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An Analysis on Japan's Circular Economy and Its effects on Japan's Economic Development

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Abstract
Circular economy lays emphasis on the harmonious intergrowth and sustainable development of economic system, social system and natural ecosystem, and is a systematic project which integrates economy, technology and society. Japan launched the developmental mode of "treatment after pollution", and promoted circular economy to achieve the sustainable development of economy, society and environment. In the process of promoting circular economy, economic development has acted as the governing factor, but it was inseparable from the support and safeguard of institution, law, technology, idea and other social factors. This article has systematically summarized the Japanese recycling economy, including its main body, security, and the development of the arterial and venous industries. By taking the manufacturing industry for example, the article has made a quantitative analysis on the role of circular economy development in the overall Japanese economy. Finally, the article has concluded the Japanese developmental experience of circular economy and the enlightenment to China's development of circular economy during the transition period.

Key words: Japanese circular economy; Industrial system; Manufacturing industry; Economic effect

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INTRODUCTION
During the postwar period of rapid economic development, Japan has adopted the economic model of catching up Western countries, and focused on economic growth supremeness under which all was subordinated to and served the rapid growth of GDP. Various industries, especially the leading industries, have implemented the policy of "production first" to pursue mass production and mass consumption in order to achieve the minimization of unit production cost. This captured the market quickly with low-cost strategy and achieved industrial modernization. In the atmosphere of such great emphasis on production and economic development, the growth rate of pollutant emissions became far higher than the growth rate of GDP, which brought serious environmental pollution, difficult social issues as well as loss of balance between ecological environment and economy to Japan. With the imbalance between environment and development, coupled with Japan's lack of natural resources, most of the resources and industrial raw materials began to rely on imports. Economic development appeared a declining trend. Since then, Japan began to explore the transition to circular economy. During the development of circular economy, Japan managed to overcome the constraints of resources, improve resource utilization, reduce production costs, win new markets, establish the new economic growth pattern, and maintain competitive in the world.

1. ON THE CONNOTATION AND RESEARCH STATUS OF JAPAN'S CIRCULAR ECONOMY

1.1 Connotation of Circular Economy
Circular economy is an economic developmental mode adhering to the principle of "reduce, reuse and recycle" and the center of improving the efficiency of resource use

in order to achieve resource conservation, comprehensive utilization and clean production. By adjusting the structure, promoting technological progress, strengthening management and other measures, it aims to reduce resource consumption, reduce waste emission, improve resource production efficiency and promote resource use to shift from the linear model of "resource-product-waste" to the circular model of "resource-product-waste-renewable resource". This includes resource conservation and comprehensive utilization, waste material recycling and utilization, environment protection and other industries. With minimal resource consumption and environmental costs, it purposes to realize the sustainable development of economy and society, and foster harmony between socio-economic system and natural ecosystem.

1.2 On the Research Status of Japan's Circular Economy

The American economist Kenneth Boulding firstly proposed the concept of "circulation" in his "Spaceship Economic Theory" (1965), However, the British environmental economists Pearce and Turner (1990) officially used the term "Circular Economy". Japanese scholars have gained a lot of useful results in this regard. Hideaki Yamada (2000), from the perspective of environmental biotechnology, believed that circular economy was a qualitative revolution in the 21st century, and would bring significant changes to all people. Yoshida Fumikazu (2001), based on the conditions of basic laws of a recycling society, described the background and solutions for waste treatment and made some prospects. Koyanagi Hideaki (2005) discussed the specific measures to construct circular economy in Japan from multiple angles. Fujiwara Yoshino (1996) described the relationship between resource recycling, utilization and recycling society. Naohiko Harada (1999) made a systematic discussion on recycling society from the perspective of environmental law. Reiji Takeishi (2003) described the issues related to environmental industry development and institution in Asia. The achievements of international academia in the related fields of circular economy have brought a great reference for us to carry forward the theory and practice in recycling-oriented manufacturing.

