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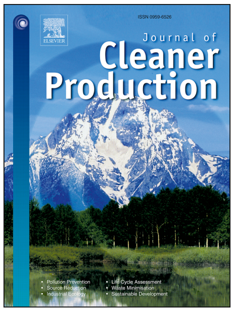

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Institutional Pressures, Sustainable Supply Chain Management, and Circular Economy Capability: Empirical Evidence from Chinese Eco-industrial Park Firms

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Highlights:

1. A concept model incorporating IP, SSCM and CEC was constructed.

2. We used questionnaires to collect data from eco-industrial park firms in China.

3. IP has a significant positive impact on SSCM.

4. SSCM is the key to enhancing the CEC of eco-industrial park firms.

ABSTRACT

An eco-industrial park is the practical application of sustainable supply chain management at an industrial park level. As the external sustainability of the supply chain becomes more difficult, integrating the circular economy concept into supply chain management is required to achieve an optimal balance of economic, social, and environmental benefits for a company. Based on institutional theory, we construct a concept model according to the paradigm of "institution-conduct-performance." We then test the mechanism and relationships among institutional pressure, supply chain relationship management, sustainable supply chain design, and circular economy capability using data collected from eco-industrial park firms in China via 363 questionnaires. The findings show that institutional pressure has a significant positive impact on supply chain relationship management and sustainable supply chain design; sustainable supply chain management practice is an important factor promoting the improvement of the circular economy capability of companies, and coercive pressure, normative pressure, and mimetic pressure exert different degrees of negative moderating effects. This study expands our knowledge of variables affecting sustainable supply chain management and also provides theoretical guidance for successful green production practices of eco-industrial park firms.

Keywords: circular economy capability; sustainable supply chain; institutional pressure; eco-industrial park

1. Introduction

In recent years, China has committed to reducing the impact of its economic development on the natural environment, establishing a “win-win” ecological and economic model, and building a resource-saving and environment-friendly society (a "two-oriented" society) in an effort to shift towards more sustainable development (Wu et al., 2014). The circular economy is considered an important component of sustainable development; the state has promulgated a series of laws and regulations targeting the government, businesses, and the society, in an effort to create a circular economy-based industrial system. Industrial parks and social dimensions of the circular economy, as well as green production and firm-level missions are strongly incentivized to achieve sustainability goals. As industrial organization patterns change, an eco-industrial park’s “resources-products-renewable resources” circular flow model has become the standard, and now represents major players in sustainable development at the new conceptual “park-level”. An eco-industrial park (EIP) imitates the “food chain” of the natural ecosystem and is designed to achieve a circular economy and incorporate industrial ecology principles. In an EIP, businesses cooperate with each other and with the surrounding community to minimize waste and pollution, efficiently share resources (i.e. materials, energy, information, infrastructure, and natural resources), utilize clean forms of production, and help achieve sustainable development, to sustainably develop economic and social gains, and improve environmental quality (Yu et al., 2015). Therefore, an EIP, as a kind of cluster supply chain management mode, is a major means of resource allocation, and more importantly serves as an important channel for firms to develop circular economy capability. As of May 2014, in China there were 85 approved national eco-industrial demonstration parks either under construction or already built, and another 26 national eco-industrial parks are planned for future construction. It is important to note that each firm in these eco-industrial parks must individually prioritize sustainable development in order for the park to collectively function in a sustainable manner (BCG, 2009).

Research related to sustainable firm development has typically focused on the constraints on the behavior of individual firms. There are few studies on the sustainable supply chain practices of eco-industrial park firms likely because these parks are relatively conceptually innovative. These EIPs attempt to incorporate many newly developed ideas, such as how to transform sustainable supply chain management (SSCM) by internal willingness to optimize production practices and which factors promote or contribute to sustainable development. Specifically:

(1) Consideration of an individual firm's SSCM practices in two parts: sustainable process management (SPM) and sustainable supply management (SSM). The literature has nearly reached a consensus on this issue (Gimenez and Sierra, 2013; Zhu et al., 2013). However, different evaluations of sustainable supply chain practices in an EIP may rely on different interpretations of the “sustainable supply chain” concept. These practices may emphasize delivery methods such as logistics or energy flow as a way to connect different factories or companies, and establish a “producer-consumer-decomposer” cycle model in the industrial system (Geng et al., 2008).

(2) There is a complex relationship between a firm and its external environment requirements. Institutional pressure (IP) is an important driver of SSCM practices and largely determines the autonomy of corporate behavior (Cavusoglu et al., 2015; Huo et al., 2013; Wu et al., 2012). However, although IP’s effect on decision-making and industrial practices is certainly related to SSCM, this relationship has not been explored in detail.

(3) Environmental performance in terms of the corporate environmental capacity of explanatory variables is widely recognized (Gimenez and Sierra, 2013; Sarkis et al., 2010). The circular economy capability (CEC) can also reflect environmental performance in terms of production, but few studies have investigated CEC as an indicator of firm performance for sustainable supply chains. Other mechanisms related to CEC, such as the influence of SSCM on CEC have yet to be characterized.

In summary, there has been much interest in the study and analysis of environmentally-friendly production practices in recent years, but few on the effect of SSCM on CEC from the IP perspective. Integrating the supply chain management and circular economy concepts is a new approach. Our study references a previous study by Wolf (2014), who used the “institution-conduct-performance” paradigm based on a conceptual model and studied the relationship between sustainable supply chain management, stakeholder pressure and corporate sustainability performance. We develop a conceptual model to explore the effects of IP and SSCM (i.e., SCRM and SSCD) on CEC for eco-industrial park firms. Our paper makes three main contributions:

(1) Unlike traditional SSCM studies where firms were treated as subjects, we consider eco-industrial park firms to be an object of SSCM research. This is an expansion of SSCM research from the perspective of institutional theory, as described by Dubey et al.(2015)and Li(2014).

(2) We depart from the convention of evaluating firm performance for sustainable supply chain management practices solely based on financial and environmental performance. Instead, we introduce the "circular economy capacity (CEC)" index, which expands and improves Wolf(2014) by introducing multi-dimensionality.

(3) This paper has important theoretical and practical contributions for eco-industrial park firms as they seek to achieve sustainable supply chains. We also study CEC to guide the development of sustainable business practices.

The remainder of this paper is organized as follows. In section 2, our theoretical model is presented based on previously literature and our research hypotheses are proposed. Section 3 focuses on our research design, including the questionnaire, data acquisition process, and non-response bias test. Section 4 presents the test procedures and methods, and provides the test results. Section 5 discusses the key findings. Section 6 concludes the study.

