

Research on Collaborative Innovation Mechanism between SMEs and Higher Vocational Colleges Based on System Dynamics

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Abstract. Small and medium-sized enterprises are the main force of the industry, and higher vocational colleges are the main suppliers of talents for small and medium-sized enterprises. The two are highly complementary. From the perspective of innovation ecosystem, both are important populations in the system. Based on system dynamics, this paper constructs the collaborative innovation system model of small and medium-sized enterprises and higher vocational colleges, and focuses on the simulation of the operation mechanism of the innovation system. The research shows that the distribution of achievements has a significant impact on the operation of the system.

Keywords: SMEs; Higher vocational colleges; Collaborative innovation; System dynamics.

1. Introduction

In recent years, the shortage of human resources, the rising cost of raw materials, the complexity of the international trade environment and other issues have become increasingly prominent. Only by vigorously carrying out technological innovation, developing new technologies and processes, and improving the technical content of products, can SMEs obtain core competitiveness. Small and medium-sized enterprises are the main force of industry, accounting for more than 99% of the total number of industrial enterprises in China, and the number of employed people accounts for more than 80% of the urban employed population. Therefore, improving the technological innovation ability and efficiency of small and medium-sized enterprises is the key to industrial transformation and upgrading. Higher vocational colleges are the main force serving regional industries and the main supplier of talents for small and medium-sized enterprises. At the same time, higher vocational colleges also need to integrate industry and education in talent training. Therefore, they are highly complementary. This paper constructs a collaborative innovation ecosystem between small and medium-sized manufacturing enterprises and higher vocational colleges, and explores the operation mechanism and characteristics of the collaborative innovation system based on system dynamics simulation analysis.

2. Collaborative innovation system between SMEs and Higher Vocational Colleges

Natural ecosystem refers to a whole formed by the continuous material circulation and energy flow between all living things and the environment living together in a certain area. The collaborative innovation system of small and medium-sized enterprises is similar to the natural ecosystem to some extent. A number of small and medium-sized enterprises carry out industrial clusters around the industrial chain and form a comprehensive collaborative innovation system through the correlation and interaction of various elements, so that multiple subjects in the system can share innovation resources, jointly carry out innovation activities, improve innovation efficiency, share innovation risks, and promote the development of the whole industry.

The collaborative innovation system of small and medium-sized enterprises has three remarkable characteristics. Firstly, there are a variety of innovation subjects in the system, including enterprises, universities, scientific research institutions, governments, etc. they have their own corresponding positions and functions in the system, similar to various biological populations in the natural

ecosystem. Secondly, these innovation subjects are connected with each other. Through various activities such as production, transaction, competition, coordination and cooperation, the material circulation, information transmission and energy conversion among the innovation subjects within the system are realized. Finally, when carrying out innovation activities, the collaborative innovation system of small and medium-sized enterprises is not only the division of labor and cooperation between the innovation subjects, but also the material circulation and energy exchange between the innovation subjects and the environment.

The community of collaborative innovation ecosystem of small and medium-sized manufacturing enterprises is mainly composed of enterprises, governments, universities and scientific research institutions.

Enterprises, as the innovation subjects who directly carry out production and operation activities, are the core population in the collaborative innovation ecosystem of small and medium-sized manufacturing enterprises. The enterprises in the manufacturing industry chain include manufacturing enterprises, suppliers, distributors, supporting manufacturers and competitors. They play the roles of producer, consumer and decomposer respectively.

The role of government in innovation activities is mainly reflected in three aspects. First, the government establishes a good innovation environment by formulating policies to stimulate the innovation vitality of enterprises and improve innovation efficiency. Secondly, the government can provide preferential policies and financial support for enterprises according to the direction of industrial development, and participate in collaborative innovation by means of direct input of innovation factors. Finally, the government builds an innovation collaboration platform to integrate innovation elements through its own advantages.

Universities and scientific research institutions here refer to general higher education and scientific research institutions that mainly focus on academic research. They provide intellectual and technological resources in the collaborative innovation ecosystem and play the role of producers.

As a type of higher education institution, higher vocational colleges are obviously different from ordinary colleges in school orientation and social responsibilities, so they should be considered as an independent group. Higher vocational education is the most important supplier of technical talents for small and medium-sized enterprises with the mission of training front-line technical talents for regional economic society.

Social service institutions are the glue in the collaborative innovation ecosystem. Although they do not directly participate in innovation activities, they have improved innovation efficiency and accelerated the diffusion of innovation achievements through the support of various resources and the establishment of contact channels among multiple subjects.

3. Modeling and analysis of collaborative innovation system based on SD

System dynamics (SD) uses the idea of system science to find the root cause of problems from the internal structure of the system according to the feedback characteristics of the internal components of the system. This method is based on the close relationship between system behavior and internal mechanism, and shows the dynamic characteristics of the system through the process of mathematical model establishment and analysis.

In the innovation collaboration system, we focus on the relevant system elements and mechanisms of the interaction between Higher Vocational Colleges and small and medium-sized enterprises, and can build a dynamic simulation model, as shown in Figure 1.

