A New Conceptual Perspective on Circular Economy: preliminarily confirmation of the 7R Principle by a descriptive Case Study in Eastern China

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Abstract

The purpose of this study is to outline and demonstrate an innovative conceptual framework on circular economy. Research questions arise from the background literature review and are further developed into the proposed 7R principle model. Its preliminary confirmation is pursued by a descriptive case study of Suzhou Industrial Park (SIP) in Eastern China, which is located neighbouring to Shanghai and extensively recognized as one of the most initial Eco-Industry Parks (EIP) in China and as one of the most successful EIP. To begin with, traditional 3R principle is introduced and, then, the evolvement into 5R is discussed. After that, a proposal for a conceptual framework promoting a 7R principle is put forward. Its components are reduce, reuse, recycle, recover, rethink, resilience and regulate. The descriptive case study based on secondary data provides instances to illustrate that every aspect of the 7R framework is properly embodied by a serial of SIP practices.

Keywords: Circular Economy, Eco-Industrial Park (EIP), Suzhou Industrial Park (SIP), 3R, 5R, 7R principle model proposal.

1. Introduction

1.1 Motivation and background

It is widely admitted that China witnessed rapid economic growth over past three decades. However, it has been suffering a high cost of resource wastage and environmental deterioration.In 2012, China took the lead as the world's champion in terms of industrial output, surpassing the United States, and became the true "world plant"(Shi & Yu, 2014). On the other hand, at present, circular economy and sustainable development are increasingly getting of public concern.In the 30-year economic miracle transition, industrial parks have played a great role as "policy pioneers"(Shi & Yu, 2014).In fact, more and more researchers and industries both in China and foreign countries are interested in such themes as circular economy and Eco-Industrial Park (EIP).

According to the definition in the "Law to Promote Circular Economy in People's Republic of China", from January 1st, 2009, circular economy is the integration of activities of reduction, reuse and recycle during producing, exchange and consumption (Shen & Qi, 2012). Thus, Circular Economy is essentially an ecological economy, which requires human economic activities in

line with 3R principle, namely Reduce, Reuse and Recycle(Ying & Zhou, 2012).Circular Economy changes the traditional one-way linear economic model of "resource – product - waste" into the feedback circular economy mode of "resource – product – waste – renewable resource", which conforms to the concept of sustainable development. It also utilizes resources and protects environment more effectively, so as to gain maximal economic and social benefits with minimal resource consumption and environment cost (Ying & Zhou, 2012).

In order to promote Circular Economy, some other hot topics like industrial symbiosis, industrial parks and Eco-Industry Parks (EIP) have drawn extensive attention rapidly. Industrial symbiosis is to engage traditionally separate entities in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products (Chertow, 2000). Eco-Industry Parks (EIP) is a new type of industrial park which is designed and constructed according to cleaner production requirements, Circular Economy concept and Industrial Ecology Theory. Thus, EIP also obey to the3R principle of Circular Economy (Paper & Chunyou, 2009).In China, industrial development was promoted, firstly in the form of Economic and Technological Development Areas (ETDA) in 1984, and then, as High-Tech Parks (HTP) in 1988. Up to the end of 2013, China had around 300 national industrial parks, including 210 ETDA and 113 HTP (Shi et al., 2012).Chinese Government initiated an ambitious national demonstration EIP programme, in 2001, and some trial EIP programmes later on (Shi et al., 2012)to increase environment awareness in harmony with industrial growth. With the quick development of urbanization in China over the past decade, it is getting urgent to create a win-win relationship between economy and environment during urbanization in an industrialized town (Yu et al., 2015a). A common definition presents the EIP as "a community of businesses that co-operate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat) leading to economic gains, gains in environmental quality and equitable enhancement of human resources for the business and local community"(Popescu, 2008).

A conceptual proposal is developed from this background and motivations, and tested in a descriptive study. The literature review starts by analysing the connotation of 3R and 5R related to circular economy. Then, an attempt to propose an innovative conceptual framework coined as the*7R principle* is made. The research questions that arise from the literature review are the following:

RQ1: What is the 3R principle, and what is its meaning?

RQ2: What is the 5R principle, and what is its meaning?

RQ3: Could these principles be developed into a more updated conceptual framework related with circular economy?

RQ4: Does Suzhou Industrial Park practices embody the principles of this new proposal, as a preliminary check?