2. Literature Review and Hypothesis Development

2.1 Literature Review

It remains a key challenge for companies to develop strategies for sustainable supply chain management that incorporate goals of integrating sustainable development and supply chain management to achieve a "sustainable supply chain"(Gimenez and Sierra, 2013). In recent years, there have been many studies of SSCM. Ahi & Searcy(2013)determined that the only difference between green supply chain management (GSCM) and SSCM is that GSCM does not explicitly include social factors, and SSCM is a comprehensive integration of the social, environmental, and economic goals of a firm. After incorporation of the concept of sustainability into supply chain management, firms must balance a "triple bottom line (TBL)", an accounting framework that includes social, environmental (or ecological) and financial components (Carter and Rogers, 2008). Models or mechanisms of SSCM include supply chain relationship management (SCRM) and sustainable supply chain design (SSCD), relatively new areas of inquiry and practice. Firms should appropriately minimize negative environmental impacts during production and processing through the use of a properly designed manufacturing network, logistic network, and downward stream supply chain network in a way that maintains the quality of products without overwhelming cost increases (Luthra et al., 2013; Pop et al., 2015). Agarwal & Vijayvargy (2012)consider green suppliers as assets, but this can increase the economic burden. SSCD is a systematic approach for the creation and distribution of products and innovative services that minimizes resources, eliminates toxic substances, and produces zero waste to reduce greenhouse gas emissions across the entire life cycle of products and services (Sudarsan et al., 2010).

Clearly, the effective implementation of SSCM strategies by companies can be influenced by many external environment factors and can be affected by both positive and negative pressures. Institutional theory stresses that organizations face both pressure from technical aspects and at the institutional level (Greening and Gray, 1994). Organizational institutional environments not only shape and strengthen the guiding principles of an organization, but also ensure that the organization complies with external rules, norms, and values (Oliver, 1991; Suchman, 1995). Accordingly, “institutional pressure (IP)” is defined as the influence of the institutional environment comprised of social norms, rules, and/or culture on the organizational form, structure or behavior, which may or may not become reasonable, acceptable and supportable(Qian and Burritt, 2009). Based on an institution’s regulations, rules, and cultural cognition, IP can be divided into three aspects: coercive pressure (CP), normative pressure (NP), and mimetic pressure (MP). Institutional factors such as national laws and regulations, government policies, and NGO guidelines that suggest standards for corporate environmental protection measures and social responsibility can affect the SSCM activities of firms(Matos and Hall, 2007; Zhu et al., 2005). Companies can exhibit high levels of environmental protection and social responsibility behavior that exceed the levels required by the government, thus reducing the potential for government-implemented stringent institutional constraints (Linton et al., 2007).

The indicators of measurable SSCM include environmental performance (Gimenez and Sierra, 2013; Xia et al., 2015), corporate social responsibility (Hsueh, 2015; Wolf, 2014)and financial performance (Luzzini et al., 2015; Taticchi et al., 2013), corresponding to the environmental, social and economic dimensions. To some extent, SSCM is essentially similar to a circular economy. Both strategies are effective ways to maximize the utilization of resources and minimize environmental pollution, and advocate for the integration of clean production and comprehensive utilization and eco-design for sustainable consumption (Ma et al., 2015; Ying and Li-jun, 2012). Circular economy capability (CEC) is the general term implementing the 3R principles (reduction, reuse and recycle) for firms (Anderson, 2007). This capability includes interrelated circular economy practices to achieve a common goal. CEC encompasses all economic activities including production, distribution, consumption, and waste recycling. Circular economies minimize the use of resources, maximize the efficiency of production, and minimize the impact of commerce on the environment, completely transforming the traditional open economic growth mode to a closed-loop mode of “resource-products-renewable resources” (Anderson, 2007; Boulding, 1966). Compared with sustainable supply chain performance that is measured usually from environmental and economic dimensions, the CEC index integrates the three comprehensive dimensions of environment, society, and economy.

Earlier studies provide a starting point for this analysis of SSCM with a focus on eco-industrial parks as a circular economy. As one of three basic models of circular economy (the other two are enterprise circular economy and social circular economy), an eco-industrial park is a circular chain based on the “3R” principles (reduce, reuse, and recycle) and established by optimizing logistics, energy transmission, and the exchange of waste (Yu et al., 2015). Here, we attempt to combine the concept of a circular economy and a sustainable supply chain, and determine the characteristics of SSCM from the perspective of a circular economy. This type of analysis is important to solve resources and environmental issues of supply chain management in eco-industrial parks and improve the coordination of the supply chain.

2.2 Theoretical Framework and Hypotheses

After carefully reviewing related theories, we use the classical research paradigm “Institution-Conduct-Performance” to construct our theoretical framework of institutional pressure (IP), sustainable supply chain management (SSCM), and circular economy capability (CEC), and propose corresponding research hypotheses. Our model is depicted in Figure 1.

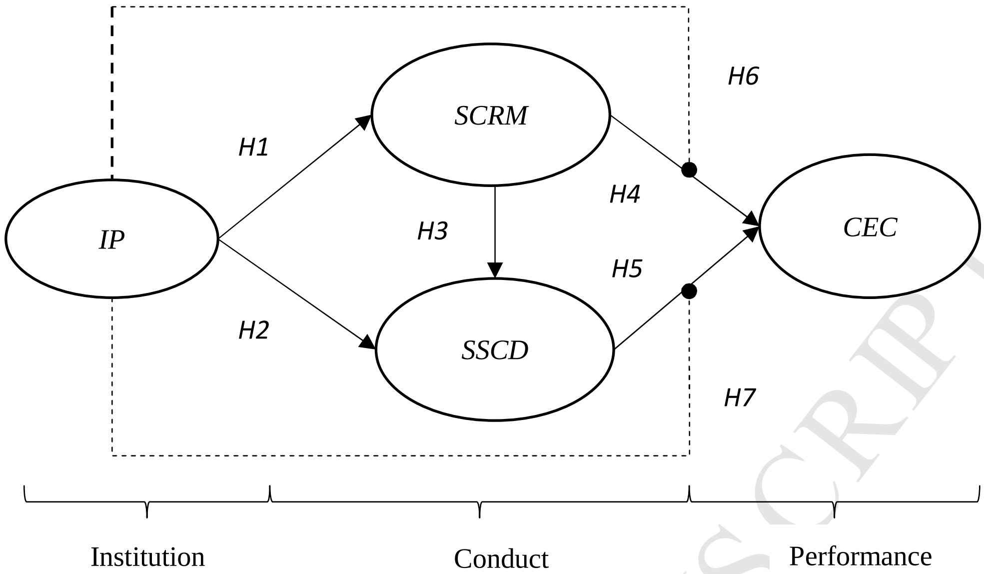

Fig. 1. Hypothesized conceptual model

2.2.1 Relationships between IP and SSCM

Institutional theory studies different types of pressures (economic, social, and political) and the effects of these pressures on management practices. Oliver (1991)argued that the influence of IP on organizational behavior is mainly characterized by the restraint and rationality that organizations show toward and receive from the outside world, as well as the outside demands to which the organization can respond. Obviously, IP (and specific components CP, NP, and MP) can serve as an important driving factor of firm supply chain management practices, as any firm must contend with institutional factors in the practice of firm management. In order to meet the requirements of regulators, consumers, and the public, an increasing number of firms have integrated sustainable products and services for consumers (Hoejmose et al., 2012; Vezzoli et al., 2012). Government policies, laws, and regulations can have positive impacts on SSCM (Linton et al., 2007; Zhu et al., 2005). Additionally, policy documents issued by non-governmental organizations (such as the Industry Association, the China Environmental Science Society, etc.) can also stimulate firms to meet their social responsibilities (Ahi and Searcy, 2013; Phan and Baird, 2015). Gualandris et al.(2014) and Dubey et al.(2015) also found that institutional pressure is an important factor shaping firm management strategy in Italy, India and other regions.

