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Theoretical Viewpoint on Value-increasing of Circular Economy—Study Based on the Practice of Circular Agriculture

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Abstract "3R" principle circular economy emphasizes the technical operation level, while the theoretical viewpoint on value-increasing of circular economy makes deep analysis based on environmental economics. The viewpoint takes for that the evaluation of any circular economic model should consider both the economic value and externalities. If the material units unattached to products in the economic system are circulated with value-increasing as more as possible, more value can be created with lower consumption of resources. The essential principle of circular economy is that the material units within an economic system should go through the multiple production to be circulated with value-increasing, the main purpose of circular economy is that the material units shouldn't attach to waste going out of the system as much as possible in order to reduce pollution emissions, the economic mechanism of circular economy is that the economic value chain should be used to pull the material units of the system to achieve smooth circulation.

Key words Circular value-increasing, Material units, Positive and negative value

1 Introduction

Material, energy and value are the existence forms of resource. Material is the foundation. Resource is useful and scarce material, as well as a kind of material which not only contains energy but also creates value. Concentrations, dispersion and transformation of material units (from the initial resources, original resources and secondary resources) not only form the material flow but also carry the energy flow and value flow. Material flow is foundation. Energy flow is power. However, only the value flow is the source of economic interests. Therefore, this paper discusses the value-increasing mechanism of circular economy based on the circular increment of material units. Resource transfer in the flow of time and space has formed value flow. It belongs to dynamic value category and resources' changing form of value. As a specific pattern of economic activities, circular economy should not only create value but pay more attention to value flow and circulation value-increasing. What should be emphasized is that: the value mentioned in this paper is the synthesis of external value of the economic system and the direct economic value of current accounting system. Only in this way can we evaluate the real benefit of circular economy comprehensively. In the open circular economy system, material flow and energy conversion is multistage circulation by using the material value sustainably through the chain, ring and net. The circular value-increasing brought by multistage circulation can reduce the loss of value attached to the waste and the negative effects on the environment, and increase the value attached to the products and the positive effects on the environment. Transferring the simple considering of purely material motion to comprehensive considering of material motion connected with value movement, ecological circulation with economic circulation, environmental protection with social security is a necessity of sustainable development. Material flow and energy conversion are the basic functions of the ecological environment system. The corresponding value flow and circulation value-increasing are the basic function of social and economic system. Circular economy must follow the laws of nature, and follow the economic law. The circular economy should ensure rational utilization of natural resources and optimize the ecological environment. At the same time, circular economy needs to develop economy on the basis of constant and circulatory use of resources and protect the ecological environment with the constant development of economy. In essence, circular economy is a reasonable coupling form of natural ecological system and social economic system, which focuses on the coordination of recourse recycling and economic reproduction, and then is coupled with the natural ecological balance mechanism and the expansion of social economic growth effectively. Between the 1970s and 1980s, as for dealing with environmental pollution brought about by the economic activities, the problem concerned by all countries in the world changed from handling the rubbish pollution to utilization of waste resources gradually. People's awareness has transformed from "controlling garbage pollution" to "using waste resources". However, the main concerns are on the environmental consequences of economic activities, and the economic operation mechanism has always been out of sight and not given enough attention. As for whether the production and disposal of wastes is reasonable and whether it should prevent the pollution from the source of production and process, such kinds of fundamental problems are not clear, and most countries still lack effective measures, making pollution control fail to keep up with the progress of pollution occurrence. Since the 1990s, especially after the sustainable development strategy has become the world trend, source prevention and entire process control have gradually replaced the end treatment to become the mainstream in the environmental pro-

