

# On Developing Industry-study-research Alliance in China Based on Circular Economy

Li Lvcheng

School of Material Science and Engineering, Wuhan University of Technology, Wuhan, P.R.China,  
430070

(E-mail: lilvcheng@126.com)

**Abstract:** Based on a comprehensive overview of the theoretical and applied researches on circular economy and Industry-Academia-Research alliance, this paper finds out that the most influential factors constraining the development of circular economy and IAR alliance in China, and concludes that developing IAR alliance is the internal requirement of circular economy. It proposes a theoretical framework and some practical measures for establishing successful IAR alliances with Chinese Characteristics, which emphasize the conducting role of the government, clustered IAR alliance by diverse cooperation ways, implanted talent-fostering system from the integration of industrial clusters and academic clusters, and improvement in policy and legal environment for developing circular economy.

**Keywords:** Circular economy; Industry-academia-research alliance; Chinese characteristics; Strategic alliance; Industrial cluster

## 1 Introduction

Since 1990s, establishing a circular economy and society has become one of the most important strategies for western countries to achieve sustainable economic growth. Circular economy is a low-carbon economy which relies on human intelligence and technologies to realize a closed material recycling system with zero carbon emission.

The experience of developed countries indicates that technological innovation is a vital approach to make full utilization of resources and maintain dynamic balance between human beings and natural environment. Technological innovation is therefore critically important for promoting transformation of economic growth models and establishing circular economy. Industry-Academia-Research cooperation, as an effective way for fueling technological innovation, is one of the most important approaches for establishing an innovative society. Such cooperation requires a complicated innovation system, “oriented by enterprise, driven by market and supported by academia”. Therefore it is meaningful to discover new models of IAR strategic alliance so as to form a cooperative trinity economic entity in technological innovation covering fundamental researches, exploratory researches, and application researches.

There have been abundant researches on Industry-Academia-Research alliance up until now. Fontana, Geuna & Matt (2006)<sup>[1]</sup> identified four basic models for Industry-Academia-Research cooperation: research grants, research joint ventures, knowledge spillovers and technology transfer, representing various reciprocate degrees among the parties involved in. Belkhdja & Landry (2007)<sup>[2]</sup> argued that Industry-Academia-Research alliance constitutes a significant tool for promoting enterprise’s competitiveness by benefiting from elevated organizational competitive status. Ponds, Oort and Frenken (2010)<sup>[3]</sup> found that the knowledge spillovers stemming from university and industry collaboration is not limited to the regional scale and can take rather long distance with complicated network. However, researchers showed almost the same concern about the inefficiency in the collaboration. Lee (1999)’s research<sup>[4]</sup> showed that industry-university cooperation hampers academic freedom in long-term, fundamental, disinterest researches which in turn has negative influence of universities’ long-term development. Siegel, Waldman, et al. (2003)<sup>[5]</sup> identified various barriers to realize efficient alliance, such as “culture clashes, bureaucratic inflexibility, poorly designed reward systems, and ineffective management of university technology transfer offices”. Veugelers & Cassiman (2005)<sup>[6]</sup> proposed that IAR alliance should be characterized as high uncertainty, strong information asymmetry among cooperating parties, and high transaction costs.

## 2 The Internal Relation Between IAR Alliance and Circular Economy

It is known that natural resources are the material basis for human beings to live on and make economic and social development. However, human beings have taken the resources as granted and

blindly maximized their economic output without taking adverse environmental impacts into consideration. Such “mass-production, mass-consumption and mass-pollution” have been creating numerous problems— shortage of natural resources, ecological imbalance, and environmental destruction. How to change such worrisome situation or even reverse it? Developing circular economy is the only choice and IAR strategic alliance is one of the most important solutions to achieve it mainly for four reasons.

Firstly, with respect to resource utilization, circular economy is oriented to make high-efficient and comprehensive resource utilization, which is a fundamental revolution towards traditional economy development strategy—“high growth, high discharge, high pollution”. Secondly, in terms of environmental protection, circular economy highly relies on a series of environmental protection standards and quality certification systems. Enterprises are encouraged to set up a comprehensive management system in order to realize ecological design, green production, recycling of resources and sustainable economic growth. Thirdly, in light of technology paradigm, circular economy demands a compatible technology supporting system, which can realize dynamic feedback process of “resource-production-recycling resource”; Fourthly, regarding the whole economic and social system, circular economy requires economic activities in harmony with environment by following scientific principles in ecology and economic rules so as to realize sustainable development.

