the literature and to the policy efforts of SIPs and similar environmental policies. First, theoretically we focus on the co-evolution of SIP policies, which can improve our understanding of the co-evolutionary dynamics (e.g. how they co-evolve and types of co-evolution) of environmental policy efforts. Second, methodologically we take into account that cases which have been presented in isolation, are in fact a part of a wider web of processes, through developing the approaches of Event Sequence Analysis and Social Network Analysis of policy assemblage. Third, practically the effects of co-evolutionary policies manifest the consequences of having two policy programs with overlapping goals. It is of great importance to identify whether this is a waste of resources, or instead accomplishes more than that a single program could do.

In this article, we argue that co-evolution is one potential dynamic for creating (non)durable policy and can further influence the development of SIPs. It is built on a previous study of policy durability of CEIP in China (Jiao&Boons 2017). In that study, the concept of policy durability is introduced and the framework of policy translation is developed, which consists of policy translation patterns and different types of policy durability. The framework is adopted to reveal the processes that brought about durable policy facilitation of CEIP in China. Building on that study, in this article we bring the concept of policy durability further by analysing 1) the co-evolution of policy processes of CEIP and EIP, as a dynamic of creating durable policy facilitation of SIPs; and 2) the impacts of their co-evolution on the overall development of SIPs in China. Our central research questions are:

- 1) *How did the policy processes of EIP and CEIP co-evolve over time, and did their co-evolution undermine or reinforce the durable policy facilitation of SIPs in China?*
- 2) *What were the effects of the durable and co-evolving policies on the overall diffusion of SIPs in China?*

The article is organized as follows. In section 2, we introduce the conceptual framework.

In section 3, the methodology is described, and section 4 presents the results. In section 5, we identify types of co-evolution, and discuss the successive dynamics in the entire period of time, and connect the policy processes to the diffusion of SIPs in China. Section 6 presents our conclusions.

2 Conceptual Framework

The relevance of durable policy facilitation for SIP development

Policy durability means stable, coherent and integral policy support and facilitation over a longer period of time for a given policy issues (Patashnik, 2008; Lockwood, 2013). It has particular relevance for the realization of SIPs (Jiao&Boons, 2017), due to the fact that the development of SIPs is a long term process. First, industrial symbiosis, the basis for a SIP, is a long term complex process of emergence, development, and decline of networks of by-products synergies and utility sharing (Boons et al. 2014; Boons et al. 2016). The work of Paquin and Howard-Grenville (2012), and Domenech and Davis (2011) supports this by distinguishing different phases of industrial symbiosis development. Second, a SIP cannot be achieved once at all, but is an outcome requiring sustained efforts. As argued by Chertow and Miyata (2011), and Ashton (2011), unless tangible or intangible benefits show up when creating the symbiotic network, companies rely more on supply chains or their own industries, rather than on cooperation with their neighbors for obtaining resources. Due to these reasons, the key question for policy makers is inspiring or even “seducing” companies to implement the practices induced by a SIP policy. In addition, the implementation can encounter barriers, leading to superficial policy outcomes and even policy failures (Patashnik 2008). For instance, EIP is sometimes merely regarded as a policy symbol and taken as a strategy of regional development and investment attraction, and often economic goals get more priority than environmental goals (Deutz&Gibbs 2004). Also, inconsistencies and tensions can exist between generating private (i.e. individual company) profits and shared (i.e. collective performance of companies in industrial parks) performance (Posch et al. 2011). Hence, a long term governmental commitment is crucial to convince and support industries to make continuous investment of time, energy, and resource in SIP. Importantly, policy actors need to deliberately adjust goals and means in the long term policy process (e.g. Park, et al. 2016; Chertow 2007) to create a dynamic fit between policy and the progress of SIP practices, thus preventing the loss of interests of industries or firms dropping out of the industrial symbiotic network.

Co-evolution of Policy Processes

The question of achieving durable policy support for SIP development is complicated when two policy programs are simultaneously seeking to support this development. To understand the consequences of this we turn to complexity theory, and more specifically the concept of co-evolution (Byrne and Callaghan, 2014). The basic idea of co-evolution is that the fit between two or more coupled systems is created and maintained through reciprocal selections (Gerrits, 2011). Specifically, in coupled systems feedback loops carry information (e.g. changes of one system) that becomes the selection pressure for the other coupled systems. So, the reciprocal selection is “a simultaneous process that consists of continuous feedback loops between systems (Gerrits, 2011)”. The systems then make adjustments and responses. The reciprocal selection and mutual adjustment are circular processes that shape

the future state of the systems.

The concept of co-evolution is originally about the relations between evolving biological systems (Odum, 1971), but has subsequently been adopted to interactions between social systems (e.g. Ruhl, 1999) and between social system and physical systems (Kallis and Norgaard 2010). The major difference is that the social system actors seek to “steer” the direction and speed of evolution, while entities in the biological/physical system do not have that reflexive ability (Mulder & Vand den Berg, 1999; Edelenbos, 2008). This is because social actors can anticipate and respond to changes of the coupled systems.