1.2 Research methodology

In this study, a *?R* updated conceptual framework related with the circular economy is expected to come out from a literature review. Then, a descriptive case study will conceptually apply and test the deducted framework within the scope of the Suzhou Industrial Park (SIP). Thus, the performance of SIP in applying ideas and methods of circular economy is preliminarily appreciated. When conducting the case study, secondary data from the official website of SIP (www.sipac.gov.cn) are used to check if the SIP practices follow the principles established by the innovative conceptual framework for circular economy that is being proposed. For the sake of the convenience of this preliminary qualitative analysis, only a very few representative organizations in SIP are introduced, as instances.

2. Theoretical background

2.1 Meaning of 3R

The principle of reducing waste, reusing and recycling resources and products is often called the "3Rs".As far as these three keywords are concerned; many researchers have contributed with their understanding and explanations. For example, Dhaka(2010) argues that (i)*reducing* means choosing to use things with care to decrease the amount of waste generated; (ii) *reusing* involves the repeated use of items or parts of items, which still have potential for use; and, (iii) *recycling* means the use of waste itself as a resource. Ying & Zhou(2012) explains that (i) *reduce* means reducing the amount of substance in the process of production and consumption; (ii) *reuse* is involved in extending the time intensity of product and service; and, (iii) *recycle* focuses on the regeneration of renewable resources after use. The 3Rs is sometimes called the waste hierarchy(Dhaka, 2010), because it sets an approach to address waste in order of importance. The waste hierarchy classifies waste management strategies according to the desirability of each R. Waste minimization can be achieved in an efficient way by focusing primarily on the first of the 3Rs, "reduce," followed by "reuse" and then "recycle." The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste (Environment & Foundation, 2006).

A basic connotation behind the first R (reduce) is to limit the amount of energy consumption, the number of purchases or the amount of waste generated. The core meaning of the second R (reuse) involves the repeated employment of items, or of usable parts of them, as much as possible, before replacing them, and the third R (recycle) means ensuring the circular utilization of products and components, or transferring waste into resources and energy by the adoption of new technology and techniques.

There are some methods to achieve the goals of 3R and fulfil circular economy, in order to decrease the amount of natural resources used and, to cut down the amount of waste generated and disposed. This kind of measures can be efficient. Examples are as follows: changing the design of the product or the production process, extending the product life cycle by improving repair and maintenance technologies, or decreasing the volume of waste discharge. Reuse can be achieved by repeatedly using products with proper maintenance and storage. At the same time, Recycle can be fulfilled by appropriate share and also, by integrated industrial symbiosis. One product or parts of a manufactured component could be the resource or raw material of another one; this means to achieve recycle by exchanging physical materials, energy, water, and by-products among a serial of companies, as it happens, for instance, in the Kalunborg Eco-Industrial Park in Denmark, the first EIP in the world. The three keywords of 3R principle are correlated rather than separated. A simple illustration, in Figure 1, shows their circular and dynamic relationships.