In conclusion, developing circular economy a complicated social project, which aims to achieve sustainable development in society, economy and environment by maximizing resource utilization and reduce pollution by the cooperation of enterprises, industry, cities and regions from different social and economic systems. Realizing circular economy is a huge systematic work as well. It is carried out by enterprises but needs supports from the whole society, especially from the cooperative power from the governments, enterprises, universities and research institutes.

By integration and optimization of industrial capital and knowledge capital, and human resources and technological resources, technical standards and assessment systems could be established through researches on general purpose technologies, core technologies and common technologies, which can provide a reference for the government to design a series of compatible institutions of finance, tax revenue, land usage and investment. It calls for intensive integration and cooperation of enterprises, universities and research institutes through diverse models, such as technology transfer, joint venture, joint research institute, joint research programs, joint human resource management, joint funding for technological innovation. By such strategic alliance, enterprises could take advantage of human resources from academia, solve technological difficulties and build up a internal circular economic system with innovation in recycling technologies, pesticide-free technologies and green technologies. Meanwhile, such alliance encourages scientific researches to work in line with the trend of circular economy. In sum, Industry-Academia-Research alliance is the internal demand of the development of circular economy.

### **3 Constraint Factors for Realizing IAR Alliance**

In recent years, the development of circular economy in China has gained much positive experience and shown a great model for the rest of other developing countries, but problems cannot be neglected.

First of all, indifferent attitudes and low level cooperation are very common. On the one side, inadequate consciousness of circular economy hampers enterprises’ investment, which is the major factor leading to weak cooperation in alliance. On the other side, universities and research institutes, which should be responsible for the researches, can’t meet up with industrial demand, but too much focus on the theoretical issues.

Secondly, for decades, environmental and resource prices are largely underestimated or ignored. Enterprises pay zero or very cheap price for the usage of environment and resources for quite a long period, which in return not only exaggerates economic growth, but also distorts the developmental strategies of enterprises. One disastrous result is that enterprises are accustomed to take the market share as the exchange for technology and exchange capital for more advanced machines. According to a survey, expenditure for the equipments and software makes up as much as 55.8% of enterprises’ innovation budget at present.

Thirdly, the alliance is accompanied with weak scientific organization management and loose cooperation forms. Most of enterprises focus on obtaining technical solutions, while universities mainly concern of research funding, giving rise to a kind of disunity in cooperation. In addition, due to the

institutional problems of China's overall management system, there are inherent management obstacles among universities, scientific research institutes, and enterprises. As a result, IAR alliance inevitably becomes oral-based, ostensible, short-sighted and virtualized, failing to establish a substantial long-term, stable, and institutionalized interest community, with real exchanges in technologies and human sources.

Fourthly, institutional arrangement for IAR alliance is absent, leading to ambiguous definition of responsibility, property right and profits. Government fails to provide relevant incentive mechanism, preferential policies and financial support. Thus, the shortage of financial investment, outdated equipment, and antiquated technologies restraint the development of circular economy and IAR alliance.

## **4 Theoretical Framework on IAR Alliance and Circular Economy and Practical Applications**

### **4.1 The innovative ideas of developing circular economy**

Firstly, technical design and implementation strategy for developing circular economy involve a broad range of interest groups and complicated coordination. At the enterprise level, it requires cleaner production process and internal material-recycling. It also should follow the rule of saving resources and energy in the process of production with significant elimination of harmful pollutants. At the stage of product design, it requires to consider reducing the adverse effects of producing process from raw material extraction to product waste disposal. Finally, environmental factors of the service requirements should be taken into consideration in product design and management, so as to establish a ecological industrial chain through internal logistics and energy flows. In the industrial park or ecological industrial park, multiple technological solutions which can make byproduct or waste of one enterprise as raw materials for other enterprises are needed, in order to realize closed cycle of materials and multi-level usage of energy.