Supply chain relationship management (SCRM) and Sustainable supply chain design(SSCD) are the two most important links in the practice of SSCM (Kuik et al., 2011; Miocevic and Biljana, 2012). Walker & Jones (2012)found that supply chain relationship affects SSCM and SCRM, and improving this relationship requires a stable and long-term relationship between the upstream and downstream partners. SSCD is based on economic, environmental, and social factors and is an effective combination of suppliers, producers, and distributors. SSCD not only determines the structure and efficiency of the supply chain, but also determines supply chain flexibility (Gimenez and Sierra, 2013). For an eco-industrial park, the integration of material and energy resources in the park depends on the relationships between the members of the park, which highlights the important role of supply chain management. The design of the whole cycle chain of an eco-industrial park is based on the creation of an industrial symbiosis network and the exchange of products among firms, and a sustainable supply chain may need to be complex in order to achieve efficiency. Here, we studied the SSCM activities of firms and the effects of IP from two aspects: supply chain relationship management (SCRM) and sustainable supply chain design (SSCD). We started with the following hypotheses:

H1: IP is positively related to SCRM practices of firms.

H2: IP is positively related to SSCD practices of firms.

2.2.2 Relationships between SSCM and CEC

SSCM is the systematic coordination of core business processes across an organization. Firms in the supply chain belong to different units and business nodes, and each firm in each node shifts their own social responsibility to their partners through cooperation. Partnerships between upstream and downstream firms in the supply chain improve the coordination of the supply chain network, and control a "bullwhip effect" in the entire network to satisfy the needs of customers (Kanji and Wong, 1999). SCRM includes the control of information, risk, and profit distribution (Dubey et al., 2015) to help the firm meet sustainability targets such as reducing CO_2 emissions, improving resource utilization efficiency, and reducing waste. SCRM includes supplier selection, technical progress, and meeting customer expectations through cooperation, and other aspects of management. For example, the selection of suppliers is based on choosing suppliers that can achieve environment and social standards, and firms that use the suppliers with the highest standards are more likely to become industry leaders in waste treatment and environmental management (Zhu and Geng, 2001). In an eco-industrial park, improving the symbiotic correlation of materials, energy, and information among firms allows the formation of a coupled lateral and vertical closed loop symbiotic relationship among firms. This supply chain relationship among firms in an eco-industrial park is the basis of SSCD, which is green-target-oriented and encompasses a network of manufacturing, green logistics, and reverse logistics, in which each firm in the network node employs diversified management behavior to improve product sustainability (Qu et al., 2015; Zhou et al., 2016). Based on these parameters of supply chain relationship management (SCRM), we propose the following hypothesis:

H3: SCRM is positively related to SSCD.

In essence, SSCM is the strategy to achieve a balance of internal ecological efficiency. From the perspective of a circular economy, pollution is a sign of the inefficient use of resources, and must be addressed by a firm if pollution results from products or processes. At present, due to the high pollution and high carbon emissions rates of Chinese firms overall, the cost of resources is increasing. One strategy to counter this trend and conserve resources is the use of incentives that are targeted to improve pollution control and waste management with the effect of encouraging Chinese companies to strengthen their environmental friendliness (Fabbe-Costes et al., 2014). From SCRM to SSCD, and then end-of-pipe treatment, SSCM has the goals of reduction, recycling, and reuse (Wu et al., 2014), which, as described earlier, coincides with the definition of circular economy capability. Studies have shown that SCRM can play a decisive role in the successful implementation of green production/sustainable manufacturing in developed countries (Miocevic and Biljana, 2012; Sjoerdsma and Weele, 2015), and Chinese manufacturers are also starting to realize the benefits of SCRM (Wu and Wu, 2015; Zhou et al., 2013). CEC includes activities that achieve energy reduction, materials and resources reuse, and waste recycling, corresponding to reduction ability (Anderson, 2007; Zhu et al., 2005), reuse capability (Garcia and Pargament, 2015; Mohammed et al., 2015), and recycle capability (Cucchiella et al., 2015; Zhao et al., 2012). From the perspective of a circular economy industrial chain, the selection of suppliers that have the capability to improve the ability of existing suppliers to protect the environment lead to improved circular economy capability (Murphy and Poist, 2003). A sustainable supply chain network design that consists of manufacturing, green logistics, and reverse logistics is an important way to achieve improved CEC (Sikdar, 2003; Stock, 1998; Xiong et al., 2015). Given the importance of supply chain relationship management (SCRM) and sustainable supply chain design (SSCD) in sustainable supply chain management

(SSCM) practices and circular economy capability (CEC), we propose the following hypotheses:

H4: SCRM is positively related to CEC of firms.

H5: SSCD is positively related to CEC of firms.

2.2.3 Moderation Effect of IP

IP is widely used in the study of adaptability and diffusion effects of organizational behavior practices (Boutinot and Mangematin, 2013). Sustainable supply chain design and operation are inseparable from the environmental system standards (Dubey et al., 2015). In the case of corporate management, it is particularly important to determine the relationship between SSCM and economic and environmental performance. Environmental pressure is placed on firms by market competition, cultural trends in eco-friendliness, legal regulations, and green supply practices (Gimenez and Sierra, 2013). Firms are urged to consider the sustainability of the processing, packing, transportation, and consumption of their products and services to meet the guidelines of eco-friendliness. The circular economy and the supply chain also must comply with the national environmental policy, placing additional pressure on the firm. The higher the IP, the more likely a firm is to undertake green procurement and waste recycling policies (Zhu et al., 2010). Supply chain management in a circular economy not only focuses on customer needs, but also emphasizes the 3R principles of reduction, reuse and recycle for each node in the supply chain. On this basis, we further reviewed the related literature. Simpson (2012) found that as the European law on recycling was proven effective, and other countries in the world followed the European example and began to prioritize waste reduction. Wu et al.(2012) studied Taiwan's textile industry, and found that IP in the internal driving factors had a moderating impact on the implementation of GSCM. Similarly, Dubey et al.(2015)used data from questionnaires completed by 174 rubber companies in India to empirically analyze the effects of court pressure, regulating pressure, and mimetic pressure. They found that IP had a significantly positive moderating effect on the relationship between the management of the supplier relationship and environmental performance.

Given the above theoretical derivation and evidence from the literature, we propose that the IP on a firm will enhance the effects of SCRM and SSCD on the CEC. In other words, IP exerts moderating effects. It is important to point out that the test of a moderating effect of IP is different from hypothesis 1 and hypothesis 2. This asks whether IP will encourage firms to increase focus on sustainable environmental performance resulting from supply chain management. However, hypothesis 1 and hypothesis 2 are designed to address whether IP is the driving factor of SSCM, including SCRM and SSCD. Obviously, there are significant differences in these two questions. Therefore, based on the above discussion we propose the following hypotheses of the moderating effects of institutional pressure (IP) on the impacts of supply chain relationship management (SCRM) and sustainable supply chain design (SSCD) on circular economy capability (CEC):

H6: IP has a moderation effect on the relationship between SCRM and CEC.