Gerrits (2008) conceptualises policy processes as Complex Adaptive Systems. Policy processes become environment of each other, thus shaping the evolving trajectory of each other, i.e. they co-evolve over time. Co-evolutionary relations can be classified into three types (Odum 1971): interference, parasitism and symbiosis.

- In an *interferential relation*, the interactions of systems mutually restrain the development of each other. For instance, the interactions of two policy processes mutually hinder the achievement of continuous policy development of each other.
- *Parasitism* occurs when the development of one system occurs at the cost of the other. For instance, the interactions between two policy programs lead to termination of one, and continuous development of the other.
- When all the coupled systems benefit from their interconnections and reach more favourable states, *symbiosis* takes place. For instance, the interactions between two policy processes mutually reinforce the continuous policy development of each other.

We use this typology to analyse the dynamic interactions between the two policy programs that aim to facilitate SIP development. To operationalize these types, we build on earlier work which provides an empirically analysis of SIP policies as evolving policy assemblages of ideas, objects, practices and actors, along with the unfolding of policy translation process (Jiao & Boons, 2014; Jiao & Boons, 2017).

Policy translation and policy assemblage

Durable policy facilitation of SIPs does not mean that the policy content remains static. Instead, it requires deliberate policy adjustment to create a dynamic fit with a constantly changing context. A durable policy is thus a complex and adaptive process that is actively shaped by policy actors through reinterpretations and modifications to adapt to the changing circumstances (Gorur, 2011). To analyse this, the theoretical concept of policy translation (Freeman, 2009) is helpful. The translation perspective highlights that, in policy-making process, policy ideas are generated throughout the process, and eventually become objectified and materialized into linguistic and material objects by policy actors. As a result policy evolves over time (Jiao & Boons, 2014). Therefore, we examine policy processes through reconstructing the sequence of policy events where policy ideas are generated, objectified, materialized, and subsequently are modified or dissolve. Policy events occur across horizontal (different governmental departments) and vertical (cross governmental layers) levels. To study the sequence, we use a typology developed by Jiao and

Boons(2017)of six translation patterns, each of which presents a typical sequential pattern of events¹. Each pattern begins with a major policy decision. Any longitudinal policy process can consist of a sequence of different patterns, delineating the overall policy process into successive phases (Teisman, 2000).

Moreover, we take the policy translation perspective a step further. Translation is taken as a core concept of Actor-Network Theory (Latour, 1986; Law, 2009). It is the key mechanism for the gradual building up of the social and natural world (Callon, 1986). Therefore, Actor-Network Theory encourages scholars to trace the detailed process of how heterogeneous entities, including human and non-human actors, gradually assemble, and how the relations between these entities become strengthened or instead dissolve (Latour, 2005). Applying this to policy processes this directs attention towards the way in which heterogonous policy components (e.g. central ideas, types of people, certain techniques, and resources), progressively mobilize, juxtapose, hold together and establish a temporally stable policy assemblage (Law, 1992; Gorur, 2011; Mol, 2011; DeLanda, 2006; Jiao&Boons 2014). The policy assemblage(Fig. 1), a central concept in our approach, refers to an association of heterogeneous policy components, including ideas, objects, practices, actors, under certain policy labels (Jiao&Boons, 2014; Jiao&Boons, 2017). Along with the unfolding of policy events, a policy assemblage is created, maintained, and reshaped over time. The termination of policy program can even lead to the dissolution of a policy assemblage.

Fig.1Components of A Policy Assemblage

Thus, we study policy processes as a translation process from two angles. The first is re-constructing the sequence of policy events that moves a certain policy concept forward; the second is mapping the policy assemblage as well as its changes over time. The two angles allow us to holistically examine the dynamic nature of policy processes. This particularly benefits our interest in the co-evolution of policies. In a situation where two or multiple policy processes co-evolve, the policy events that belong to different policy trajectories influence each other. This influence may be intended (i.e. revealed from policy event sequence), but it may also be the result of policy components that are shared by several programs(i.e. revealed from policy assemblage). Thus, their assemblages become linked. This is essentially a bottom-up process of building up a large assemblage (DeLanda 2006).Therefore, combining these two angles allows us to systemically study the co-evolution of policy processes, and dig deeper into their contribution to durable governmental facilitation of SIPs.