At the same time, taking the advantages of eco-industrial parks can help realize regional circular of materials, such as transverse coupling of ecological park, longitudinal closure, regional integration and soft structure. For instance, Jiangsu Shagang Group Company of China used to make serious environmental pollutions, but now has become one of the biggest steel production bases which take the lead in developing ecological circular economy. It has established 30 energy saving recycling circles, and innovatively built up a multi-level circulation system named "circulatory circle of five applications"<sup>[1]</sup>.

Secondly, circular economy, characterized by the recycling and reusing of industrial wastes, is a range of economic production and reproduction activities focusing on efficiency of resource utilization and environmental protection and is a comprehensive analysis of material input, output and environment. Hence, it inherently should focus on the holistic system and process, rather than small parts or sections. It is in agreement with the classical theories hold by the Canadian Researchers (Ecological Footprint Theory) and Austrian researchers (Sustainable Island Theory): An authentic circular economy only takes place within a region. It doesn't mean to set inter-regional or international boundaries, but gives prominence to the local and neighbor economic participants. They both stressed the researches on technological breakthrough not only at the regional level but also at the product production level, which demands a strategic alliance among enterprises, academia and research institutes to form a united power for breakthrough researches on general techniques and key techniques in an industry or a region or a system, for finding incremental multi-level technologies and a set of strategic thoughts.

Finally, circular economy is not once for all but a strategic alliance with persistent improvements, because a new technological strategy should be selected on the ground of the whole technical system rather than a single technique or sector or producing process<sup>[2]</sup>.

### **4.2 Practical solutions for realizing IAR alliance based on the theory of circular economy**

#### **4.2.1 Successful western experience and conductive role of governments**

Up until now, the successful stories of Industry-Academia-Research alliance can be summarized into three major categories, from which China's "Industry-Academia-Industry alliance" can learn: the American "Silicon valley model", Japanese and Korean "Government-Industry-Academia model" and Brazilian "Strategic Partner Plan model". The American "Silicon valley model" should be the earliest and most successful case for the cooperation between enterprises and universities. Massachusetts Institute of Technology (MIT) is one of such representative universities, which connects teaching, research and commercial economy by penetrating industrial consultancy into academic systems, technology transfer and Intellectual Property (IP) licensing and commercializing technologies by starting up new ventures. The Japan model is much more relying on the government. The current

Second Science and Technology Plan was formulated in 2001 which encompassed expansion of governmental investment in R&D and reform of the science and technology system for improvement in innovation. Since this law came into force, most of big Japanese companies have been actively exploring various cooperation forms with universities, such as Tokyo University's "Proprius21" program<sup>[3]</sup>. A combination of these policies and financial investment has established the institutional framework for science, talented workforce and innovation, in the perspective of national development strategies, such as "creation of a country with intellectual protection", "creation of an affluent society based on educated workforce", "creation of knowledge economy", and "creation of innovative society". It worthy of special focus on India's cooperation model, where open research platform has been built by multiple approaches, including education and training program for the workforce, practical application of research outcomes and direct involvement of enterprises in setting college modules. One the one side, it is beneficial for improving research quality and providing abundant internship and job opportunities for the students. On the other side, it assists enterprises to find technological solutions and expand information flows, leading to strong cluster effects of technological innovation. India's model set up a very good model for China to follow, especially in terms of the involvement of the enterprises in research activities and technical education.

At present, IAR cooperation is under its way in China, with various forms, including government-led, enterprise-led and academia-led cooperation. In the government-led cooperation, governments invest in several programs of vital importance as a part of national or local development plans and provide a set of preferential policies in financing, tax rates, and other policy aspects, attracting universities, research institutes and other parties to participate in projects and programs, such as "The National High Technology Research and Development Program of China (863 Program)", "The National Basic Research Program of China (973 Program)", "The National "Climbing" Program of China", "China Spark Program" and "China torch Program". Enterprise-led cooperation is initialized by the demanding of technical improvement or innovation by the enterprises during their producing process, in the form of entrusting universities or research institutes for technical support and technical services. The fruits of research activities go directly to the enterprises while the enterprises take on all of the risks of all investment in innovation, researches and application process. The academia-led cooperation is in contrast authorized by the universities and research institutes. They set up ventures or industrial parks to realize technological transfer with their own advantages in scientific subjects, information, talents and social capital, such as Tsinghua Unisplendour of China, BD Founder of China, which all have achieved grant commercial profits and social influence<sup>[4]</sup>.