H7: IP has a moderation effect on the relationship between SSCD and CEC.

Institutional factors have been introduced to economic study and used to establish a set of analysis frameworks based on ideas such as "institution-conduct (selected)-economic and social results." Firms exist in a social network, in which the institutional environment impacts their behavior. With the influence of this effect, all organizations in that network will eventually converge on structure and morphology (DiMaggio and Powell, 1983). We next focus on the discussion of the three kinds of IPs categorized according to the definition of institutional pressure used by Scott & Richard(1987) and discuss their moderation effects on the relationship between SCRM and CEC and the relationship between SSCD and CEC.

Coercive pressure (CP) comes from other organizations and sociocultural expectations, and is characterized by external agencies with the authority or coercive power to influence the firm's structure or behavior. Specifically for park firms, CP might include laws of organizations with legal authority or similar organizations that seek to improve green production practices, or other regulations and policies (Zhu et al., 2013). Examples of organization guidelines that could contribute to this kind of pressure would be the *Energy Conservation Law of the People's Republic of China* and the *Circular Economy Promotion Law of the People's Republic of China*. Organizations are embedded in the political environment, and the authority and the punishment system of the laws and regulations urge compliance by the firms to follow existing governmental guidelines when carrying out SSCM. Thus, the next research hypotheses about CP are as follows:

H6a: CP has a positive moderation effect on the relationship between SCRM and CEC.

H7a: CP has a positive moderation effect on the relationship between SSCD and

CEC.

Normative pressure (NP) is the result of the pressure of the specialization process, and is characterized by the firm's goals to practice certain norms and values. Specifically for park firms, the NP they encounter when carrying out SSCM refers to the constraints set by the norms, standards, and expectations of the external stakeholders for green production behavior (Gualandris and Kalchschmidt, 2014). The recessive characteristics of NP hinder its identification, but would include industry standards of the media and non-profit organizations, and the expectations of customers for corporate social responsibility. Here, we focus on the environmental awareness of customers and their partiality for green and eco-friendly products in the promotion of sustainable supply chain practice. This suggests the hypotheses of the effect of normative pressure (NP):

H6b: NP has a positive moderation effect on the relationship between SCRM and CEC.

H7b: NP has a positive moderation effect on the relationship between SSCD and CEC.

Different from CP and NP, mimetic pressure (MP) does not comes from an external organization, but describes organizational and individual cognition under the influence of the social environment. MP, also known as "cognitive pressure," is a kind of internal pressure or psychological pressure that is characterized by simulation and internal benchmarking of the most favorable firms in the same industry (Munir, 2002). For park firms' SSCM practices, when the firm lacks clear goals or shows environmental uncertainties (such as demand uncertainty, supply uncertainty, or technology uncertainty), the management team becomes more inclined to emulate the behavior of successful firms in the industry that serve as benchmarks (Dubey et al., 2015). Accordingly, each firm's supply chain management practices and sustainable supply chain design gradually converge. MP is mainly reflected in the imitation of green innovations among competitors and corporate management's imperative to assume social responsibility for the competition. We posited the following hypotheses testing the moderation effects of mimetic pressure (MP):

H6c: MP has a positive moderation effect on the relationship between SCRM and CEC.

H7c: MP has a positive moderation effect on the relationship between SSCD and CEC.

3. Research Design

In order to test the conceptual model, we adopt a large-scale questionnaire survey administered to eco-industrial park firms in China. This section describes the process of questionnaire design, data collection methods, sample characteristics, and non-response bias test results.

3.1 Questionnaire Design

In order to ensure reliability and validity, we reviewed the literature on institutional pressure (IP), sustainable supply chain management (SSCM), and circular economy with special focus on the scales and key indicators used in previous studies prior to the design of our questionnaire. As shown in Table A1, the core content of the questionnaire has been consolidated into three sections (not including the participants' background information). Section 1 includes questions on indicators of IP, covering legal, customer-related, competitor-related, business executive-related, and social identity pressure. This section had seven items and is divided into three dimensions. Section 2 has sixteen items in total, including questions on indicators of supply chain relationship management (SCRM) and sustainable supply chain design (SSCD). Section 3 has ten items including questions on circular economy capability (CEC). Respondents were asked to provide ratings on a five-point Likert scale (where 1="strongly disagree", and 5="strongly agree").

3.2 Data Collection

The sample data was limited to firms in eco-industrial parks. In order to ensure sufficient representativeness of the sample, we mainly selected parks that were included in the "National Eco-Industrial Demonstration Park" list (85 eco-industrial parks in the whole country) as the targets for the survey. Additionally, we considered the features of the geographical distribution of the industrial parks and incorporated representative industrial parks of each region into the overall sampling frame. During the survey, we encountered many problems in terms of approaching the firms, so we mainly selected parks that we had contact with for the sampling. As a result, our data was collected from the following target parks: *Minhang Economic & Technological Development Zone* (Shanghai), *Changzhou Zhonglou Economic Development Zone* (Jiangsu), *Urumqi Economic & Technological Development Zone* (Xinjiang), *Eco-industrial park of Dongguan* (Guangdong), *Shenyang High-tech Industrial*

Development Zone (Liaoning), *Changsha Economic & Technological Development Zone* (Hunan), *Zhuzhou High-tech Industrial Development Zone* (Hunan), and *Guiyang Economic & Technological Development Zone* (Guizhou). In order to ensure the representativeness of the samples, we only issued one questionnaire to each firm in the park.

From May to September, 2015, we used a combination of paper questionnaires and e-mail to distribute questionnaires mainly through the help of our alumni and friends, and provided a gift for each participant. Overall, 620 questionnaires were distributed and we received 435 questionnaires back (response ratio of 70.16%). Of the returned questionnaires, 72 were invalid (mainly due to the following reasons: a. answers that did not fit the requested format; b. incomplete, as too many questions on the questionnaire were unanswered; c. all answers marked similarly indicating that the questions were not read properly). After removal of the invalid responses, there were 363 valid questionnaires. Thus, the effective response ratio was actually 58.55% and the basic statistical characteristics of the sample are listed in Table 1. Though the response ratio was lower than we would have liked, the sample size was far more than 200 (and the number of respondents was nearly five times the number of items), so it fits well with the requirement for a medium-scaled sample (Kaplan and Ferguson, 1999). The sample was sufficient to test our research hypotheses, and our empirical analysis results should reliable.