2. JAPAN'S CIRCULAR ECONOMIC SYSTEM

2.1 The Subject and Security of Japan's Circular Economic System

Circular economic system eases the contradictions between environment and economy, requesting that production, consumption and other economic activities should adapt to environmental and resource constraints. According to *The Basic Law to Promote the Establishment of A Recycling-Oriented Society* and *The Basic Plan to Promote a Recycling-Oriented Society* of Japan, the state departments, local governments, enterprises, non-governmental organizations and citizens, etc. should play their respective roles as per their responsibilities and obligations, cooperate and effectively implement various measures based on the principle of reasonable and fair cost burden. The Japanese central government has established a good partnership with the local governments, enterprises, organizations and citizens. It has developed complete laws and regulations and adopted a variety of effective and comprehensive measures to promote the implementation. Meanwhile, it has supported the activities to form a recycling-oriented society through funds, provided administrative services, taken the lead to practice green procurement and other actions to promote circular economy.

Enterprises have an active participation and play an important role in promoting the construction of a recycling economy. Enterprises have fully considered the environmental factors in product design and production, implemented extensive ecological designs in production processes, used renewable and recyclable materials, focused on reduction from the source and pollutants control to provide high quality and low environmental impact products. At the same time, enterprises have taken the advantages of their talents and technologies to get involved in the cause of recycling-oriented society, trying to make a full use of the wastes from society.

Japanese people have a good awareness of environmental protection. Under the government's propaganda and advocacy, a public atmosphere of everyone involvement has been formed. Governments and enterprises' efforts to promote recycling economy has been disclosed to safeguard public access to environmental information, strengthening public supervisory on government environmental policies and corporate environmental behaviors.

Agencies have also promoted recycling society. The bridge among governments, enterprises and the public is agency, which plays an important role in information consultation, technical training and guidance, university-industry conversion and other aspects. It has played a significant role in developing recycling technology with enterprises, providing information consultation and investigation for governments, providing technical training for enterprises and carrying out public propaganda and education.

2.2 Japan's Industrial Development Model of Circular Economy

Some Japanese scholars divide circular economic system into "arterial industries" and "venous industries". The former refer to the industries engaged in raw materials extraction to production, distribution, consumption and waste, and the latter refers to those engaged in wastes collection, transportation, decomposition, recycling and safe disposal. The target of artery industries is environment of industry, focusing on reducing the input of pollutants into environment through the development

of cleaner production, eco-design and environmentally friendly products; The target of venous industries is industrialization of environment, focusing on developing waste treatment, disposal companies and resource recycling enterprises to solve pollution and resource shortage. When combine the two, we can hope to realize a rational use of resources from resource extraction, production, consumption, discharge to waste disposal.

2.2.1 The Developmental Model of Arterial Industries

Firstly, the implementation of cleaner production. According to the "3R" principle of circular economy, reduction is the priority rule. Therefore, the implementation of cleaner production, reduction of waste generation and resource consumption is the primary task, including the production of environmentally friendly products and eco-design of production processes, such as the clean use of conventional energies, development of new energies, reuse of wastes, reduction of unnecessary process steps, standardization of production and design of green packaging.

Secondly, the clarification of producers' responsibilities. Japan's *The Basic Law to Promote the Formation of A Recycling Society* clearly states that: Enterprises and citizens should assume the responsibility to reasonably recycle and dispose wastes. Producers, in all aspects of production, need to bear the responsibility for environmental impacts, and even re-use recycled products. Many Japanese enterprises in large household appliance industry and automobile industry need to establish a waste disposal center.

Thirdly, the establishment of a park-based circular economic development mode outside enterprise. In addition to constructing internal circulation, Japanese circular economy has also focused on building a circular production system among different arterial enterprises in accordance with the principle of natural ecological cycle, integrating and establishing eco-industrial parks. Through the horizontal linkages and resource sharing among different enterprises and processes, downstream decomposers can be found to form an industrial ecological chain, so as to achieve a full use of resources, reduction of waste generation and recycling of materials.

2.2.2 The Developmental Mode of Venous Industries

In addition to the chain of arterial industries, Japan has also strengthened laws and propaganda to reinforce the responsibilities of producers, and has extended a venous industrial chain on each leading arterial industrial chain. In home appliance industry, for example, a household appliance recycling industry has been developed based on the arterial industrial chain of air conditioner, refrigerator, television and washing machine. Japan has 26 venous industry-based eco-parks, which not only serve as the starting point and priority area of Japan's circular economy strategy, but also play a leading role in the development of regional circular economy.