Diffusion of SIPs

Creating durable policies is a means to an end. The ultimate goal of policy actors is to achieve

¹ For further detailed contents about the translation patterns, see Jiao and Boons (2017).

specific policy outcomes. To assess the outcomes of governmental efforts on SIPs development we examine the overall diffusion patterns of SIPs in China, including EIPs and CEIPs, looking specifically at the number and diversity of diffusion. The number refers to the newly involved industrial parks in each phase of the policy processes. The diversity indicates the variety of industrial parks that have become involved in programs, i.e. the extent to which the policy concept of SIP is diffused in diverse industrial parks. Diversity is examined through the indicators of spatial location, levels of administration, and industrial structures of industrial parks:

1) The delineation of three super-regional systems of China (eastern, central and western China) is adopted to assess the spatial distribution pattern of SIPs;

2) According to the hierarchy of the administrative bodies of industries parks in the governmental system, industrial parks can be classified into national level industrial parks and provincial level industrial parks;

3) Building on the number and diversity of industrial sectors in industrial parks, they can be classified into sector-integrated industrial parks, sector-specific industrial parks, and venous industry based industrial parks. The venous industry based industrial parks refer to industrial parks that focus on recycling and reusing waste from existing industrial clusters or urban areas, like the veins in human body.

In addition, we are interested in the overall outcome of diffusion of SIPs because the survival of co-evolving policy programs does not necessarily mean that positive outcomes are achieved for the development of SIPs. For instance, the survivals of both policies may lead to competition and ineffective allocation of governmental funds, and thus to poor SIP development. In contrast, the development of one policy program, which is on the cost of the termination of another, may result in wide diffusion of SIPs due to concentrated and effective usage of governmental funds. The conceptual framework of this study is summarized in Figure 2. While we highlight the role of co-evolutionary dynamics, we acknowledge that other factors (e.g. Yu et al.2014) impact on the diffusion process.

Fig. 2 Conceptual Framework

3 Methodology

Data Collection

We collected the data for the EIP and CEIP policy programs separately. For the EIP policy the main types of events are national governmental actions in formulating and implementing the *China National EIP Demonstration Program*. For the CEIP policy², the main types of events are national governmental actions in formulating and implementing the Circular Economy

²Circular Economy in China is defined as a rather comprehensive concept, covering the levels of firms, industrial parks, and regions.

Pilot program at industrial parks level³. The main data sources for both programs were archives and written materials, including governmental reports (policy documents, speeches, progress and reports) and news items. These documents were collected in a search of the database of State Environmental Protection Agency (SEPA) and National Development and Reform Commission (NDRC). If a document was mentioned but couldn't be downloaded in these databases, we searched for them using Google and Baidu⁴ search engines. Data collection took place from November 2011 to March 2013. The data were saved in two separate files, CEIP file and EIP file. These were the data sources for both the construction of event sequences and the identification of policy assemblages, as will be described below. In addition, the data of EIPs and CEIPs were collected, including the number of industrial parks registered under either category, the time of their involvement in policy programs, and their spatial location, levels of administration, and the number and dominance of industrial sectors.

Sequence Construction and Phase Identification

Following the steps of Event Sequence Analysis as developed by Boons et al. (2014), we have reconstructed the event sequence of the CEIP policy and identified phases in our previous study (Jiao&Boons 2017). With the collected data, the basic steps of analysis included incident coding, event colligation, intentional linkages coding, breakpoint identification, and phase delineation. In a similar way, we reconstructed the event sequence of the EIP policy and delineated phases. As our goal is to understand the co-evolutionary relations of the two policies, we further established a large event table of SIP-related policies by integrating the events tables of CEIP and EIP. Eventually, the overall event table consisted of 95 events, chronologically arranged(see Appendix 1 for the event table). We then coded the intentional interconnections between the two policy trajectories. It means that if a later event (e.g. a meeting organized by a set of policy actors) intentionally referred back to an earlier event (e.g. decision of cooperation between policy actors), we draw an arrow between the two events (Fig. 3).

Fig. 3 Policy sequences and intentional linkages

Mapping Policy Assemblage

Building on the data sources (e.g. policy documents) collected, and the events constructed as mentioned above, we mapped the policy assemblage. In the CEIP case, the evolving policy

³As our central theme is SIP related policies, we focus on CE policy at the level of industrial parks, skipping the contents of CE policy at the operational levels of firms and regions. This is similar to our previous work (Jiao&Boons 2017).

⁴Baidu is a search engine, used specifically in China.

assemblage of CEIP has been established (Jiao&Boons 2017). Following the same steps, we first coded the policy components of ideas, objects, practices, actors, and policy labels of each policy event in the EIP policy trajectory. We then conducted a focused coding of the two policies through grouping similar codes to arrive at a same level of abstraction and format. In this way, each event was deconstructed into heterogeneous policy components(labels, objects, ideas, practices and actors). Second, all the components and events of each phase were imported into Gephi software as a two-mode network graph. Nodes were partitioned into two types: events and policy components, respectively. The graph then visualizes the policy components present in different policy events(Fig. 4).We then adopted the function of MultiMode Networks Projection to transform the two-mode network into one-mode (i.e. policy components)network graph (i.e. policy assemblage). The rationale of the visualisation is that if two policy components are present in one event, an edge between the two components can be drawn. In the graph, the size of nodes represents frequencies of occurrences, and the thickness of edges represented the frequencies of the co-occurrences of any of the two nodes(Fig.4).