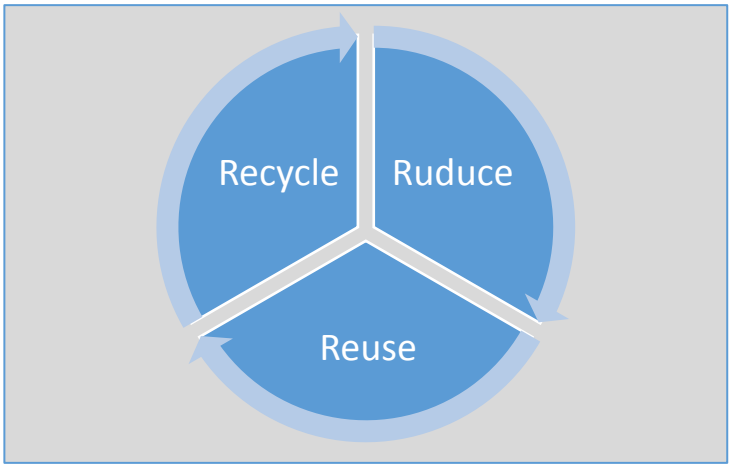

Figure 1.*The illustration of 3R principles*

2.2 Meaning of 5R

In addition to the basic 3R principle, there are some other keywords contributing to circular economy such as rethink, recover, rescue, or repair. Shen & Qi(2012)hold a view that 5R principle appears with the addition of "to rethink towards the maintenance of ecosystem" and "to repair the destructed ecosystem". Liet al. (2015) regard 5R spirit in the life-cycle of the production process, as “Recycling, Reducing, Reusing, Recovery of Energy, and Reclamation of Land”. Generally speaking, besides the 3R principle, the remaining two Rs in 5R refer to "recover" and "rethink". Recover refers to the practice of putting waste products to use. Rethink, which is the last R, is sometimes added to the front of the waste hierarchy, meaning that people should consider their options and think about their impact on the environment. For example, decomposing garbage produces methane gas (one of the greenhouse gases), which some landfill sites recover and burn for energy rather than letting it dissipate. Felicio & Amaral(2013) suggest that EIP have been seen as an opportunity for companies to reduce their waste, recover values and achieve economies of scale, in their production processes, in which, recover means to recover values. Nevertheless, some researchers refer the fifth R as to rescue, and argue that the recycling-based technologies should be promoted and implemented in EIP (Li et al., 2015). Figure 2 is an illustration of 5R principle (reduce, reuse, recycle, recover and rethink).From an innovative perspective, rethink is not a parallel keyword with others, because rethink means not only being aware of the impact any human behavior on the environment, anytime and anywhere, but also making sure to reconsider all other Rs. That is why the area of rethink in this figure is a little bit overlapped to each of other keywords. To be more specific, Reduce can imply decreasing any physical items and curtail inefficient production activities, as well as, high energy consumption; Reuse can imply utilizing products and sharing goods at their most; Recycle refers to material recycle, substance recycle, energy recycle, application recycle and data recycle, etc.; Recover alludes to the resilience that we will analyze in our innovative proposal. So, among the 5R principle, the most important is to rethink holistically in an all-around way.

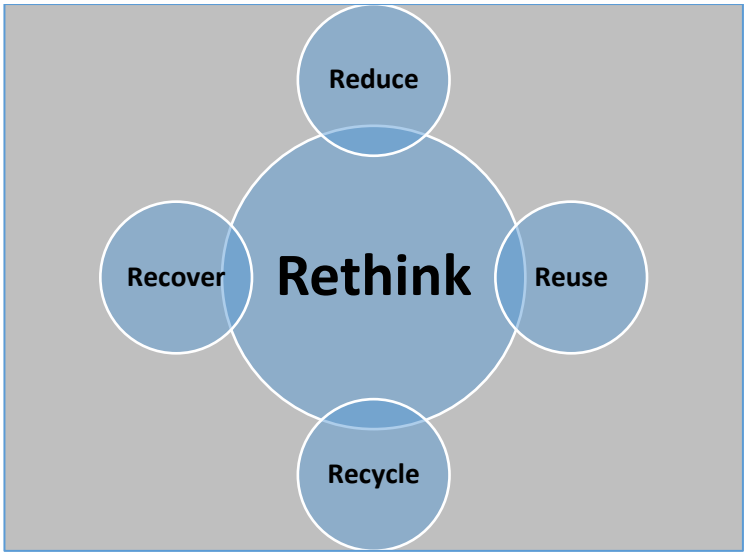

Figure 2.*The illustration of 5R principles*

2.3 Conceptual proposal of the 7R Principle

Circular Economy is essentially an ecological economy, which requires human economic activities in line with 3R and 5R principles. It is Circular Economy that further strengthens the consciousness of both resources conservation and environmental protection, thus promoting the implementation of the strategy of green supply chain management and the popularization of EIP.EIP is designed based on the requirements of clean production, principles of circular economy and industrial ecology. It is composed of the enterprises inside the EIP, and the material flow and energy flow among the enterprises maintaining industrial symbiosis by means of shared resources and exchanged by-products. The goal of an EIP is to seek: (i) loop-closing circulation of material, (ii) multi-level energy utilization and (iii) waste minimization, by simulating the natural ecological system and establishing "producers-consumers- decomposers" circulation path in the industrial system (Li & Xiao, 2017). So, in this sense, 5R is still not enough. As is shown in Figure.3, the illustration of 7R principle proposal, two more Rs are introduced, i.e. resilient and regulate, respectively.

Resilience is the ability of a system to respond to change. Indeed, comprehensively analysing the possible perturbation process is crucial for developing adaptive capacity in an EIP from topological structure and ecological feature. To track the resilience progress in an EIP, not only snapshot analysis, but also time trend need to be followed, in order to develop novel mechanisms to avoid disruptions, improve the resilience of EIP and safeguard(Li & Xiao, 2017).As it is shown in "Transforming our world: 2030 Agenda for sustainable development"(Zachariah et al., 2016), the9th goal from17 sustainable development goals, addresses the development of a resilient infrastructure, the promotion of inclusive and sustainable industrialization and fostering innovation. The literal meaning of "resilient" is returning to the original form or position after being bent, compressed, or stretched. So, in the context of circular economy, "resilient" means the internal capacity of recovering from the depletion situation of resources and energy. "Regulate" refers to the necessary management, adjustment or control from the government. For example, some laws and regulations from the state and local government, some conventions and proposals from trade associations, some suggestions and supports from non-profit sectors and some supervision and urges from mass media.