Firstly, establish a waste and energy recycling system. According to local industrial characteristics, industrial relevance, type and quantity of wastes, the parks have developed plans to regulate dismantlement, recovery and recycling. The entire process is completed in the parks among different enterprises to achieve large-scale processing.

Secondly, gather research institutions in the industrial parks to achieve an in-depth research and production cooperation. With government support and market boost, basic researches, raw materials, product distribution, waste reduction technology, resource recycling technology, waste recycling technology and other technologies have been developed to provide a solid technological support for the development of venous industries.

Thirdly, make propaganda and education a regular activity. Kitakyushu City, for example, serves as the base for environmental education. It organizes environmental lectures, receives delegations, displays recycling technologies and products, and firstly realizes waste recycling in the vicinity.

3. AN ANALYSIS ON THE EFFECTS OF CIRCULAR ECONOMY TO JAPAN'S ECONOMIC DEVELOPMENT—TAKING MANUFACTURING AS AN EXAMPLE

3.1 Data Processing and Model Establishment

This analysis is based on the 2011-2015 data and relevant Japanese statistics. In addition, we use two-variable models, including an independent variable of circular economic volume EX, and the other independent variable of circular economic volume in manufacturing FEX, and use GDP (an indicator of economic growth) as the dependent variable to explore the relationship between EX and GDP, FEX and GDP. In order to facilitate research, taking into account the characteristics that natural logarithm does not change time sequence but reduces the impact of heteroscedasticity, we name the natural logarithms of EX, FEX and GDP as lnEX, ∆lnFEX and lnGDP respectively. The empirical analysis uses the software Eviews3.1.

3.2 Empirical Test

3.2.1 An Elastic Analysis of Japanese Manufacturing Circular Economy

With reference to the theory of elastic demand price in economics, the article uses elastic analysis to describe the impact of recycling economy to Japan's GDP. So, we get the following equation:

$$\begin{cases} \mathrm{E}_{EX} = \dfrac{\Delta \mathrm{EX}/\mathrm{EX}}{\Delta \mathrm{GDP}/\mathrm{GDP}} \\ E_{FEX} = \dfrac{\Delta \mathrm{FEX}/\mathrm{FEX}}{\Delta GDP/GDP} \end{cases}$$

EX represents the total volume of Japan's circular economy, and FEX represents the volume of circular economy of manufacturing; ΔEX represents the increments of Japan's circular economy, and GDP is the gross domestic product of Japan; Similarly, ΔGDP is the increments of gross domestic product of Japan.

The above equation indicates the change (%) of the growth rate of Japan's circular economy when the growth rate of manufacturing gross value increases or decreases 1%. If the elasticity is more than 1, it indicates that circular economic growth plays a significant role in promoting economic growth; On the contrary, if the elasticity is less than 1, it indicates that circular economic growth has no significant impact on promoting economic growth.

Table 1
The Elasticity of the Growth Rates of EX and FEX to the Growth Rate of GDP

Year	The elasticity of the growth rate of EX to the growth rate of GDP	The elasticity of the growth rate of FEX to the growth rate of GDP
2011	1.73	1.70
2012	0.82	0.66
2013	0.88	0.74
2014	-1.05	-0.65
2015	1.63	1.59

As shown in Table 1, speaking on the elasticity itself, manufacturing growth rate has reached 1.73 in 2011. As far as the significance of elasticity be concerned, when the elasticity is more than 1 it can be considered to promote economic growth significantly, and it's apparent that circular economy of the year played a significant role in promoting economic growth. However, in 2014, both of the two represented negative values, indicating that a decline in the total volume of recycling economy did not promote economy obviously. Here, in order to compare the elasticity of the two, we use the data obtained in Table 1 to conclude Figure 1.