Fig. 4 Projection from two-mode to one-mode network

The analysis of each policy assemblage combined qualitative interpretation and quantitative assessment via the approach of Social Network Analysis (Borgatti et al. 2009). We drew the centre of the assemblage in order to analyze main policy components and their relations. To do so, we selected the ten components with the greatest Eigenvector Centrality of policy assemblage of that phase. The underlying idea of Eigenvector Centrality is that the component that connects other central components is more central, which reflects importance or authority of policy components in the assemblage (Ruhnau, 2000; Bonacich, 2007). Within the central assemblage, we further identified smaller clusters through examining the linkages with normalized weights higher than 0.20. The components that are grouped into one cluster represents that these components frequently co-occur in the same policy events. The linkages between different clusters helped us derive better interpretations of the co-evolutionary relations of the two policy programs.

4 Results

4.1 Policy processes of EIP and CEIP and phases

CEIP Policy Trajectory. In 1998, a Working Group of Shanghai Agenda21st organized a trip

in Germany to learn sustainability-related practices. A professor in the Working Group was inspired by the concept of Circular Economy. Afterwards, he published several articles and news reports to introduce the concept Circular Economy into China (Zhu, 2009). In 2002, SEPA picked up the concept and initiated the National Demonstration Program of Circular Economy Zone. This was the first stage of Circular Economy policy in China (Fig.5, CEIP trajectory, stage a). The second stage (stage b) began with the emergence of active policy actions of NDRC. NDRC gathered a research group and developed a report about developing Circular Economy in China. The report was submitted to and got positive feedbacks from the State Council. Supported by the State Council, NDRC then established an investigation group, organized seminars, and drafted *Instructional Views on Promoting Circular Economy Development in China*. Meanwhile, SEPA also organized a *Circular Economy Experience Sharing Meeting*, during which SEPA reinterpreted its role, and highlighted the importance of NDRC and cooperation between ministries, in facilitating Circular Economy. Mostly, stage b was featured by the emergence of an anti-force against the primary role of SEPA in coordinating Circular Economy policy. However, the tension was weakened by the publication of programmatic document of *Several Opinions of Speeding up the Development of Circular Economy* by the State Council. This was the starting point of stage c. The document defined policy goals and means, and indicated the central role of NDRC and the importance of cooperation among ministries. Then NDRC, cooperated with five ministries, initiated the first (2005) and second (2007) batches of Circular Economy pilots, including CEIPs. Meanwhile, they engaged in developing policy instruments (e.g. Circular Economy indicator, Circular Economy standardization), and more importantly, NDRC took the lead in drafting *Circular Economy Promotion Law*. The breakpoint between phase c and phase d was the enforcement of *Circular Economy Promotion Law*, manifesting the institutionalization of Circular Economy in China (Zhu, 2007). Following the law, the programs of Circular Economy Transformation of Industrial Park, and Urban Mining were initiated, with the approaches of piloting, periodic performance evaluation, contracting and refunding system, presenting a mixture of experimental and administrative approaches.

EIP Policy Trajectory. The concept of EIP was introduced in China through a Special Issue: *Industry and Environment*, published by United Nations Environment Programme in 1997 (Shi et al., 2010). The concept was picked up by SEPA who initiated National Demonstration EIP Program in 1999. This was the starting point of EIP policy process. The overall process underwent two stages (Fig.5, EIP trajectory). In the first stage (stage A), SEPA was the key policy actor, who pioneered to embed the innovative concept with a western origin in the Chinese context. Before developing explicit policy goals and means, SEPA firstly selected pilots, and then inquired into research and international similar experience to accumulate knowledge. The provisional policy documents about management procedures and planning guidance was published after two-year piloting. Mostly, the stage was a major process of learning by doing, and it was characterized by tentative attitudes and experimental approaches, relatively open to Chinese contexts. The breakpoint between stage A and B was the establishment of coalition among three ministries: SEPA, Ministry of Commerce (MOC), and Ministry of Science and Technology (MOST). The established of coalition resulted from the idea of concentration on eco-transformation of national level industrial parks that were

mainly coordinated by MOC and MOST. The coalition engaged in adjusting previous policy papers, and formalizing them as National Environmental Standards, and also fashioning the concept of EIP through connecting EIP to other heated national policy themes, such as energy conservation and emission reduction and low carbon economy. The stage B was evolving toward more cooperative and administrative approaches.

Two policy trajectories together. Following the steps as described in section 3, an event graph with five successive phases (Fig.5; Table 1) is arrived at. The policy events of CEIP and EIP are more intentionally connected in the first three phases (e.g. events of 8,11,12,14,15,25,30,36) than that in the last two phases. There is a clear and gradual division of the highly intersected one-channel beginning into two separated trajectories yet accompanied with certain intentional interconnections. We will analyze the interconnections in details in the following section.

