Study on Multi-agent Synergetic Diffusion Theory of Sea Rice Technology Innovation

Shao-jian HUANG, Sai-nan CHENG*, Hai-yun LIU and Shi-yan FENG

School of Business Management, Hunan University of Commerce, Changsha, 410205

*Corresponding author

Keywords: Sea Rice, Technological Innovation, Synergistic Diffusion, Coordination Degree.

Abstract. The sea rice (salt-tolerant rice) technology can effectively alleviate the trend of arable land and grain output in China, which is of strategic significance for safeguarding national food security and accelerating agricultural modernization. We found that sea rice diffusion is unstable in the traditional diffusion system composed of government and farmers. Based on synergetics, we conduct a comprehensive and systematic analysis of sea rice technology diffusion. In the traditional extension system, the main variable of agricultural enterprise is added, and the multi-agent collaborative diffusion model with its core is established. We find that the new diffusion system is stable and has good coordination. We conclude that the multi-agent synergetics theory of sea rice technology innovation with agricultural enterprises as the core has explanatory power for the diffusion of sea rice technology. According to the new system, sea rice diffusion can be guaranteed. The multi-agent synergistic diffusion theory complements and improves the traditional diffusion theory.

Introduction

Statistics from the Chinese Ministry of Land and Resources show that, in recent years, the area of cultivated land in China has declined gradually; it was 13,493 square kilometers in 2016 and 12,000 square kilometers in 2017. At the same time, China has also faced the problems of decreasing rural labour force, higher agricultural cost than in developed countries, poor quality of grain output, and so on. Speeding up the research into agricultural technological innovation is a fundamental way to realise agricultural modernisation and solve the "three agricultural problems"; agricultural technological innovation can be transformed into real productivity only through diffusion. As the order parameter of the traditional agricultural system, the household contract responsibility system cannot maintain the stability of the diffusion system against the background of intensive development. It is a trend in development of modern agriculture to promote large-scale operation and intensive production under the guidance of the policy of separation of three powers. The emergence of technological innovations in sea rice (saline-tolerant rice) can effectively alleviate the problem of reducing grain production in cultivated land and ensure grain security. Academician Yuan Longping and his team (2016) postulated that, after the sea rice technology matures, it can be used to improve more than 1,333 square kilometers of saline-alkali land in China, increase 60 billion catties of grain and feed 80 million more people. Sea rice technological innovation diffusion is of great strategic significance for ensuring food safety, improving the level of agricultural modernisation and optimising the environment of saline-alkali land in China. According to our research, there are plenty of obstacles to the diffusion of sea rice technology in the traditional mode: (1) the classical diffusion theory lacks a realistic explanation for the diffusion of sea rice technology innovation. Rogers (1983) believes that technology diffusion under the market economy is influenced mainly by technology, capital, potential users, propaganda, and so on. This is a law of technological innovative diffusion under the free competition of capitalism, but not against the background of the household contract responsibility system in China. Bass (1969) used time series historical data to construct a rigorous mathematical model, the classical S model, which started the quantitative research paradigm. Scholars have expanded the S model from many angles, which can be closer to the actual situation of new product diffusion, but there is still no explanation as to how
to carry out large-scale diffusion of sea rice technology innovation on the basis of the transformation of saline-alkali land in China. Mansfield (1961) brought imitation into technology diffusion and put forward seven factors affecting the diffusion of technology innovation. These factors cannot explain why Chinese farmers do not choose to plant rice under multiple comparative advantages. It is necessary to construct new theories to guide sea rice innovation diffusion rapidly. (2) With the development of the economy in China, it is difficult to adapt to the development of agricultural modernisation in the low-efficiency agricultural model of small-scale agriculture and decentralised management (Zhang et al., 2017). The gradual diversification of farmers' income generation also brings gradual reduction in the labour force engaged in agricultural production (Agwu et al., 2008; Styger et al., 2011; Zaidi et al., 2016). Compared with the western developed countries, agricultural development in China has the characteristics of low per capita benefit, large input, more labour, and low output. Modernisation of agriculture is fundamental for a country to realise prosperity, and it is urgent to explore the road of intensive, intelligent, and automatic development of agriculture in our country. (3) Technological innovation of sea rice is required in technology, economy, and reskilling bearing, but the yield and income of sea rice are not as good as those of traditional hybrid rice and general crops. According to the cost-benefit principle, this suppresses to some extent the demand for and willingness of small-scale operators to adopt technological innovation of sea rice (Zhu et al., 2016). It is unrealistic to rely only on government promotion and farmers' adoption for sea rice innovation diffusion. To solve successfully the strategic problem of planting rice in saline-alkali land, ease the decrease in cultivated land, and increase the self-supply of grain, we need to construct a new diffusion theory.