Tab. 1
Statistical characteristics of the sample data

Category	**Number**	**Proportion (%)**	**Category**	**Number**	**Proportion (%)**
Firm property:			Industry:		
State-owned	102	28.1	Industrial machinery/equipment	36	9.9
Private	91	25.1	Instruments and related products	35	9.6
Foreign-owned/joint-ventured	158	53.5	Rubber and plastic products	38	10.5
Others	12	3.3	Transportation equipment	12	3.3
Position of respondent:			Chemical products	20	5.5
President/General Manager	64	17.6	Fabricated metal products	9	2.5
Vice President/Deputy General Manager	40	11	Appliances	22	6.1
Manager/Supervisor	196	64	Electronic/electric equipment	93	25.6
Others (eg. department heads)	63	17.4	Automobiles or auto parts	24	6.6

Time period that the firm has focused on environmental protection issues:			Furniture and fixtures	18	5.0
≤1 year	26	7.2	Others	56	15.4
2~5 years	176	48.5	ISO certification:		
6~10 years	102	28.1	ISO9000	320	88.2
11~15years	22	6.1	ISO14000	243	66.9
≥15years	37	10.2			

3.3 Non-response Bias Test

Non-response bias refers to difference between target respondents who did or did not choose to participate in a survey, and is the major source of sampling errors. Non-response bias testing is an effective way of ensuring the generalizability of study outcomes. In some cases, however, it is almost impossible to acquire information from non-respondents. To account for non-response bias, earlier researchers Chen & Paulra (2004) proposed an approach that compares the responses of early and late waves of returned surveys. Here, the first one-third of responses (121) and the last one-third of responses (121) were selected and compared with a Chi-square test (indices such as Pearsonχ^2, DOF, P-value) to determine if there were differences between the earlier and later responses. The results indicated no statistical difference between early and late responses, at the 95% confidence level (results are shown in the appendix). We thus concluded that non-response bias was not an issue.

4. Data Analysis

This study employs two statistical analysis software programs (SPSS19.0 and AMOS22.0) to analyze our survey data. The data analysis includes two aspects: 1) reliability and validity of the scale, tested with reliability analysis, validity analysis, exploratory factor analysis, and confirmatory factor analysis; 2) hypothesis test, accomplished primarily through structural equation modeling and hierarchical regression analysis.

4.1 Reliability Test

Reliability is a reflection of the consistency or stability of scale measuring results (i.e., data). This study utilized the Cronbach's Alpha coefficient as a scale reliability index (using SPSS19.0 software). As shown in Table 2, the Cronbach's Alpha coefficient is 0.955 after standardization, confirming that our scales are reliable. In terms of internal consistency, the scale composite reliability (SCR) values are all above 0.7. Thus, the scales used in this study are sufficiently reliable for our analysis.

The circular economy capability (CEC) dimension has been innovatively explored in this study. We conduct a further exploratory factor analysis on the sub-dimensions of the questionnaire using principal component analysis (KMO = 0.886 > 0.7; Bartlett sphericity test P value = 0.000 < 0.001). Factor loading values of maximum variance (varimax) after rotation are shown in Table 2. Exploratory factor analysis (EFA) can be used to separate the circular economy capability (CEC) into three dimensions: reduction, reuse, and recycle capabilities. Similarly, the factor loading of other dimensions can also be obtained.

Tab. 2

Scale reliability and validity test

Dimensions	Sub- dimensions	Code	Mean	S.D.	Factor loading
IP Alpha=0.818 SCR=0.9394 AVE=0.6892	Coercive pressure (CP) Alpha=0.827, SCR=0.8609,AVE=0.6736	CP1	3.02	1.068	0.809
		CP2	3.13	1.033	0.835
		CP3	3.64	0.951	0.818
	Normative pressure (NP) Alpha=0.743, SCR=0.7996,AVE=0.6663	NP1	3.78	0.957	0.794
		NP2	4.14	0.952	0.838
	Mimetic pressure (MP) Alpha=0.716, SCR=0.8475,AVE=0.7353	MP1	3.84	0.858	0.857
		MP2	4.07	1.003	0.858
SCRM	Alpha=0.903, SCR=0.9290, AVE=0.6858	SRM1	3.65	0.964	0.851
		SRM2	3.69	0.878	0.816
		SRM3	3.64	0.988	0.836
		SRM4	3.43	1.053	0.810
		SRM5	3.59	0.977	0.833
		SRM6	3.54	1.041	0.822
SSCD	Alpha=0.905 SCR=0.9624 AVE=0.7195	SSCD1	3.55	1.054	0.805
		SSCD2	3.91	0.860	0.819
		SSCD3	3.93	0.936	0.907
		SSCD4	3.79	1.034	0.824

		SSCD5	3.94	0.871	0.864
		SSCD6	3.96	0.864	0.833
		SSCD7	3.65	0.924	0.872
		SSCD8	3.75	0.940	0.823
		SSCD9	3.91	0.928	0.872
		SSCD10	3.84	0.983	0.858
CEC	Alpha=0.897 SCR=0.9601 AVE=0.7067	CEC1	3.98	0.904	0.854
		CEC2	4.18	0.790	0.837
		CEC3	4.22	0.850	0.838
		CEC4	3.77	0.973	0.851
		CEC5	3.90	0.942	0.860
		CEC6	3.87	0.970	0.783
		CEC7	3.88	0.938	0.859
		CEC8	3.58	0.995	0.812
		CEC9	3.66	1.054	0.840
		CEC10	3.65	1.169	0.869

4.2 Validity Test

We test content validity, convergence validity, and discriminant validity for the scales. Content validity is sufficient as the measurement items are available in the literature. Before setting a final scale, we invite scholars and experts in ecological industry management to conduct a semi-structured interview, and we revise partial content and several items of the scale according to their suggestion and advice. As shown in Table 2, the factor loading of each item was between 0.783 and 0.907, significant at the 0.001 level, confirmatory factor analysis (CFA) can be used and each latent variable' average variance extracted (AVE) values were between 0.6663 and 0.7353 (AVE≥0.5); on the whole, the scales in various dimensions show high convergence validity. As presented in Table 3, relative to the AVE square root, the correlations between institutional pressure (IP, three sub-dimensions including CP, NP, and MP), sustainable supply chain design (SSCD), supply chain relationship management (SCRM) and circular economy capability (CEC) are small, further indicating favorable discriminant validity between dimensions.

Tab. 3
Correlation coefficient and AVE square root

Items	1	2	3	4	5	6
CP (1)	0.8207					
NP (2)	0.180^{**}	0.8163				
MP (3)	0.439^{**}	0.203^{**}	0.8575			
SSCD (4)	0.217^{***}	0.117^{***}	0.407^{***}	0.8547		
SCRM (5)	0.223^{***}	0.126^{***}	0.369^{**}	0.419^{***}	0.8281	
CEC (6)	0.151^{*}	0.096^{**}	0.232^{***}	0.296^{**}	0.260^{***}	0.8407

Note: the diagonal shows the AVE square root and the correlation is under the diagonal. * p<0.05, ** p<0.01, *** p<0.001.

4.3 Hypothesis Test

In order to further validate our research hypotheses using SEM, we use AMOS22.0 to test our model. The results show $\chi 2$/df is less than 4 (3.571); RMSEA is less than 0.08 (0.074); and NFI (0.950), RFI (0.916), IFI (0.907), TLI (0.978) and CFI (0.905) were all greater than 0.9. All indexes are close to corresponding standard values (Hu and Bentler, 1999), confirming favorable structural model fitting. Estimated using SEM, the results of testing our five hypotheses are shown in Table 4. The standardized path coefficients evaluating the impact of IP on SCRM and SSCD are 0.604 and 0.360, respectively. Both are significant at the 0.001 level, indicating that IP has significant positive effects on SSCM. This supports H1 and H2. The standardization path coefficient of the impact of SCRM on SSCD is 0.615(P<0.001), showing significant positive influence and supporting H3. The path coefficients of impact on CEC from SCRM and SSCD are 0.409 and 0.178, respectively, supporting H4 and H5.