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tection and development policy. On the basis of continuous exploration and summary, focusing on improving resource utilization efficiency and reducing waste emissions, people has gradually integrated ecological design, clean production and resource comprehensive utilization, etc. into the circular economy development strategy. From the direction of the material flow and energy conversion, conventional economy is a kind of unidirectional flow linear economy, namely the "resource→waste→product". The characteristics of linear economic growth are high strength resources mining and consumption and high-intensive environmental pollution and ecological damage. While circular economy is a kind of economic development model which promotes harmony and coordination between man and nature. Circular economy requires "reuse, reduce, recycle", by using the ecology to organize the economic activities into a circular process in order to realize "lower mining, higher using and less emissions", moreover, best use of material and energy that enter into the system, improve resource utilization efficiency and reduce emissions as much as possible. Circular economy tries to increase economic benefits and improve the ecological environment quality and social quality of life as well. The author has done a long-term research of agricultural circular economy and participated in many practices about circular agriculture. In the process of research, in order to help every member of the team to accurately grasp the essence of circular economy and understand the direction of thinking and analysis of the point, the author constructed theoretical point of view of circular economy value-increasing mechanism from theoretical derivation and practical instruction. The author thinks that the "3R" theory of circular economy emphasizes technical analysis. However, the essence of circular economy is a kind of economic operation mode to be coordinated with natural capacity, which requires using the rules of ecological environment and social economics, not only to be guided by the technology way. Circular economy value-increasing mechanism explains the inherent law of circular economy from environmental economics, which can be as theoretical supplement for deep analysis of circular economic theory.

2 Explanation of value-increasing of circular economy

Material units' circular value-increasing at the same level within an economic system or multistage circular value-increasing between subsystems is a basic requirement of circular economy. With material units' circular value-increasing in the system, the economic system can create more values with the same resources. Only all material units unattached to products in economic system are being circulated with value-increasing as much as possible, greater value can be brought to the economy system. The value here is net value equaling positive value minus negative value. Positive value is a value increment, produced from the economic activity process and product as positive effects on the ecological environment and economic society. Negative value is a value loss, produced from the economic activity process and product as negative effects on the ecological environment and economic society. The positive and negative values corresponding to positive and negative effects in economic activity process and its product do not be reflect in the current period, but appear gradually in the future. To measure the quality of an economic system, we not only need to measure the present positive and negative value, but also need to measure the positive and negative value in the future. In other words, measuring the quality of an economic system should put net value at present and net value for the next period of time together. For example, if physical unit in the economic system attached to the utility products (becoming the active components of work) steps out of the economic system, it will form the positive value. On the contrary, if physical unit attached to the non-utility products (part of the waste) in the economic system steps out of the economic system, it will form negative value. Only material units are fully circulated in the economic system, and then pass through the production process many times, they can walk out from the system, the more the utility products and the less the wastes. In this way, economic system can form larger positive value and smaller negative value under the same premise of resource input. However, the value measurement merely from the product is not comprehensive. We must consider the net value of economic activity process on the ecological environment and economic society deeply, for example, environmental positive benefits (such as straw recycling repairing production environment and increasing soil organic carbon) correspond to the positive value, environmental negative benefits (such as the production environmental pollution and overexploitation of groundwater) correspond to the negative value. All of these benefits must be considered. How can we make material units achieve full circular value-increasing by passing the production process many times within economic system? Only by using the value chain to pull the material unit, can we form a smooth circulation channel. Because subsystems (each sector and different link) of the economic system are different reasonable units, they need to transact through the value chain. In other words, they care about value, so value stream is the actual pulling force of material flow and energy flow. The necessary condition of circular economy running, or the precondition of the value stream in the economic system coordinating with material flow and energy flow, is that reuse cost of material and energy as resources in the system is lower than that of the corresponding resource input from outside the system. We can improve the level of technology to reduce recycling costs of material and energy. Also we can internalize the positive externalities of circular economy (positive impact on ecological environment and social economy) through policy subsidies to offset part of the costs of material and energy recycling.

3 The main aspects of value-increasing of circular economy

3.1 Key principle The key principle of circular economy is that the material units in the system generate circular value-increasing by going through the production process many times. The comparison of conventional economy and circular economy is de-