In conclusion, it is of vital importance to put the IAR alliance based on circular economy up to as high as the national or regional level. It indicates that the development strategies of academia should have detailed strategic cooperation blueprints. Governmental conduction and macro-supervision are invaluable for simulating and supporting the cooperation within IAR alliance. Governments not only provide plenty of solutions for the financial difficulties and encouraging technology innovation and transfer, but also set up a range of long-term mechanisms such as incentive mechanism, profit sharing mechanism, financial support mechanism and workforce training mechanism in accordance to the developing needs of industries and circular economy.

#### 4.2.2 Clustered IAR alliance based on circular economy

"Industrial cluster" is a regional or urban concentration of related enterprises and organizations (e.g. universities, research institutes, governments and intermediary agents), based on similarities or complementation. More specifically, within a formal contract framework, all parties of the alliance can realize win-to-win in the long-run from circular economy by benefiting from complementary knowledge and value transfer from one industry to another. Industrial clusters can meet up with the requirements of an energy-saving and environment-friendly society in three ways: designing the producing processes based on circular economy, establishing knowledge-based industrial parks or eco-industrial parks, and at the same time setting up assessment system of economic growth, resource circulation, and environmental pollution. Such clustering alliance based on circular economy gives consideration to the differences in interests and development targets of enterprises, universities and research institutes and cultivates a positive cooperation with complementary advantage, shared economic profits, distributed innovation risks, and win-to-win development. It is a proper integration between modern market and hierarchy Chinese management system and is most ideal model for economic transformation at present, which has both of relatively strong coordination and flexible policy-making, lowering the transition costs, but not increasing management costs.

Such ideal model to realize circular economy, requires enterprises as the major subjects to realize

new integration of knowledge capital, technological resources and industrial capital, by taking advantage of universities and research institutes in knowledge capital and talents according to their own development strategies. It is a clustered IAR alliance based on circular economy instead of a single innovation system which is capable of solving the key or common technological problems in more than one industry, and can bring up fundamental transformation in economic development strategies. Hence, clustered IAR alliance should cover every aspects of the social economy in every stage and every field. It is the time to develop such clustered alliance to push the transformation of economic growth and at the same time to realize economic development, in order to achieve the overall improvements in value chains of circular economy and in-depth cooperation of the IAR alliance.

The internal circulation within enterprises should be the first step for consideration. Circular economy requires the wastes of downstream processes can be recycled as the inputs to the upstream ones, such as recycling of waste water, consumable products, and byproducts. The following step should be the resource circulation between firms. It calls for the recycling of wastes and reusing of energy from the downstream firms back to the upstream ones. Finally, it is necessary to realize the comprehensive circulation within the whole system. The discarded final products of one enterprise can be partly or wholly used as inputs for the primary industry sectors. In one word, it is pressing to realize limitless circulation of the limited natural resources with minimizing negative impacts of economic activities on the environment.

#### 4.2.3 “Implanted” education system for innovative talents in the integration of academic clusters and industrial clusters

IAR alliance in China used to take the form of “Point to point”, which can hardly benefit from the industrial clustering effects for decades. Nowadays, the situation has changed. The new alliance has put a combination of cooperating economic venture, cooperating technology innovation funding and cooperating innovative talent base into the target of innovative country and society. China is on its way of forming a new IAR alliance where enterprises are the principle parts, academia provides knowledge support and the market determines the direction of technological innovation. In addition, technology transfer should be taken as the breach, with innovation mechanism as the threshold and fostering innovative workforce as the target. Such model aims to move gradually from simplified technology transfer to a comprehensive technology innovation system and innovation-based talent-fostering system, in order to accomplish all-in-one integration among enterprises, universities and research institutes<sup>[5]</sup>. It gives special emphasis on “implanted” talent-fostering of the IAR alliance, from enrollment, module design, education targets to thesis design and job-seeking, so as to ensure the future talents have good sense of circular economy and recycling technology. Cooperation in high quality talent-fostering is a very effective approach to push further cooperation in the IAR alliance: it does not only contribute to the national strategy of developing innovative and knowledge country, but also secures the knowledge-based human resources for the enterprises which are trying out new circular economy.