The main focuses of the academic research on the diffusion of traditional agricultural technology innovation in China include the diffusion mode, the diffusion process, the influencing factors, and quantitative research. Government, which is the main part of the diffusion system, has the administrative means to promote traditional agricultural technological innovation, supplemented by institutions, research institutions and intermediaries. Diffusion target farmers voluntarily accept technological innovation to achieve successful diffusion (Lin, 1991). Most scholars use the Bass model and the modified model to study the diffusion characteristics of the time dimension, such as the diffusion speed and the inflection point of new technology. The relationship between the maximum planting area, diffusion velocity, and inflection time was analysed by a Logistic model (Lu et al., 2017). In the field of spatial diffusion, the mechanism of diffusion as a process of demonstration, dissemination, and adoption from innovative sources is stressed (Holloway and Lapar, 2007; Wollni and Andersson, 2014). We found that little has been done to consider whether the relevant actors form a collaborative system and that the issue of diffusion has not been discussed in theory from a synergistic perspective (Liu, 2016; Wu et al., 2018). The traditional linear model and its diffusion theory are inefficient in explaining how the new rice products spread over a large area on the saline soil.

Based on the Synergetics theory, which can explain the relationship between complex systems, this paper makes a comprehensive and systematic study of how to spread the technological innovation of sea rice. By considering the conditions that must be met in the diffusion of sea rice, the parameter variables of agribusiness are introduced into the traditional diffusion system. Against the background of China's reform and guided by national strategy, this paper studies a new model of multi-agent cooperative diffusion of sea rice technology innovation with agricultural enterprises as the core. The innovation of this paper includes two aspects. In practice, in view of the fact that traditional decentralised management is not enough to undertake the task of technological innovation diffusion of marine rice, a multi-agent diffusion model with agricultural enterprises as the core is proposed to explain and guide the diffusion of sea rice technology. In theory, the multi-agent cooperative diffusion theory with Chinese characteristics is constructed to guide the practice and enrich the existing diffusion research.

Analysis of Instability of the Traditional Agricultural Technology Innovation Diffusion System

The traditional agricultural technology innovation diffusion system takes the government
department as the core, and it centres on agricultural technology promotion stations at all levels, along with agricultural research institutions, seed companies, farmers, and rural credit organisations. Under the market economy condition, the seed company takes the extension station as the channel, while building the channel by itself. As the institutional system, the extension station is not as flexible as is the seed company in the system, so the system of agricultural science and technology promotion in our country is unstable. On the other hand, for a long time, the order parameter of the traditional diffusion system is the household contract responsibility system, which has played a positive role in the recovery and enhancement of rural economic development since the reform and opening up. With the continuous improvement of economic development in our country, the contract responsibility system has become a repressive factor for the development of agricultural intensification and modernisation. The questions of how to build a new agricultural development system and agricultural technology extension model, further promote the land contract responsibility system on the basis of "three separate rights", and explore a new path to promote intensive management have become a top priority.

Construction of Multi-agent Synergetic Diffusion Theory of Rice Technology Innovation Based on Agricultural Enterprises

Before the collapse of the diffusion system between the government institution subsystem and the peasant household subsystem, a random fluctuation force was introduced to provide active resources for diffusion, balance the system, and achieve sustainable and stable diffusion. A new agricultural technology diffusion system was formed by adding agricultural enterprises in the market background and taking them as the main body in the traditional extension system, together with the elements of government management, seed companies, financial institutions, scientific research institutions, and so on. The goal of the system is to achieve the national strategy of large-scale diffusion of sea rice technology in saline-alkali land and to ensure the independent supply of grain in China. As the order parameter of the new system, the national strategy guides the resource allocation and the benefit sharing mechanism to make the main body produce the coordination.