Fig. 5 Event Sequence and Phases

Table 1 Phases of overall event sequence

Phase	Period	Description
1	06/2000-12/2003	Both the concepts of Circular Economy and EIP were translated into Chinese national policy programs by SEPA around the same time. This was the starting point of the policy processes of Circular Economy and EIP.
2	01/2004-06/2005	The breakpoint between phases 1 and 2 was the emergence of NDRC as an active actor in facilitating the development of Circular Economy. At the same time, SEPA reinterpreted the concept of Circular Economy and its own role, highlighting the importance of cooperation between governmental departments. In this phase, the Circular Economy and EIP policies start to separate into two policy distinctly evolving trajectories.
3	07/2005-03/2007	The breakpoint between phase 2 and 3 was the publication of a programmatic document entitled <i>Several Opinions of Speeding up the Development of Circular Economy in China</i> by the State Council. It emphasized the importance of cooperation between governmental departments to facilitate the circular Economy development.
4	04/2007-08/2008	The breakpoint between phase 3 and 4 was the establishment of a coalition between SEPA, MOC and MOST to facilitate the development of EIPs in China.
5	08/2008-12/2011	The breakpoint between phase 4 and 5 was the Circular Economy legislation in August 2008, reflecting the institutionalization of Circular Economy in China.

Fig. 6 Policy Assemblage from phase 1 to 5

4.2 Interconnections

In this section we analyse the way in which the policy assemblages of the two processes intersect. We do this by analysing the combined dataset of both processes. This forms the basis for our analysis of co-evolution between the CEIP and EIP programs.

Phase 1. The policy assemblage for the combined processes shows a central cluster which is constituted by the main policy components of both Circular Economy and EIP (Fig.6). Central in this cluster is the actor SEPA, who in this phase established itself as the single shared central actor. As described in the previous section, SEPA initiated programs of EIP and Circular Economy Zone at the same period of time. To create the possibility of acting as the single coordinator of the both programs, SEPA differentiated the two programs by concentrating on different operational levels, i.e. EIP at the industrial park level, and Circular Economy at the regional level (e.g. city or province). Therefore, as showed in Figure 6, two pilots of Circular Economy program (i.e. Liaoning province and Guizhou province) linked to an existing program of Eco-Zone, which was about ecologically transition of regional system. Both the policy assemblage graph and the event graph (Fig. 5) show an integrated starting point of the two policies, characterized by SEPA as the most central coordinator with intentions of simultaneously making and implementing Circular Economy and EIP policy programs at different operational levels.

Phase 2. From phase 1 to 2, the single central cluster of the policy assemblage splits into two: a Circular Economy cluster and an EIP cluster, respectively (Fig.6). The EIP cluster displays a structure similar to that in phase 1. In the Circular Economy cluster, the policy actor of NDRC, linked to the State Council, are strongly connected with the Circular Economy label through learning, discussions and seminars. Although the two policy labels now clearly constitute two separate clusters, they share some common ideas. The most central idea is Restructuring Industrial Parks, reflecting an overlapping overall interest of the two policies. Other shared ideas include reduce, reuse, recycle, transformation of economy, resource productivity, and resource recovery. However, while the first five ideas associate more closely with Circular Economy concept, the last one links more frequently with the EIP label.

Generally, the evident feature of phase 2 is the divergence of the two policies, as indicated by the division of two clusters in the assemblage, and the reduction of interconnections between events of the two processes (as can be seen in the event graph; Fig.5). The divergence results from the emergence of NDRC with proactive and ambitious intentions to facilitate Circular Economy. Furthermore, the intentions did not connect to the previous Circular Economy Zone program that was initiated by SEPA in phase 1, but was instead a beginning with new interpretations and actions (event 16 and 17), supported by a powerful actor, i.e. State Council. Therefore, NDRC to a large extent replaced SEPA in coordinating Circular Economy. This probably led to the great reduction of the interconnections between two policies. Furthermore, their overlapping interests in industrial parks provided potential competition in enrolling industrial parks and attracting resources (e.g. governmental funds) in subsequent phases. It shows that the instabilities of CE policy trajectory intervened the development of the EIP policy, and they started to perform a co-evolutionary relation.

Phase 3. Intentional interconnections of the two policies were built between events 28/30

and 38 (Fig. 5). It concerns the publication of Assessment of Standards of EIPs by SEPA (event 38), which referred back to the Guiding document of Several Opinions of Speeding up the Development of Circular Economy by State Council (event 28) and SEPA's re-interpretation of its role in facilitating the development of Circular Economy (event 30). Through the intervention of the powerful actor of the State Council in the policy trajectory of Circular Economy(event 28)⁵, SEPA gave up its leading role in facilitating Circular Economy and concentrated mainly on EIP policy. Consequently, the policy trajectories of CEIP and EIP became sustained as two separated trajectories, and the intentional interconnections were mainly about SEPA's re-identification of its leading role in the EIP program, and supporting role in the CEIP program.