scribed by Fig. 1. The weak and strong cycle chains in the diagram respond if material units within the system go through the production process for many times. The production process is described as a single closed cycle simply, but in fact it is mostly a net-chain-ring type composite multistage production process. For example, most of agricultural wastes are organic residues. If being collected and disposed, they can increase the agricultural production materials, such as planting organic fertilizer, livestock feed, fungus makings, etc. This is important content of agricultural circular economy. In fact, the composite industry system in agriculture (the 1st, 2nd and 3rd industrial convergence) is a vast area for circular economy. Crop planting, livestock breeding, aquaculture, fungus production, product processing as well as the leisure restaurants, etc., can become a whole by using the circular economy chain. In the system, the artery industries for producing agricultural products are combined with venous industry for dealing with waste, in order to use resources efficiently and emit less even no waste and to embody the essential requirements of circular economy. We want to improve the value of agricultural output, ensure agricultural resource consumption zero growth and reduce agricultural pollution emissions[1]. Essentially speaking, waste is also a kind of output of resource going through the production process, corresponding to a certain amount of resource consumption. For example, we produce more than 600 million tons of grain in China every year, at the same time, we also produce 800 million tons of straw. There are 300 million tons of straw stalk being rot and burned in vain. It is a waste of arable land, fresh water and other agricultural inputs which produce 300 million tons of straw[2]. If the 300 million tons of straw is reused through the internal circulation of agricultural system in the production process, then the corresponding material units' recycling utilization rate is equal to 3/(6 + 8) or 21%. In general, r is the utilization rate that the material unit can be used for the next level after every level of production (every utilization level is constant for simplicity hypothesis), n-time recycling can enlarge the original resource of 1 material unit to resource y. So y's computation formula is as follows:

$$y = 1 + r + r^2 + r3 + \cdots r^n = (1 - r^n)/(1 - r)$$

Because r is less than 1, when n is very large, y can be about equal to $1/(1-r)$.

Therefore, if the 300 million tons of straw that has not been used at present can be recycled fully, a straw material unit would transform into 1.27[1/(1 − 21%)] unit. This is equivalent to a 27% increase of cultivated land, water and other agricultural inputs. If the production structure remains the same, the production efficiency will increase 27%. Of course, it will be between 21% and 27% in general. For example, simply returning straw can only increase about 21% of the resource. If the straw is to feed livestock, the resources would increase above 21%, even close to 27%. Just for the reason, the price of the straw for fodder has risen to 300 − 500 yuan per ton in some places. In addition, the livestock waste into fertilizer will bring positive benefits in resource, environmental and ecological aspects. The data in 2015 in Jilin Province shows that the cycle value of puffed straw is mainly reflected in the substitution of conventional feed to reduce costs and increase profit margins. With straw puffed feed, a fattening cow can reduce costs $9 per day, which saves more than 3.5 kg of grain. A cow's fattening period is 180 days, reducing feed costs 1620 yuan and saving 630 tons of grain. Jilin Animal Husbandry Bureau made experiments about puffed straw feeding pigs in county Siping, Songyuan and Nongan. The results showed that every pig reduced feed costs 150 yuan in 120 days and saved 72 kilograms of grain. Apparently, the recycling utilization of material units in the system can bring circular value-increasing effect. The higher the material units' circulation utilization rate, the bigger the circular value-increasing effect. The effect of single circulation may be not very obvious, but the overall effect of multistage circulation among subsystems is remarkable. For example, "compound cycle of planting − (straw + mushroom + cultivation) − (mushroom residue + manure) − (biogas + organic fertilizer) − planting", material units in the straw go through multiple links and finally return to the soil forming crop nutrient. The circular value-increasing effect would be more significant. Therefore, as a composite resource utilization system, circular economy produces immeasurable multiple value-increasing. Moreover, not only the value, but also the original resources of mine for chemical fertilizers and other agricultural production materials would decrease substantially. At the same time, with the utilization of waste, the utilization of system resources become more sustainable, the destruction of the ecological environment becomes smaller. The sustainable development will be effectively promoted. From different aspects, circular economy can be divided into minor cycle of enterprise level, middle cycle of garden level, as well as macro cycle of social level. Minor cycle of enterprise corresponds to the material units' circulating utilization and value-increasing in minimum economic system. The cycle of the garden level is, in fact, super cycle structure and value exchange among different enterprises; this structure is a kind of dynamic joint between enterprises, changing with time. Macro cycle of the social level corresponds to generalized circular economy; it refers to composite value-increasing system formed by the producers, consumers and reducers through the primary, secondary and tertiary industries, in order to maintain social and ecology virtuous cycle, and promote the sustainable development of social economy system.