As it is shown in Figure 3, regulate or regulation is seating in the centre of the schematic diagram, and it causes an impact to all other Rs, because in our opinion, regulation is a pivotal driver to exert the efficiency of an EIP and circular economy as well. Especially in developing countries, all other Rs can be a failure if regulation is absent. EIP do work more efficiently under proper regulation and management from a holistic perspective. The proposed framework of 7R principle will be analyzed and demonstrated by the following case study on Suzhou Industrial Park, one of the most successful EIP, in China.

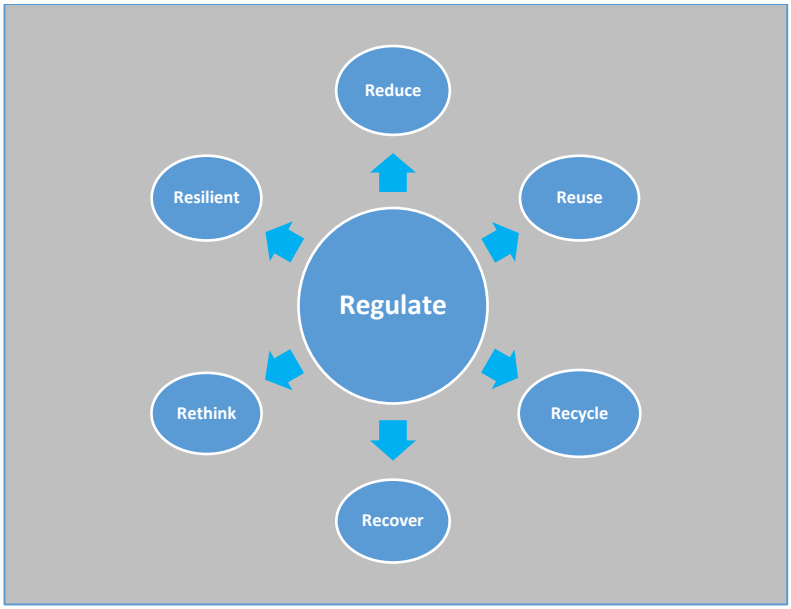

Figure 3.*7R principle model proposal*

3. Preliminary Confirmatory Descriptive Case Study

3.1 Introduction to the Suzhou Industrial Park (SIP)

TheSuzhou Industrial Park (SIP) was established in 1994 and is a flagship of the economic cooperation project between Chinese and Singapore governments. It is located in the eastern part of Suzhou, a city known as "the paradise on earth". Suzhou is also a traffic hub, about only 200 km of Nanjing, and around 100 km of Shanghai. It takes only 20 minutes to arrive in Shanghai and 45 minutes to Nanjing by high-speed train. With an advantageous transportation network, it appeals to more and more big enterprises and global talents. SIP covers a total jurisdiction area of 288 km^2, among which, 80 km^2area belongs to China-Singapore Cooperative Zone.SIP is recognized as a pilot zone of reform and opening-up, a successful model of international cooperation, and one of China's fastest-growing development zones with the most international competitive edges. In SIP, the total number of permanent residents reached over 700,000 in 2012, including registered and non-registered population. Currently, approximately 25% of the land is industrial, and 30% is residential and commercial. The remainder is green space and water (Yuet al., 2015b). Nowadays, the development goals of SIP are to develop into a hi-tech industrial park with international competitiveness and, into an innovation eco-township of internationalized, modernized, information-based happy district of Suzhou (www.sipac.gov.cn).

3.2 Achievements of SIP

Concerning the performance in environment protection, SIP obtained the label of ISO 14000 National Demonstration Zone, in 2001. As the national EIP program was launched, SIP was approved as a pilot in 2004 and started to implement EIP planning in accordance with the national EIP development guideline. In 2008, SIP passed the evaluation and obtained the label as one of the first three National Demonstration EIPs. Currently, the energy consumption per GDP is 61% lower than the national level. The discharge amount of Chemical Oxygen Demand (COD)and SO_2 are only one-eighteenth and one-fortieth of the national average, respectively.SIP is among the first national IRP (Integrated Resource Planning)

demonstration parks, among the country's first demonstration eco-industrial parks, and among the first new-type industrial demonstration bases in China(www.sipac.gov.cn).