The policy assemblage for this phase again shows the two-cluster structure (Fig.6). A major difference with the previous phase is that both clusters expand substantially as a result of new policy components becoming attached. In the EIP cluster these include regional actors; in the CEIP cluster they are ideas and a range of ministerial level actors (e.g. MOST, Ministry of Finance-MOF, MOC, and National Bureau of Statistics). Along with this growth, the interconnections between the two clusters also increase. In addition to the shared ideas as listed in phase 2, strong connections occur between SEPA and NDRC, as a result of cooperation between NDRC and SEPA in coordinating CEIP program. Generally, the two policy programs remain distinct. Both clusters grow substantially, and they become more interconnected with bridging roles of SEPA. This indicates favourable effect of the separation yet increase linkages of the two programs, reflecting mutual reinforcement for each other.

Phase 4. In the following phase the two policy trajectories still remain separate, accompanied with some interconnections between events 28 and 50/53/55 (Fig. 5). This concerns references to the Guiding document of Several Opinions of Speeding up the Development of Circular Economy by the State Council (event 28) in the establishment of a coalition between SEPA, MOC and MOST in coordinating EIP policy (event 50),the publication of the Guide of EIP Planning (event 53) and the Management Procedure of EIPs (event 55). The intentional linkages, as well as those in phase 3, reflect the significance of the intervention and guidance about the Circular Economy policy by the State Council also influenced the development of the EIP program.

In the policy assemblage, the interconnections between the two policies grow substantially (Fig. 6). From phase 3 to 4, the policy assemblage underwent a critical change, shifting from two separate clusters to one integrated centre. One major change is that, in addition to the shared ideas as listed in phase 2 and 3, the two policies simultaneously embraced new ideas of Energy Conservation and Emission Reduction, which became a salient national policy theme at that time. Another change is that SEPA, MOC and MOST establish themselves as bridging actors between the two policies. Generally, the two policies were sustained as two

⁵The State Council is the chief administrative authority of China. It is chaired by the premier, and consists of General Office of the State Council, and various ministries/departments. As the increase of complexity of public services that requires cooperation and coordination between public sectors, inter-ministries/departments coordination is one of the important functions of the State Council. For some issues, the General Office can administratively identify the roles and responsibilities of ministries/departments and ways of cooperation, as indicated in the Circular Economy policy. And sometimes, it is done by establishing temporal organizations as a platform for inter-ministries negotiations.

independent policy trajectories; however, they are more integrated in terms of shared common ideas and bridging actors. And they two continued their relation of mutual reinforcement.

Phase 5. For this phase, both the event graph and the policy assemblage show the two policies as separate. The policy trajectories continued as two separated processes with limited intentional connections (Fig. 5). The intentional connections were mainly between events 64 and 28/60. Specially, the publication of revised Assessment Standards of EIPs (event 64) referred back to the documents of Several Opinions of Speeding up the Development of Circular Economy (event 28) and the Circular Economy Promotion Law (event 60). Similar to phases 2 and 3, the policy assemblage also shows a two-cluster structure (Fig. 6). However, the interconnections between the two clusters are less strong compared with previous phases. Actors SEPA, MOC and MOST lose their roles as bridging actors, and NDRC cooperates frequently with MOF to allocate and regulate several subsidies that aim for the wider diffusion of Circular Economy practices. The results show the two policies remained distinct; however, their interconnections greatly reduced in the last phase.

Throughout the period studied the interconnections between the policies of EIP and CEIP presented a trajectory of rise and fall. The interconnections are summarized in Figure 7. This is our basis for analyzing the co-evolution of the two policy processes in section 5.

Fig. 7 Abbreviated central policy assemblages

4.3 Diffusion of SIPs

The number of newly involved SIPs. Figure 8 presents the number of EIPs and CEIPs that were newly enrolled in each phase (part A) and the accumulated number over phases (part B). The result (part A) shows that over phases the number of newly enrolled EIPs increased, with a slight decrease in phase 4. As for CEIPs, although there were no CEIPs in phase 1 and 2, the number increased quickly from phase 3 to 5, ending even higher than EIPs. The tendency is also evident in part B of figure 8. The total number of both EIPs and CEIPs shows a steady increase. Although the EIP program has a longer implemented time than the CEIP program, the total number of CEIPs exceeded EIPs from phase 4, reflecting much rapid growth of the CEIP program.

Fig.8 EIPs and CEIPs across phases

Spatial distribution. The geographic delineation of eastern, central, and western China aligns with regional economic performance, which decreases going from the east to the centre to the west. Figure 9 (part A) shows the total number of national and provincial level industrial parks in each super-region⁶. There is a clear tendency of higher numbers of industrial parks in Eastern China with lower diffusion in Central China and yet lower in Western China. Figure 9 (part B) depicts the spatial distribution of newly involved CEIPs and EIPs of each phase. It shows that in all the five phases, a large percentage of EIPs were located in eastern China. And the number of EIPs goes from high to low from the east to the centre to the west, following the level of regional economic performance. This corresponds with the total number of industrial parks in each super-region. In contrast, CEIPs diffused evenly, with a slightly higher diffusion in Western China.