3.2 Main purpose The main purpose of the circular economy is that the less material units attached to the waste go out of the system to reduce the loss of value. Every economic system produces a utility product and a non-utilitarian material at the same time. If the non-utilitarian materials go out of the economics system, they may form wastes, bring pollution and increase the value of loss at the same time. On the contrary, if the non-utilitarian material is recycled in the system, less material units are attached to the final waste, but are attached to the products going out of the financial system, and loss of value will be reduced. Circular econ-

omy eventually makes less material units attached to the waste out of the system to reduce emissions, so that it can be more attached to the product out of the system in order to bring greater output. Even if some material units can't be attached to the product in the short term, but as long as they are in the economic system and circulate in the system, they will be constantly attached to the product rather than being attached to the waste, meanwhile value loss will be reduced. Straw is organic residue, for example, if it is used as a basic material by the edible fungus industry, edible fungus production increases. Also, the residue of the ground mass for edible fungus can be used as organic manure returned to the field in order to increase crop output. If the straw is used as feed in the breeding, the output of aquaculture increases. In this case, the material units of straw are no longer waste from agricultural system; they are converted to effective components of agricultural products[3]. The government document from the Ministry of Agriculture points out that the nutrition value of 4 tons straw feed is equivalent to that of 1 ton grain; if replacing 25 million tons feed grain with processed straw feed, it needs 100 million straw, it means decreasing the pollution of 100 million tons straw. At the same time, the livestock (fed by the 100 million tons straw) excrement would produce 40 million tons organic fertilizer. The measure not only reduces the corresponding livestock manure pollution emissions, but also improves the soil quality and protects the ecological environment. Generally speaking, compared with internal recycling within one level, the material units can be attached to more utility products with recycling in multistage circulation and multiple layers. For example, the effect of straw returning soil directly is not as good as returning by livestock breeding. The richer the production structure in an economic system is, the more the material units would be fully recycled. Therefore, it is more attached to the effectiveness of the product and out of the economic system to increase output, rather than generating a large number of waste emissions from the economic system which has a negative value. At the same time, transforming level of every stage is also the key factor to influence whether more material units can be attached to the products. If the transformation level of this stage is higher, more material units can be attached to the products when going through this stage. The level of technology plays a decisive role in the transformation level of all levels of circulation, and it is also an important prerequisite for the reduction of pollutant emissions from the system.