With respect to annual economic growth in SIP, 30% annual average growth occurs in key economic indicators, ranking second among national development zones in comprehensive development indexes. It accomplished four "Hundreds of Billions" of achievements, as follows: RMB 133 billion of GDP, RMB 165 billion of accumulated taxes, USD 18.9 billion of accumulated utilized foreign capital and RMB 197.2 billion of accumulated registered domestic capital. Besides that, there also are remarkable achievements in economic transformation and upgrading, as follows: RMB 147.2 billion of output value from new emerging industries in 2010, accounting for 45.4% of scale industries and ranking the first in Suzhou and, ranking the first, for years, in using foreign capital, among China's development zones(www.sipac.gov.cn).

As far as sustainable development is concerned, SIP achieved many awards. For example, it was recognized as China's only new-tech innovation & industrialization base, as China's only demonstration base of service trade innovation, as China's only national demonstration area of business tourism, no.1 among most competitive development zones, as China's first service outsourcing demonstration base and, as China's first experimental area on preferential policies for technologically advanced service enterprises (www.sipac.gov.cn).

3.3 7R principle application in SIP

When observing SIP, there are a large amount of exemplary enterprises, which conduct very good practices, in environmental protection and sustainable development, corresponding to each component of 7R principle, namely reduce, reuse, recycle, rethink, recover, resilient and regulate. Here we provide some supportive examples, analysis and beneficial implications.

3.3.1 Reduce

In SIP, it is obvious that there is a great amount of reduction on energy consumption.According to the official website of SIP, currently, the energy consumption per GDP is 61% lower than the national level.SIP learns from the experience of Singapore and adopts high standards in promoting energy-saving circular economy. In 2012, SIP recorded 0.28 ton of standard coal for producing 10,000-yuan GDP, with 0.149 kg COD, releasing 0.07, 0.008, and 0.151 kg of sulfur dioxide, ammonia, and nitrogen oxides, respectively. These are above national averages and made SIP the leader among national development zones, for four consecutive years, in the main indicators of environmental protection, energy conservation, and emission reduction (www.sipac.gov.cn).

3.3.2 Reuse

The SIP management has organized some representatives to learn from companies with outstanding performance in practicing Corporate Social Responsibility (CSR). For example, Fuji Xerox Eco-Manufacturing (Suzhou) shared with the participants the company's experience in recycling and reusing resources. From its establishment in January 2008, the company has been recycling the waste, copying machines, printers, and consumables as printing drums and powders from Chinese mainland, to make full use of resources and reduce their impacts on environment. The company, therefore, won the honorary title of SIP CSR Company 2013 (in the category of "Environment Responsibility") and was named "Model Company of Circular Economy" by Suzhou Economic and Information Technology Commission in 2014 (www.sipac.gov.cn).

3.3.3 Recycle

Green production has been part of corporate culture among most manufactures, in SIP. Nitto Denko (Suzhou), which is a member of Suzhou Industrial Park, since its founding in 2001, launched a clean production program, investing in energy-saving and emission-cutting projects. Their aim was bringing down energy consumption and waste water discharge. The company renovated the entire AC system and, as a result, saves2.35 million kw annual use of electricity power and 8,000 tons of steam, which equals to 1,716.1 tons of standard coal. In order to save the water resource, the company recycles steam condensate and reclaimed water. Every year, the steam reused amounts to 420 tons (47 tons of standard coal) and the water recycled totaled 27,000 cubic meters (2.3 tons of standard coal) (www.sipac.gov.cn).

3.3.4 Recover

In order to optimize the regional environmental to build a beautiful SIP, for years, SIP has kept investing in environment-related infrastructure to improve the monitoring system and to use energies to their full potential. With 100% coverage of sewage pipe network, it manages to achieve Grade-1, a standard for all the waste water discharged. Moreover, the waste water treatment plant, the sludge drying plant, the thermal power plant, and the heating & cooling center create an integrated system maximizing the use of public amenities, resources, and energies as well as minimizing the discharge of pollutants. The efforts include the protection of Yangcheng Lake, the source of potable water, 45.8% coverage of green grounds, surveys on biological diversity and ecological environment with 131 bird species being confirmed around the year, the river dredging projects, and the restocking of aquatic organisms in Jinji Lake (www.sipac.gov.cn).