The main factors affecting the operation of the system include land, technology, seeds, talents, funds, and policies. The main elements are farmers, scientific research institutions, seed companies, universities, banks, governments, and diffusion agents. According to the function of each main body in the technology innovation diffusion system of marine rice, it can be divided into external main body and internal main body. The government, agricultural universities, scientific research institutions, and financial institutions constitute the external main body, and the agricultural enterprises, seed companies, and farmers constitute the internal main body. The external main body takes the government department as the core and mainly stabilises the diffusion environment, formulates the system and the rule, provides the diffusion motive force, guarantees the capital, and so on, thus participating indirectly in the diffusion process. The internal main body takes the agricultural enterprise as the core and undertakes the sea rice planting, the diffusion, the seed development, the product deep processing and so on, thus participating directly in the diffusion process. The external subject has the function of ensuring the synergistic environment for the internal subject. The internal subject is the deepening and practicing of the external subject, and the internal and external multi-agents together constitute the system of the sea rice technology diffusion.

According to their own resources and ability, each subject forms the environmental subsystem with the government as the core and the management subsystem with the agricultural enterprise as the core. Government policy, national strategy, and agribusiness organisation affect the evolution and development of the organisation. Multi-agent agribusiness serve as the centre to achieve synergy through the exchange of resources. Agricultural enterprises control and balance the diffusion network through collaborative innovation with the government, R & D with agricultural universities and scientific research institutions, and cooperation with farmers to control and balance the diffusion rhythm. By providing a platform to achieve information synergy with agricultural
universities and scientific research institutions, the government formulates different policies to strengthen synergy according to the different stages of proliferation. The establishment of an upstream relationship between seed companies and agricultural universities can achieve technological innovation synergy, and the establishment of downstream relationships with agricultural enterprises based on production and planting activities can achieve collaborative innovation. Financial institutions, scientific research institutions, and agricultural enterprises achieve financial synergy through a variety of investment and financing activities. Based on the principle of pairwise cooperation, the main bodies can exchange and restructure the technology flow, information flow, and capital flow with agricultural enterprises either directly or indirectly. The agribusiness gathers the resources and the strength of each main body to achieve the overall synergistic effect, with the national strategic guiding mechanism and the benefit mechanism among the main bodies.

Conclusion and Prospect

The analysis shows that the organisational model of rice diffusion carried out according to the traditional agricultural technology innovation diffusion mode is unstable. In the traditional mode, the government formulates the diffusion development policy, universities and scientific research institutions carry out research and development, and farmers accept innovative technology to achieve diffusion. Farmers in the multi-comparative advantage will not choose to plant sea rice to create wealth, as the resources are limited, and it is impossible to transform salt and alkali land on a large-scale for the cultivation of sea rice. By adding an order parameter of agribusiness in the traditional diffusion system and taking agribusiness as the core subject of the system, and also taking the national strategy guiding mechanism and the benefit driving mechanism of market economy as the fluctuation force, this research constructs the new mode. These include rice R & D institutions, seed companies, farmers, agricultural universities, and government departments. The new theory of cooperative diffusion of sea rice technology innovation with the participation of financial institutions and other entities is used to explain the system instability existing in large-scale cultivation of sea rice in China by using saline-alkali land. This is a good solution to the sea rice proliferation problem. It is found that the new system can overcome the shortcomings of the original system and that the diffusion system under the multi-agent cooperative action with agribusiness as the core is robust and can promote the continuous diffusion of marine rice technology innovation.

Acknowledgement

The National Social Science Fund Project, No 16BJY024.

References

[1] A E. Agwu, M U. Dimelu, M C. Madukwe, Innovation system approach to agricultural development: Policy implications for agricultural extension delivery in Nigeria, African J. of Biotechnology, 711(2008).

[2] F. M. Bass, A new product growth for model consumer durables, Management science.155 (1969) 215-227.

[3] F. Hua, T. Xueyu, Coordination degree Model of compound system and its Application, J. of China University of Mining and Technology. 04. (2006)515-520.

[4] F. Lifang, Study on time-space effect and early warning of coordination degree of energy-economy-environment system in provincial area, China University of Mining and Technology (2017).

[5] H. Haken, Synergetics: an introduction 3nd ed. Berlin:Spring Verlag , 1983.
[6] G. Holloway, M. L. A. Lapar, How big is your neighbourhood? Spatial implications of market participation among Filipino smallholders. J. of Agricultural Economics, 581 (2007) 37-60.

[9] L Liu, From "production, Learning and Research" Cooperation to "political production, Learning and Research object" An Analysis of the Network of actors in the Research and Development of Super Rice Technology, Research on Science and Technology Management, 36 24 (2016) 30-24.