Fig.9 Types of Diffusion: spatial distribution, administration and industrial sectors

Administrative levels. According to the hierarchy of the administrative bodies of industrial

⁶In collecting data, we only accessed officially published information of industrial parks of 2006. So we adopt the data to present an overview of industrial parks in China.

parks in the government system, the industrial parks were classified into national level and provincial level⁷. Usually, the higher the administrative level, the better the quality of industrial parks (in terms of better infrastructure for environmental protection, better economic performance). Figure 9(part A) presents that the number of provincial level industrial parks was much higher than the number of national level industrial parks. In Figure 9 (part C), the results show that for EIPs, both national and provincial level industrial parks were involved in all phases, except phase 1, and there was a clear tendency toward national level industrial parks from phase 4 to phase 5. In contrast, CEIPs shows a decline of national level industrial parks being involved.

Industrial structures. Figure 9 (part D) shows the diversity of diffusion of SIPs in terms of sector-integrated industrial parks, sector-specific industrial parks, and venous industry based industrial parks. In the EIP program, a relatively balanced number of sector-integrated and sector-specific industrial parks were involved in phase 1; however, they presented contrasting developing trajectories over time. The sector-integrated industrial parks presented a steady growth over time and reached a climax in phase 5, while the type of sector-specific industrial parks declined over time. So EIPs presented a clear tendency toward industrial parks with multiple and diverse industrial sectors. Alternatively, for the CEIP program, in phase 3 and 4, both sector-integrated and sector-specific industrial parks became involved, and the former presented quicker increase than the latter; however, in the last phase, they both declined into a low number, and the type of venous industry-based CEIPs increased greatly, resulted from a new CE pilot program on Urban Mining. The pilot of urban mining focused on reclaiming, recycling and recovery of secondary resources from waste in urban systems, such as compounds, energy, and elements from products, buildings, and wastes. Therefore, CEIPs presented a mixture of sector-specific and sector-integrated industrial parks, and stressed recycling through urban mining.

All the three indicators manifest that the governmental selection patterns of industrial parks in the two programs presented similar starting points(e.g. in phase 3), but gradually differentiated from each other as time passed, which became evident in the last phase.

5 Durable policy facilitation of SIPs: linking co-evolution of policy processes and diffusion of SIPs

From phase 2 onward, the policies of CEIP and EIP started to diverge into two independent programs that shared a common interest in promoting SIPs. The initial trigger for the divergence was the emergence of NDRC as an active policy actor in the CE policy translation trajectory. It challenged the state quo of the Circular Economy Zone program that focused on environmental protection and was initiated by SEPA. NDRC's new interpretation of Circular Economy as sustainable transformation of economic development made a better fit with the Chinese context of economically developing country. This caused uncertainties and tensions about whether SEPA or NDRC should be the leading actor in bringing the Circular Economy policy further in China. Meanwhile, the proposed program of Circular Economy by NDRC also intended to focus on industrial parks, which created a tendency for competition with the EIP program for enrolling industrial parks in the near future. Generally, the emerging events in

⁷It included municipal level industrial parks.

the Circular Economy policy interfered with the status quo of its own evolving trajectory, and also intervened in the development of the EIP program to a certain degree. So both policies and its associated actors seemed to enter into a complex and even chaotic situation of tensions and potential competitions.

This complex situation, especially in the Circular Economy policy translation trajectory, led the State Council to act. The State Council provided positive support for NDRC and in addition published a formal document about the coordination of Circular Economy policy (event 28), in which the leading role of NDRC in coordinating Circular Economy policy was identified and the importance of cooperation between governmental agencies was stressed. This event became a turning point in the Circular Economy policy, and helped to formally separate the policies of CEIP and EIP into two programs.

Subsequently, the two policies seemed to enter into a co-evolutionary relation of symbiosis in phase 3 and 4, i.e. they mutually reinforced the development of each other. We label this as the symbiosis, based on the observation that, along with the increasing linkages between the two policies, both clusters of CEIP and EIP in the policy assemblage grew substantially and presented continuous development over time. Moreover, the symbiotic relation brought about continuous development and similar diffusion patterns of CEIPs and EIPs in terms of diversity, such as relatively even spatial distribution, hybrid administrative bodies, and both sector-integrated and sector-specific industrial parks. In addition, Jiao and Boons (2017) also indicated a higher number of overlapping industrial parks became involved in both programs in these phases. The results probably came about in part because both policies were in their early stage of development, during which the dominant dynamic among actors was learning by doing and adapting to environment (Jiao&Boons 2017). Specifically, in phase 3, SEPA acted as the bridging actor between the two policies, and the knowledge and experience it had accumulated in phase 1 and 2, could benefit the policy making and implementation of CEIP. In phase 4, the establishment of the coalition among SEPA, MOC and MOST in the EIP program was likely inspired by the implementation of CEIP program. The coalition improved the adaptation of the EIP policy to the fragmented coordinating systems of diverse industrial parks, thus reinforcing the policy facilitation of EIP. The increasing number of bridging actors established the possibility of similar governmental selection patterns of industrial parks. And the different resources from the two programs that flowed to same industrial parks may enhance the policy outcomes of each program.