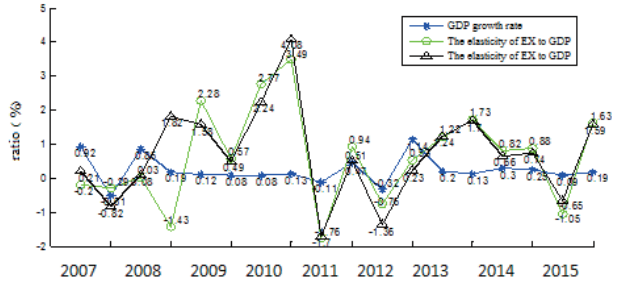

Figure 1
The Elasticity of Circular Economy to Japan's GDP Growth Rate

Figure 1 shows the elasticity of manufacturing to economic growth during 2007 to 2015, that is, the elasticity is substantially the same. In addition, the overall trend of the elasticity of circular economy growth rate to GDP growth rate is fairly consistent with the trend of GDP growth rate. Specific data show that the elasticity of 2010, 2011, 2012, 2013, 2014 and 2015 is all more than 1, indicating that in recent years circular economy of manufacturing had a larger elasticity to economic growth, promoting it obviously. But in some years it had an elasticity of less than 1, or even a negative value. Generally speaking, the growth of Japan's circular economy has played a certain role in promoting the overall economic growth, but the role is unsteady.

3.2.2 Unit Root Test

Because data is listed in accordance with time sequence, in order to prove that random variable is a stationary sequence able to perform the next co-integration analysis, we must first implement unit root (ADF) test on the sample. This is because once the random variables become a non-stationary sequence, spurious regression will appear if co-integration analysis is conducted, and the conclusion obtained is likely to be wrong.

In the unit root analysis, we find that the random variables are not stationary, so we need to take difference or logarithm. In the beginning, in order to reduce the influence of heteroskedasticity we have already taken the logarithm of the data. Therefore, we choose to take difference of the random variables, and the result is as follows:

Table 2
Stationary Test on Each Variable

Variable	ADF test value	Threshold (5%)	Result
Circular economy	0.956286	-3.0521	Non-stationary
Technological innovation	-4.932555	-3.0659	Stationary
lnEX	-0.220313	-3.0521	Non-stationary
ΔlnEX	-6.605660	-3.0659	Stationary
lnFEX	-2.513746	-3.0400	Non-stationary
ΔlnFEX	-3.331620	-3.0521	Stationary

Table 2 clearly shows that when the ADF values of recycling economy, technological innovation and lnFEX are all greater than the threshold of 5% in the original time, the random variables represent to be non-stationary. When we take the first difference of lnGDP, lnEX and lnFEX, we get the corresponding ΔlnGDP, ΔlnEX and ΔlnFEX, whose ADF values are all less than 5%, that is, their difference sequence is a stationary sequence integrated of order 1.

3.2.3 Granger Causality Test

The result of co-integration test shows that Japan's economic growth has a co-integration relationship, a long-term stable equilibrium relationship with the circular economy, but whether this equilibrium relationship constitutes a causality, we need a further verification. We

use the causality test described by Granger (1969) for verification: The first is to estimate the explanation degree of the value of current lnGDP in the lag phase, then verify that whether the introduction of lag phase of the sequence lnEX, lnFEX can increase the explanation degree of lnGDP. If yes, then we say that the sequence lnEX, lnFEX is the Granger Cause of lnGDP. Here the lag phase coefficients of lnEX, lnFEX are statistically significant. According to the above definition, Granger causality test formula is as follows:

Table 3
Granger Test Results

Null hypothesis	Number of lag phase	F test value	Conclusion
lnGDP does not Granger Cause lnEX	1	6.96348	Accept
lnEX does not Granger Cause lnGDP		20.5974	Accept
lnGDP does not Granger Cause lnFEX		6.07930	Accept
lnFEX does not Granger Cause lnGDP		2.24275	Reject
lnGDP does not Granger Cause lnEX	2	2.80217	Reject
lnEX does not Granger Cause lnGDP		3.66169	Reject
lnGDP does not Granger Cause lnFEX		0.51961	Reject
lnFEX does not Granger Cause lnGDP		2.14708	Reject
lnGDP does not Granger Cause lnEX	3	1.24989	Reject
lnEX does not Granger Cause lnGDP		2.00017	Reject
lnGDP does not Granger Cause lnFEX		1.05333	Reject
lnFEX does not Granger Cause lnGDP		1.93411	Reject

Table 3 shows that when lag phase is 1 and significance level is 5%, F0.05(1,17)=4.45, F=6.96348>F0.05(1,17), F=20.5974>F0.05(1,17), all accept the null hypothesis, that is to say, Japan's circular economy has no causality with the economic growth. F=6.07930>F0.05(1,17) accepts the null hypothesis, but F=2.24275>F0.05(1,17) rejects the null hypothesis. This shows that Japan's economic growth is not the cause for the growth in manufacturing recycling economy, but Japan's manufacturing recycling economy can promote the growth of the Japanese economy.