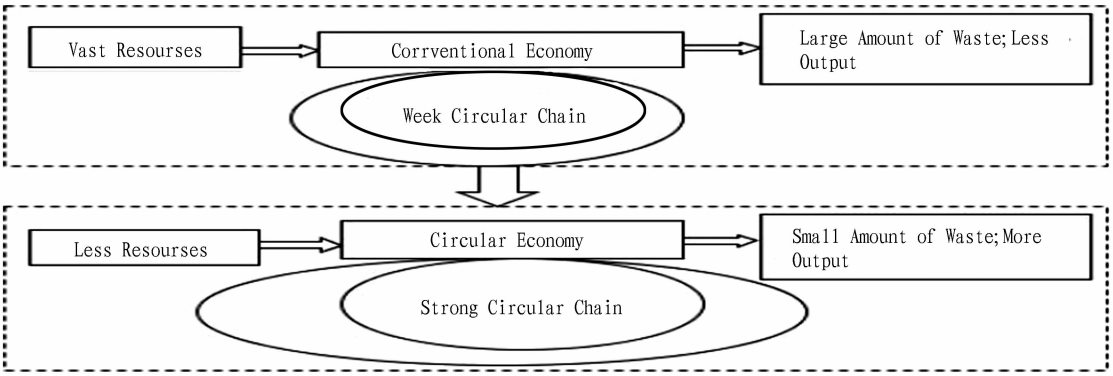

Fig. 1 Comparison of conventional economy and circular economy

3.3 Effective mechanism The effective mechanism of circular economy is to use value chain pulling material units in the system to realize unblocked circulating. Only the material units in the economic system go through the production process for many times, the system can increase circulation value constantly and create higher value and bring more products for the economic system, and at the same time reduce the pollutant emissions and negative value significantly. However, material units circulating among the economic system is not a simple thing. This is why many straw burning phenomena still exist; many large-scale farms of livestock and poultry discharge wastes that lead to environmental pollution. Practice has proved that, in order to make the material units in all levels of production and all aspects of production flow smoothly, it is necessary to establish a reasonable economic mechanism. We know that each subsystem in the economic system is a different rational man. For example, circulation of straw and manure between planting and breeding has to come from the interests boost. While behind the stimulus is the distribution of value, in other words, they focus on value return mainly[5]. For the stable operation of circular economy, on the one hand, it depends on each subsystem to connect with each other through the market mechanism, which perfects the value chain through the contract management standard and realizes the reasonable distribution of benefits; on the other hand, the government should implement the subsidy for the positive externality of the ecological environment which is brought by the circular economy. It is beneficial to value balance of economic system and an important means of strengthening circular economy value chain. Biogas project, for example, to ensure operation, we should first know the value balance of unit gas. It requires calculating unit gas production cost on the basis of engineering construction cost, operation cost and capital opportunity cost. Data in 2014 by Biogas Institute, Chinese Academy of Agricultural Sciences show that natural gas contains 95% methane and biogas contains 50% –70% methane. Natural gas price is 1.89 yuan/m^3, so the price of biogas is 1.2 yuan/m^3. A biogas project supplies 800 households (the most economical scale according to per unit cost of investment, operating and supplying), for example, the value balance of every cubic meter biogas is 2.83 yuan, 1.63 yuan higher

than the actual price. Therefore, to keep biogas project in operation, it should have 1.63 yuan/m^3 value added. It can be done by the state subsidies, or be compensated with renewal, biogas slurry as crop fertilizer. Of course, if considering the positive effect of biogas project on ecological environment, the corresponding value of state subsidies should be higher than the price difference in the current market system. Therefore, to protect the development of circular economy, there is a need to establish such a mechanism, and its essence is using value chain to pull material units in circulation channels in the economic system, which is able to guarantee the effective operation of circular economy. The mechanism is also a fundamental guarantee for the effective operation of the circular economy. For example, the straw as feed for livestock becomes manure and fertilizer returning back to farming; farmers (department) and feeders (department) (in some places including mediation of collecting straw, straw professional cooperation organization, *etc.*) need to trade reasonably on the straw value chain to guarantee the circulation economic model to work effectively. Of course, government subsidy is a necessary driving force sometimes. In other words, only material units in the straw are pulled by a perfect value chain, they can circulate freely between planting and breeding.

4 A preliminary idea about the theory model for circular value analysis

The author designs the theoretical model of the circular agriculture value analysis according to the operation characteristics of circular agriculture and the value-increasing mechanism of circular economy. The model consists of the overall value analysis module, the marginal value analysis module, the value distribution analysis module and the layout optimization analysis module. Circular agriculture value analysis theory model is as follows:

$$V = \sum a_i A_i + \sum b_i B_i + \sum c_i C_i$$

$$Y = AV\alpha X_1^{\beta} x_2^{\lambda} X_3^{\gamma}$$

$$S = 1 + (\sum V \cdot Y - 2\sum(V\sum Y))/(\sum V \sum Y)$$

$$R_j = y_j/\sum y_j - V_j/\sum V_j$$

where V is the amount of material circulating utilization value; a_i is the value coefficient of material recycling for all kinds of planting; A_i is planting area for all species; b_i is coefficient of material recycling value of all kinds of livestock and poultry breeding; B_i is quota of livestock and poultry standard breeding; c_i is coefficient of material recycling value for all kinds of aquaculture; C_i represents all kinds of aquatic area; Y is product value output; X_1 is cultivated area; X_2 is labor; X_3 is material input; α, β, λ, γ are input and output elasticity; S is Lorenz coefficient of material recycling value distribution; Y is product output value; R_j is material recycling structure deviation in area j.

The operation results of model are material recycling value output of overall and each industry, material recycling output elasticity, material recycling value distribution Lorenz coefficient and the internal material recycling structure distribution deviation in different areas. The value of material recycling can not only reflect the material recycling, but also is an important basis for further analysis and evaluation of circular economy; material recycling output elasticity can reflect material recycling and resource's marginal utility of circular economy. Lorenz coefficient of material recycling value distribution can reflect the rationality of the layout of circular agriculture, and determine the need of structure deviation analysis; the material recycling structure deviation can reflect the potential of various areas to improve the utilization ratio of material circulation and give the direction to adjust circular agriculture in different areas.

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