In phase 5, there was a reduction of interconnections between the two policies. The reduction did not result from intentional coordination, as evidenced by the lack of intentional linkages in Figure 5. We interpret this as the probable damping out of the co-evolutionary dynamics. This may be a result from the increasing administration and stabilization of both policies, which entered into a stage of formalized implementation. As analysed above, in phase 3 and 4, the main policy dynamics were learning by doing and adaptation. As a result, both policies became the environment of each other, thus shaping each others' development. With the accumulation of knowledge and experience over time, the primary fit was created, and then the policy efforts concentrated on increasing policy stability in order to promote wide diffusion of policy concepts in industrial parks (Jiao&Boons 2017), which was in consistent with our results of diffusion. In phase 5, the

number of both CEIPs and EIPs presented continuous increase with higher speed than in the two previous phases. Meanwhile, the types of industrial parks became divergent. EIPs tended toward national level, sector-integrated industrial parks that located in economically developed areas. While CEIPs were more likely developed in provincial level industrial parks that located in economically developing areas, highlighting urban mining and circular transformation of both sector-integrated and sector-specific industrial parks. With the gradual damping out of the co-evolutionary relation, the divergent selection patterns reduced the potential competition in enrolling industrial parks, promoting the mutual survival of both policy programs.

6 Conclusion

Durable policy implementation is an important dynamic for effective governmental facilitation of SIPs. To increase our understanding of such dynamics, we have concentrated on the co-evolution of the Chinese stimulation policies of EIPs and CEIPs. We focused on whether and how they have reinforced or dampened the durable development of each other, and how that mutual influence has affected the overall diffusion of SIPs. In doing so, we have employed the approaches of Event Sequence Analysis and the Social Network Analysis of policy assemblages, highlighting the fact that the individual policy processes are parts of a wider “web” of processes.

The co-evolutionary relation of the two policies did not appear immediately, but became established after tension emerged which were then reduced in the Circular Economy policy, as a result of emerging initiatives of a newly involved policy actor and the involvement of a powerful actor. The intervention in the Circular Economy policy brought the two policies into a co-evolutionary relation of symbiosis which seemed to have become less intensive over time.

In all, the case manifests three main dynamics, which provides insights for policy actors to coordinate co-evolution of policies towards effective policy outcomes. First, the policy issues of SIP and many other environmental policy efforts often require cooperation among diverse governmental actors. However, because of their different organizational properties, preferences and interests, these various governmental actors can create tensions and disagreements in the manners and contents of cooperation. In such situations the coordination of powerful actors is helpful for them to rapidly achieve a common ground, especially in the Chinese context. Second, for a policy concept that arrives in new contexts, learning by doing and adapting to new environment characterize the activities of policy actors. One important activity of such adaptation should be discerning relevant policies that can become a selection environment for each other, which shape each others’ evolving trajectory. Accordingly, a symbiotic relation of co-evolution is likely to occur, for which developing bridging actors who involved in both policy programs can be helpful. It should be noted that the symbiotic relation in the early stages of policy development reflects continuous development and adaptation of policy, which does not necessarily mean abundant diffusion of SIPs. This is because in the early phases, creating adaptation and accumulating knowledge can be the priority of policy actors, and wide diffusion of SIPs then become secondary. Third, along with the accumulation of experience and knowledge of

policy making and implementation over time, main policy goals are likely to shift from adaptation to effective policy outcomes. In the case, the effectiveness of policy outcomes in the last phase was faster development and widespread diffusion of SIP in certain types of industrial parks. To achieve effective outcomes, policy stability is required, which may result from decreased intentional interactions between policy trajectories and the divergence of governmental selection patterns of industrial parks.

The co-evolution of the policies of CEIP and EIP greatly enhanced the diffusion of SIPs in diverse types of industrial parks. The diversity of industrial parks among which the SIP concept diffused indicates that SIP is not only suitable for industrial parks with solid economic performance, but is also attainable for industrial parks where economic conditions are more difficult. Our results indicate a co-evolutionary dynamic which led to differentiation of policy programs was enabled the mutual survival of two policies with overlapping policy goals. Co-evolution of environmental policy programs increases the complexity for public managers, but it is a common feature in environmental governance, and as our study shows, it can have positive consequences.

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