Tab. 4
Path coefficient of SEM and hypothesis test results

Hypothesis	Standardized coefficients	S.E.	C.R.	Supported/rejected
H1:IP→SCRM	0.604^{***}	0.069	8.736	Supported
H2:IP→SSCD	0.360^{***}	0.060	5.996	Supported
H3:SCRM→SSCD	0.615^{***}	0.066	9.362	Supported

H4:SCRM→CEC	0.409***	0.059	6.888	Supported
H5:SSCD→CEC	0.178***	0.049	3.645	Supported

Note: IP, which consists of CP, NP, and MP, here when testing H1 and H2, is treated as a single variable. * *p*<0.05, ** *p*<0.01, *** *p*<0.001.

In order to test H6 (H6a, H6b, and H6c) and H7 (H7a, H7b, and H7c), we refer to Wen (2005) to conduct a moderation effect test and adopt hierarchical regression analysis to test the hypotheses. The first step is the regression of the dependent, independent, and moderator variables. The second step is the regression of these variables and the interaction term (independent variable*moderator variable). The results are then used to determine if there is any moderation effect based on the significance of changes in the two R^2 values and the interaction term's coefficient.

As shown in Table 5, we individually test the moderation effect of CP, NP, and MP, on SCRM and CEC. The results show that both CP and NP play significant negative moderating roles; the interaction terms' (CP*SCRM and NP*SCRM) standardization coefficients are -0.644 (P<0.01) and -0.445 (P<0.05), respectively, and R^2 changed (ΔR^2) significantly, supporting H6a and H6b. Interestingly, CP and NP actually weaken the positive influence of SCRM on CEC. A moderating effect of MP has not been detected, as the coefficient (-0.373) of interactive item (MP*SCRM) and change in R^2 (ΔR^2=0.003) was not significant, rejecting H6c. Thus, hypothesis H6 has not been fully supported.

Tab. 5
IP moderation effect test for SCRM and CEC

	IP=CP		IP=NP		IP=MP	
Step 1:						
IP	0.106**	0.137**	0.102**	0.125**	0.181***	0.039***
SCRM	0.545***	0.636**	0.540***	0.630***	0.475***	0.039***
R^2	0.474**		0.471*		0.488	
Step 2:						
IP	0.447***	0.580***	0.305**	0.375**	0.346***	0.118***
SCRM	0.835***	0.975***	0.781***	0.911***	0.666***	0.135***
IP×SCRM	-0.094**	-0.644**	-0.061*	-0.445*	-0.050	-0.373
R^2	0.488**		0.476*		0.491	
ΔR^2	0.013**		0.005*		0.003	

Note: The dependent variable is the circular economy capability (CEC). The second (not the first) column is the standardized coefficient. Significance: * *p*<0.05, ** *p*<0.01, *** *p*<0.001.

Table 6 details the moderating effect testing process of the three types of IP between SSCD and CEC. The results show that the moderating effect of CP has not been verified in this study. The coefficient (-0.437) of interaction item (CP*SSCD) and the ΔR^2 change (0.004) are not significant, rejecting H7a. However, the negative moderating effects of NP and MP has been confirmed, as the standardized coefficients of interactive items (NP*SSCD and MP*SSCD) are -0.491 ($P<0.05$) and -0.511 ($P<0.05$) respectively, and R^2 has changed significantly, supporting H7b and H7c. We have also observed an interesting phenomenon where NP and MP weaken the positive influence of SSCD on CEC. All in all, H7 has not been fully supported.

Tab. 6
IP moderation effect test for SSCD and CEC

	IP=CP		IP=NP		IP=MP	
Step 1：						
IP	0.020	0.025	0.011	0.013	0.097^{**}	0.036^{**}
SSCD	0.758^{***}	0.757^{***}	0.762^{***}	0.761^{***}	0.701^{***}	0.700^{***}
R^2	0.589		0.589*		0.597*	
Step 2：						
IP	0.272^{*}	0.353^{*}	0.266^{*}	0.327^{*}	0.345^{**}	0.405^{**}
SSCD	0.938^{***}	0.937^{***}	1.016^{***}	1.015^{***}	0.975^{***}	0.974^{***}
IP×SSCD	-0.064	-0.437	-0.069^{*}	-0.491^{*}	-0.072^{*}	-0.511^{*}
R^2	0.593		0.594^{*}		0.603^{*}	
ΔR^2	0.004		0.006^{*}		0.006^{*}	

Note: As in Table 5, the dependent variable is the circular economy capability and the second (not the first) column is the standardized coefficient. Significance: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

The results of our hypothesis tests are detailed in Figure 2. Overall, H1, H2, H3, H4, and H5 have been supported, but IP's moderation effect hypotheses (H6 and H7) have not been fully supported; we have observed negative moderating effects (H6b and H7b) of NP on the relationship between SSCM and CEC.

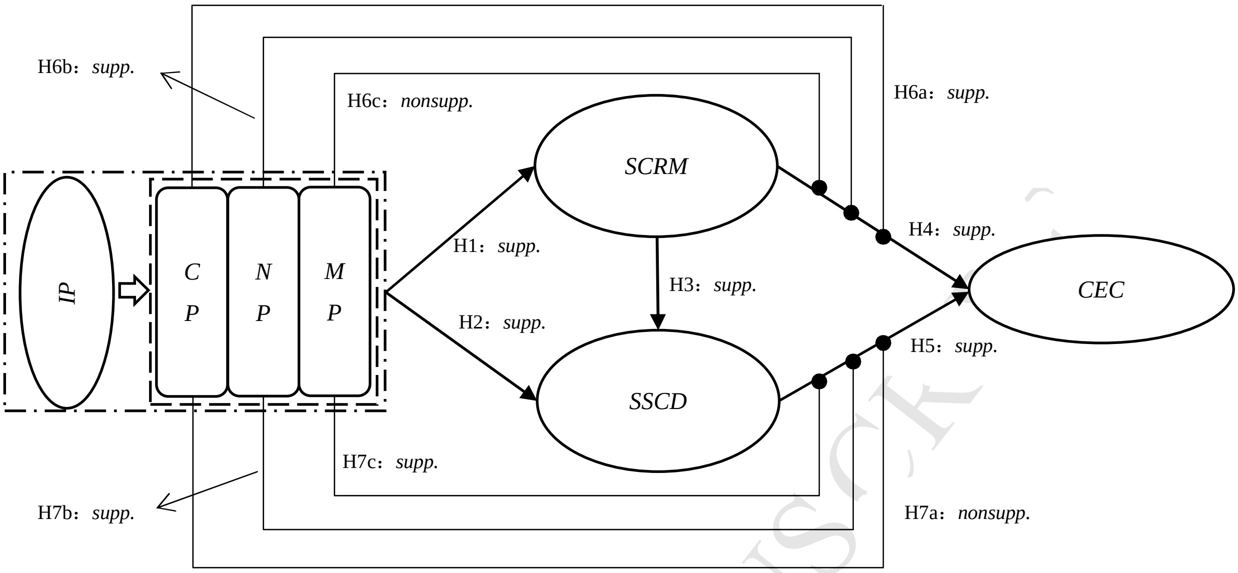

Fig. 2. The results of hypothesis testing

5. Discussion

This paper explores the effect of IP on SSCM practice and the relationship between SSCM and performance of a circular economy. Although not all of the individual hypotheses are supported, the constructs stand together reasonably well, grounded on the good fit of the structural model and the statistical support for the majority of the hypotheses. However, the detailed mechanisms underlying the empirical results require further analysis to clarify the relationship among IP, SSCM, and CEC for eco-industrial park firms.