3.3.5 Rethink

Taking Nitto Denko (Suzhou) as an example, the company introduced a lot of programs to stimulating rethink, among which "Green Design Action", which encourages employees to build up the belief that environment protection should become a part of its corporate culture. With the "Light Down" program, the employees are required to turn off their computers during lunch break. The company also regulates the AC (air-condition) temperature and arranges people to be in charge of lights and AC. The workshops should follow the plans and turn off the production equipment not in use. The company also participates in the "MOTTAINAI Campaign", a program aiming to promote environment awareness and to cultivate sense of responsibility among employees. The survey shows that the average awareness increased from 73.1% to 80.2%, which is transformed into a reduction of 11,557 kg of carbon dioxide emission (www.sipac.gov.cn).

3.3.6 Resilient

The Administrative Committee of the Suzhou Industrial Park has been calling on companies to work together to build SIP into a model of ecological civilization through Learning and Innovation. The committee often organizes all kind of forums. For example, there is a forum, which is part of the agenda for China International Green Innovative Products & Technologies Show (CIGIPTS). Enterprises are encouraged to contribute in building ecological industrial parks through international cooperation, and to demonstrate their achievements in exploring a new path of industrialization through technological innovation and low-carbon environment-friendly circular economy.

3.3.7 Regulate

Chinese Governments (both state and local) play an essential role in improving the performance of EIPs, especially when it comes to the integration and balanced development of industrialization and urbanization.In order to secure economic sustainability and optimize industrial structure to promote sustainable low-carbon economy, SIP authorities have vetoed down more than 400 projects totaling approximately 3-billion-dollar investment, which posed potential high hazards to surrounding environment.SIP government carried out energy auditing on 74 companies and set a record of 310 million RMB Yuan from local enterprises invested in technological renovation projects, cutting down energy consumption by 100,000 tons of standard coal. The enterprises are also encouraged to reuse water and wasted heat, to conform to standards on clean production, to invest in upgrading and renovating technologies and equipments, and to make a constant goal to reduce pollutant discharges. Meanwhile, SIP Eco-Science Hub and Suzhou Environmental Protection Sci-tech Industrial Park have contracted over 100 energy conservation and environmental protection companies, including Sujing and Great, with total output of 30 billion Yuan.SIP has three air monitoring stations and other two under construction, as well as three stations monitoring water quality and one under construction, which make possible to achieve real-time online monitoring and the releasing of PM2.5, PM1, and ozone, among 135 other atmospheric factors. 62 companies, including all key companies in the area, have installed 72 sets of automatic devices in total for online monitoring of pollution sources (www.sipac.gov.cn).

4. Conclusions

In order to maintain the three bottom-line pillars, namely economic, social and environmental, holistic balance and sustainable development is getting more and more critical. When retrospect the evolvement of these principles from 3R (reduce, reuse and recycle) to 5R (reduce, reuse, recycle, recover and rethink) and then, to the innovative conceptual framework of 7R principle (reduce, reuse, recycle, recover, rethink, resilient and regulate), it is safe to conclude that 7R principle is essentially pivotal to practice circular economy and sustainable development. That is to say, all participants including enterprises in the supply chain, governments from different levels, local trade associations and consumers can get involved and shoulder responsibility by applying the 7R principle.Both Corporate Social Responsibility (CSR) and Consumer Social Responsibility (another CSR) should be attached to pursuing economic growth, social progress, and environmental sustainability, as well. As a matter of fact, individuals can vastly contribute to protect the earth by consistently practising 7R in many aspects and in a variety of ways.

To sum up, this preliminary confirmatory study tries to be inspiring to current research in the area of circular economy. In fact, the conceptual 7R principle proposal can be an adventurous try for pursuing theoretical efforts in the *?R* domain (e.g. 3R and 5R). For researchers, this is also a nice attempt to stimulate more systematic thinking. Finally, for practice, Suzhou Industrial Park is just an exemplary model among hundreds of EIP all over the world. Moreover, it will be significantly desirable if there is an increasingly number of industrial parks to introduce 7R principle. Of course, there are some obvious limitations during this study, such as the lack of primary data and a more detailed and structured field study. Nevertheless, future research on the theme of EIP and in-depth theoretical exploration is worthy of much more effort, research directions could be to conduct more exemplary case studies, quantitative analysis on connotative value of 7R, and comparative analysis on EIPs from different countries and areas.

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