#### 4.2.4 Optimizing policy and legal system, establishing IAR alliance with Chinese characteristics

The “Circular economy promotion law of People’s Republic of China” was adopted in August 2008 and has come into effects since January 1st 2009, putting circular economy into one of the most important development strategies for national economy and society. It is the first time to give a clear definition of circular economy in the form of a national law, which gives special priority on two reductions: significant reduction on resource consumption and reduction in waste generation. It also emphasis the critical role of the central government in encouraging and supporting the researches, innovation and promotion of new technologies for circular economy; in promoting relevant knowledge dilution of circular economy and international cooperation; in fostering and supporting industrial associations’ role as a director and service providers in the development of circular economy; in encouraging and supporting intermediary agents, academic associations and other social organizations to participate in disseminating relevant knowledge, promoting new techniques and providing consultancy services about how to develop circular economy. The national law on circular economy promotion provides legal and institutional support.

However, China is still short of detailed measures and practical applications compatible with developing circular economy, especially regarding the legal system of the management, incentive, assistance and assurance of the IAR alliance. There is much room for improvement in defining the entry-exit system of all parties, corporation contract system, intellectual property protection system, risk assessment system, interactive communication in talents and talent-fostering system. Therefore, governments should establish the relevant legal systems and policies to simulate the development of circular economy and IAR alliance, based on the “Circular Economy Promotion Law of People’s

Republic of China". At the practical level, the government should give proper preferential policies or financial subsidies to the enterprises, universities and research institutes, such as tax exemption or reduction, direct investment or special funding so to attract all parties to actively get involved. Meanwhile, it is helpful to establish risk investment funding and other embedded financial support systems with diverse investment ways. It is also necessary to establish the supervising and assessment incentive mechanism to encourage technological innovation in the IAR alliance to solve the common difficulties among industries.

## 5 Conclusions

A successful Industry-Academia-Research alliance should be one that can meet up interests of all parties involved and can realize the most effective integration of the needs from enterprises, talents and academia.

Though there are abundant researches on industrial and academic collaboration, few ones have studied it in terms of circular economy. With this concern, this paper put forwards an innovative framework for realizing efficient Industry-Academia-Research collaboration in China and put forwards some practical solutions. The framework to constitute a successful alliance meeting up with full circular economy has three basic elements: (1) comprehensive technology upgrading, innovation and design both within the enterprises and among the industrial cluster, (2) environmental-friendly production system with careful design and assessment of the output and input material within an industrial area, (3) persistent strategically collaboration between universities and industries with proper arrangement in key technological breakthroughs.

Based on this framework, the paper argues that it is not only the requirements of developing circular economy, but also should be promoted to a regional and country strategy with concern of social security and sustainable development. The paper provides some important but also novel suggestions to realize successful Industry-Academia-Research alliance and circular economy for governments, enterprises and universities.

Governmental conduction and macro-supervision are invaluable for simulating and supporting the cooperation within IAR alliance. Hence, governments should follow the guidelines of comprehensive planning, reasonable arrangement, flexible measures according to circumstance, focusing on actual effects, promoting role of governments, market-orientation, enterprise-application and public participation. Governments should also put innovative researches and applied researches of great importance for technological breakthrough in circular economy into the agenda of the development of science and high technological industry both at national and provincial levels.

Industrial clusters, based on similarities and complementation, can realize win-to-win in the long-run from circular economy by benefiting from complementary knowledge and value transfer from one industry to another, and satisfying the requirements of an energy-saving and environment-friendly society. Such ideal model to realize circular economy requires enterprises as the major subjects to realize new integration of knowledge capital, technological resources and industrial capital, by taking advantage of universities and research institutes in knowledge capital and talents according to their own development strategies. It is the time to explore new forms of clustered alliance to push the transformation of economic growth and at the same time to realize economic development, in order to achieve the overall improvements in value chains of circular economy and in-depth cooperation of the IAR alliance.

The paper also proposes that the "implanted" education program based on circular economy and IAR alliance should be the new form for future talent training, where both of the universities and enterprises will be actively involved in the enrollment, module design, thesis composing and job market to realize full integration between academic clusters and industrial clusters. Finally, this paper also cautions that China is still short of detailed measures and practical applications compatible with developing circular economy, especially regarding the legal system of the management, incentive, assistance and assurance of the IAR alliance, though the national circular economy law have made much progress.

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