5.1 IP and SSCM Practices

Our empirical results showed that IP, which includes CP, NP, and MP, has a significant positive effect on SCRM (β=0.604, sig. at the 0.001 level) and SSCD (β=0.360, sig. at the 0.001 level) of eco-industrial park firms. This means that laws and regulations, constraints and pressure from non-government organizations, cooperation with suppliers, customer satisfaction, and other factors all contribute to IP and promote firm's capability to improve its SSCM, consistent with previous studies of non-eco-industrial park firms(Walker and Jones, 2012; Zhu et al., 2005). SSCM is a complex, comprehensive and dynamic cross system engineering (Gimenez and

Sierra, 2013). The SSCM practices of manufacturing firms must balance external and internal pressures and challenges and also meet the social responsibility of the external organization to achieve financial performance (Walker et al., 2012). Similarly, firms in an eco-industrial park exist in an institutional environment that controls its behavior and therefore, its performance. The institutional environment can promote eco-industrial park firm's SSCM due to pressure from the government, non-governmental organizations, suppliers and customers. Customers can directly pressure eco-industrial park firm to fulfill social responsibilities. This finding is also supported by previous research (Zhu et al., 2013). Additionally, in the common pursuit of green supply chain network or sustainable supply chain network design, SSCM practice for park firms should consider the dynamic characteristics of the external environment in combination with applicable environmental protection measures and relevant laws or regulations.

On the other hand, SCRM shows a positive impact on SSCD with standardized coefficients β = 0.615 (sig. at the 0.001level). This indicates that cooperating with suppliers that offer environmental and social benefit is the basis of SSCD and allows the provision of green products or services to customers. These results are consistent with the findings of Dubey et al.(2015). We therefore suggest that firms in eco-industrial parks should positively apply environmental laws and regulations to the development and management of supply chain relationships, and select suppliers and vendors that also strive for outstanding environmental protection and social performance. In the design of sustainable supply chain, it is necessary to integrate environmental considerations and stakeholder demands into product development and production process design, and to reduce the impact on the natural environment throughout the entire life cycle.

5.2 SSCM Practices and CEC Performance

As the empirical results show (see Table 4), the SSCM practices, which include SCRM (β=0.409, sig. at the 0.001 level) and SSCD (β=0.178, sig. at the 0.001 level), are positively and significantly associated with CEC. This indicates that in response to the increasing environmental pressure, SCRM and SSCD are important ways that eco-industrial park firms can integrate and allocate resources, and improve overall environmental performance. SSCM is a vital antecedent affecting the eco-industrial park firms' CEC. An eco-industrial park is an industrial symbiosis combination that shares resources and exchanges products, and connects different factories or firms by transferring material or energy (Tian et al., 2014). The original intention of building eco-industrial parks is to construct a circular economy industrial chain at the park level. This essentially consistent with SSCM in the pursuit of economic benefits combined with a reduction of resource consumption and waste emissions through a closed-loop flow between matter and energy. SSCM combines sustainable development and supply chain management. It requires the strategic integration of a firm's economic, environmental and social objectives; and considers the long-term economic benefit of the firm and the entire supply chain by system coordination of all aspects of the organization.

From the comparison, we believe that SCRM shows a more significant positive impact on CEC than does SSCD. Consistent with Zhang et al.(2015), eco-industrial park firms can be divided into producers, consumers, secondary consumers, and so on. There is a kind of ecological relationship among these firms and the firms connected with upstream and downstream firms have a more significant effect on the circular economy, so that the performance of each connected firm contributes to the overall CEC. Accordingly, to enhance the CEC of eco-industrial parks, each firm must consider environmental protection for the whole supply chain system, but SSCD depends on the upstream and downstream industrial metabolism and symbiotic relationship of firms. This conclusion not only expands the application of institutional theory to supply chain management research, but also fills the current research gap in the existing literature (Dubey et al., 2015; Walker and Jones, 2012) that limits the research object to a single industry.

Additionally, this study has an interesting finding: CP, NP, and MP show different degrees of negative moderation effects on the relationship between SSCM and CEC. Among them, CP and NP have significant and negative moderation effects on the relationship between SCRM and CEC; however, MP does not shown that kind of moderation affect (see Table 5).

Furthermore, NP and MP have significant and negative moderation effect on the relationship between SSCD and CEC; however, CP does not show that kind of moderation effect (see Table 6). These results are unexpected, and are contrary to Dubey's (2015) empirical results based on a general business sample. It suggests that compared with general firms, eco-industrial park firms have special characteristics, and the government and other organizations should appropriately shape the institutional environment to promote their practice of sustainable supply chain.

6. Conclusions and Implication

This paper focuses on eco-industrial park firms and uses institutional theory to discuss the CEC of firms from the perspective of a sustainable supply chain.

We have assessed a comprehensive "Institutional Pressure → Sustainable Supply Chain Management → Circular Economy Capability" model using Structural Equation Modeling to reveal the influencing mechanism of SSCM practices on the establishment and improvement of circular economy capability. This study not only enhances our understanding and awareness of sustainable supply chain practices and eco-industrial park firms, but also provides valuable information to guide future academic research and eco industrial park operations.

6.1 Contributions

This study makes a significant contribution to on-going research that relates sustainable practices along the supply chain to environmental performance.

1) This paper provides empirical support that, under the influence of IP, SSCM can improve the circular economy performance of an eco-industrial park. In contrast to Large & Gimenez (2011), Dubey et al.(2015) and others who considered general firms or firms in a single industry as the research object, the research object of this paper is the set of eco-industrial park firms. Additionally, compared with Wolf (2014), Gualandris & Kalchschmidt (2014), Ortas et al.(2014) and others who studied the driving factors of SSCM from the perspective of stakeholder pressure, customer pressure, and the social responsibility of the firms, this paper incorporated IP into the external environment system faced by SSCM.

2) We have applied the concept of organization ability to the field of circular economy in eco-industrial park firms, and attempted to develop an index to measure CEC from three dimensions: reduction capability, reuse capability, and recycling capability. Compared with previous literature (e.g. Dubey et al., 2015; Gimenez and Sierra, 2013; Qu et al., 2015) that used financial and environmental performance to evaluate the performance of SSCM practice, green production practices within a circular economy require comprehensive consideration of environmental, financial, and social performance factors. As an assessment index, CEC prevents dependence on "environmental performance" when evaluating green production practices (Emilie and Valérie, 2014; Wolf, 2014).