When lag phase is 2, 3 and significance level is 5%, we find that both circular economy and manufacturing circular economy have a two-way causal relationship with economic growth, in other words, Japan's economic growth has a mutual promotion with the recycling economy.

3.3 The Result of Empirical Analysis

From the above elastic model, we analyze the elasticity of circular economy to Japan's GDP to describe the impact of total circular economic volume to GDP, and find that it is basically consistent with the elasticity of manufacturing. According to the chart, their overall trends are more consistent in certain years. In a sense, we can see that manufacturing circular economy is the main force of the development of circular economy.

In the Granger test model, we have come to that the circular economy of Japan and circular economy of manufacturing both have a long-term two-way relationship with economic growth. In particular, no matter how many phases circular economy of manufacturing falls behind economic growth, its F value indicates that it's one of the reasons to boost economic growth, that is, the increase in circular economy of manufacturing can drive the overall economic growth of Japan. Except that one phase lag does not show a causal relationship between the two, when it lags two or more phases the F value shows an interaction between the two. Generally speaking, both the circular economy of Japan and circular economy of manufacturing have an interaction with economic growth, but there is a certain lag due to the longe period. Therefore, according to the analysis and experience of Japan, it is necessary to plan early and make corresponding measures, develop comparative advantage of manufacturing, strengthen cluster advantage and institutional supply, promote related policies and services, complete industrial structure adjustment, expand circular economy and promote economic growth.

CONCLUSION

Since the reform and opening up, China's economic construction has made remarkable achievements, but the achievements have been realized at the expense of resources and environment. At this stage, facing the evident economic downward pressure and increasingly urgent environmental protection need, we have to accelerate the transformation of economic developmental model and build a resource-saving and environment-friendly society, so that enterprises and the public will be more aware of the importance of urgent development of circular economy. In this respect Japan's successful experience is worth learning.

Firstly, develop a sound legal system for circular economy. The Japanese government has spent nearly 40 years to develop a multi-level progressive legal system for the development of circular economy. The basic law to clarify the developmental direction is *The Basic Law to Promote the Formation of A Recycling Society*. Two comprehensive laws for waste disposal and recycling are *The Law of Waste Disposal* and *The Law to Promote the Efficient Use of Resources*. The five laws and regulations developed for different nature of products involve household appliances, food, packaging materials, automotive and construction, etc. There are also comprehensive laws to advocate procurement of

recycling economy. These laws have provided a solid legal protection for the development of Japan's circular economy.

Secondly, play a leading role of government and improve policy support. Externality and long-term benefit of circular economy determines that there is a conflict to the interests of enterprises and the public. We should make strategic objective and scientific plan to clarify the basic strategy to form a recycling society. Under the guidance of this strategy, administrative organs at all levels should formulate their own plans to clarify their functions and focuses. On fiscal policy, we need to subsidize the researches of innovative technologies; On revenue, we should give tax rebates or tax incentives for the introduction of recycling equipment. Conversely, we need to increase the taxes and penalties for the industries harming the environment. We should establish the demonstrative industrial clusters of circular economy, vigorously develop venous industries so as to realize industrialization of environment and environmentalization of industry.

Thirdly, carry out environmental education, strengthen multi-stakeholder involvement and raise public awareness of environmental protection. While regulating corporate responsibility, obligation and penalty system, the Japanese government also strengthens education and advocacy to promote recycling economy, raising public awareness of environmental protection and establishing new social ethics. While emphasizing the integration of consumers and producers, central government and local governments, they advocate to maximize the initiative of social intermediary organizations and residents. For example, the general public should bear the responsibilities to seal up garbage, classify emissions, pay according to the regulations, reduce packaging wastes, properly go shopping and consume, supervise governments and enterprises.

Fourthly, improve the technological level of recycling economy. Circular economy is a technological paradigmatic revolution, and technology is the key to develop circular economy. According to the 3R principle of circular economy, everything cannot do without technological support. Clean production technology, reduction technology, alternative technology, reuse technology, recycling technology and other technological supports are indispensable. On the other hand, circular economy is not static, but is constantly developing and changing. In order to develop circular economy rapidly, we need carry out continuous innovations on technology for recycling economy and promote their application in practice.

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