This research also furthers the study of SSCM practice and can guide eco-industrial park firms in efforts to develop a circular economy.

(1) For firms located in an eco-industrial park, it is important to consider the significant importance of IP due to climate change and other environmental factors. During this time of continuous deterioration of the Earth's environment, increasingly severe resource shortages, and growing public consciousness of environmental protection, consumers now expect greener products and services and increasing regulation of environment-related behavior. Eco-industrial park firms should actively participate in the "producer-consumer-decomposition" recycling network and be aware of (and comply with) their external institutional environment. The cleaner production practices should be consistent with the external system environment.

(2) Sustainable supply chains improve CEC and should be integrated into firms and evaluated for their efficiency. In order to improve CEC, firms should select suppliers that consistently demonstrate eco-friendly behavior. There are also environmental considerations for supply chain design, including material flow and energy efficiency of connecting different firms, allowing formation of an industrial symbiotic resource sharing and waste product exchange system. The ultimate goal is a closed-loop material cycle that allows multi-level energy utilization and the elimination of waste.

6.2 Limitations and Future Directions

As with any research, this study has some limitations. First, our sample data is limited. This study obtained 363 valid samples, a sufficient number for empirical analysis. However, there are three types of eco-industrial parks in China: industrial, comprehensive, and venous industry. We did not clearly distinguish the park types of the firms we surveyed, so the universality of our research conclusions will need to be further verified. Second, there are limitations with the scales and metrics. In this study SSCM scales are relatively mature and CEC scales are quite new. However, MP items (see IP scales), whose main focus is to investigate corporate executives' individual cognitive change and their social identity but not to reflect the level of corporate's sensitivity to competitors' behavior, still need further revision. Additionally, we only surveyed one manager in each firm, so the answers might not reflect the real situation of the firm, and a broader survey might be required for improving accuracy. Moreover, we were not able to avoid the contingency of time point data when conducting our survey. Therefore, the robustness and generality of these conclusions depend on the sample's ability to provide sustained attention to the study.

These limitations and shortcomings provide opportunities and directions for further research. First, future studies could subdivide the eco-industrial parks into three types, and perform a comparative analysis of SSCM and CEC for the three-type of parks. Simultaneously, data can be collected from other countries to further validate the research hypotheses and conclusions of this study, so that a more holistic view can be achieved. Second, to avoid contingency of point data and increase the robustness of the research conclusions, future research is warranted to collect panel data by continuous focus on the particular samples. Moreover, an effective measurement scale of SSCM's sustainability performance requires further optimization and improvement. A comprehensive scale that integrates social, economic and environmental factors remains to be developed.

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Appendix

Tab. A1
Measurement Items and References

Constructs	Code	Item description	Reference
IP	CP1	Laws and regulations have provided guidance for the firm on environmental protection and green production	Simpson (2012), Liu et al.(2010), DiMaggio and Powell (1983), Dubey et al.(2015), Li and Ye (2011), Munir (2002)
	CP2	China has penalties on environmental damage and waste of resources in the firm	
	CP3	The environmental protection department monitors environmental pollution situation of firms strictly on a regular basis	
	NP1	Management principles responsible for the social and environmental consciousness of firms are very highly regarded by customers	
	NP2	Customers are more willing to cooperate with firms who show strong social responsibility	
	MP1	Corporate management advocates green production and sustainable development	
	MP2	Companies follow the laws and regulations of environmental protection during production and business operations	
SCRM	SCRM1	There have been reviews on environmental performance and social performance of suppliers in recent years	Gimenez and Sierra (2013), Dubey et al.(2015), Hoejmose et al.(2014), Walker and Brammer (2012), Wolf (2014)
	SCRM2	The ability to provide environmentally friendly products of suppliers has been assessed	
	SCRM3	Environmental and social performance of the production workshop of suppliers have been audited	
	SCRM4	The firm helps existing suppliers establish rules and regulations related to environmental protection	
	SCRM5	The firm cooperates with suppliers technically to reduce the environmental impact of product production and consumption	
	SCRM6	The firm forecasts and solves problems relative to the implementation of sustainable development in cooperation with suppliers	
SSCD	SSCD1	Clean energy such as solar or wind is used during production processes	Ageron et al.(2012), Bag (2014), Murphy and Poist (2003), Stock (1998)
	SSCD2	Environmentally friendly production technology and production processes are emphasized	
	SSCD3	The firm attaches great importance to environmentally friendly product design (such as green design, product life cycle analysis, etc.)	
	SSCD4	The firm sells waste and used materials to other firms	
	SSCD5	The firm optimizes logistics facility location to reduce the demand for logistics	
	SSCD6	Efficient modes of transportation between logistics facilities are used	
	SSCD7	The development and implementation of rules and regulations in	

		environmental protection are evaluated when selecting dealers	
	SSCD8	The firm considers its ability to provide environmentally conscious products and packaging when selecting dealers	
	SSCD9	The firm designs/optimizes ways to recycle waste materials and spare parts	
	SSCD10	A waste product recycling, classification, and processing center is established	
CEC	CEC1	The firm is devoted to reducing the unit product manual input	Zhu et al.(2005),Unob et al.(2007), Lee et al.(2007),French and LaForge (2006)
	CEC2	The firm is devoted to reducing the consumption of raw materials and energy	
	CEC3	The firm initiatively enhances the energy efficiency of production equipment	
	CEC4	Product packaging materials are used repeatedly	
	CEC5	Equipment cleaning materials are used repeatedly	
	CEC6	Leftover material is used repeatedly to manufacture other products	
	CEC7	Waste produced in the manufacturing process is recycled	
	CEC8	Waste products from consumers is recycled	
	CEC9	Recycling waste and garbage is reprocessed	
	CEC10	Waste and garbage is used after reprocessing to manufacture new products	

Tab. A2
Chi-square test results for no-response bias

Code	Pearsonχ^2	DF	P-value
CP1	13.869	8	0.085
CP2	18.375	8	0.109
CP3	7.465	8	0.487
NP1	6.566	8	0.584
NP2	7.363	8	0.498
MP1	3.167	8	0.923
MP2	2.625	8	0.956
SCRM1	17.237	8	0.280
SCRM2	18.593	8	0.378
SCRM3	20.573	8	0.180
SCRM4	13.081	8	0.303
SCRM5	12.742	8	0.106
SCRM6	12.596	8	0.263
SSCD1	15.359	8	0.101
SSCD2	6.979	8	0.559

SSCD	6.980	8	0.350
SSCD4	5.428	8	0.711
SSCD5	11.912	8	0.207
SSCD6	10.426	8	0.306
SSCD7	13.075	8	0.109
SSCD8	13.228	8	0.093
SSCD9	13.653	8	0.083
SSCD10	14.299	8	0.074
CEC1	11.627	8	0.169
CEC2	10.017	8	0.264
CEC3	4.822	8	0.776
CEC4	7.981	8	0.301
CEC5	15.255	8	0.123
CEC6	8.863	8	0.354
CEC7	13.700	8	0.090
CEC8	6.197	8	0.317
CEC9	7.708	8	0.201
CEC10	13.578	8	0.095

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