Taking the number of technological innovation achievements in the collaborative innovation system as the object, the causal relationship is analyzed as shown in Figure 2 and figure 3.

In the collaborative innovation system between small and medium-sized enterprises and higher vocational colleges, the variables that can best reflect the characteristics of the system mainly include the number of Higher Vocational Colleges participating in innovation, the number of small and

medium-sized enterprises participating in innovation, the number of technological achievements and the number of technical skill talents. Therefore, these four variables are taken as level variables.

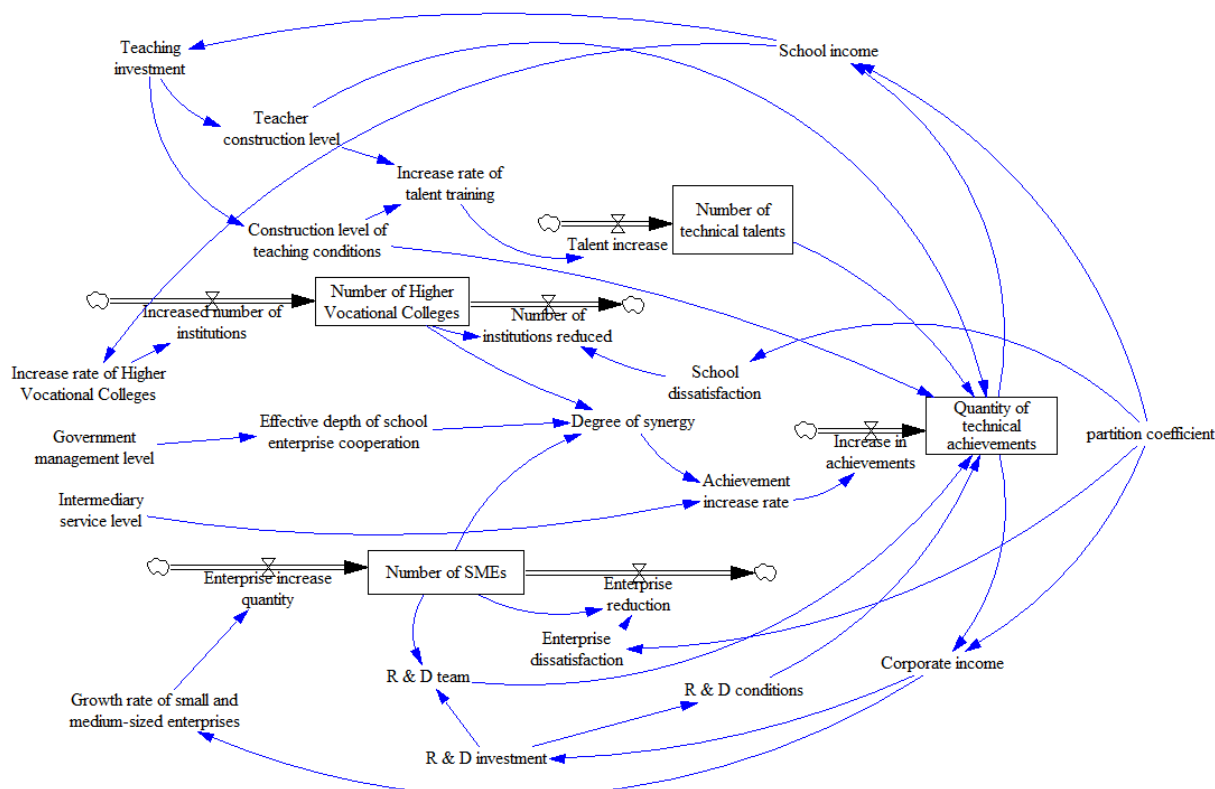


Fig. 1 Dynamic modeling of collaborative innovation system

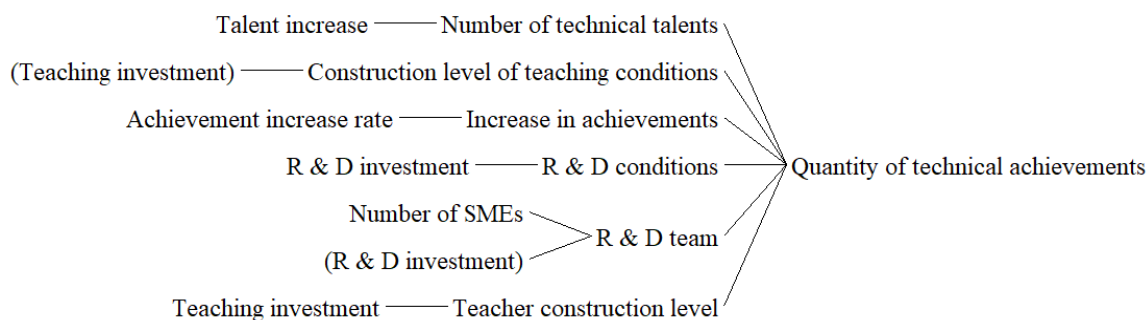


Fig. 2 Cause tree of technical achievements

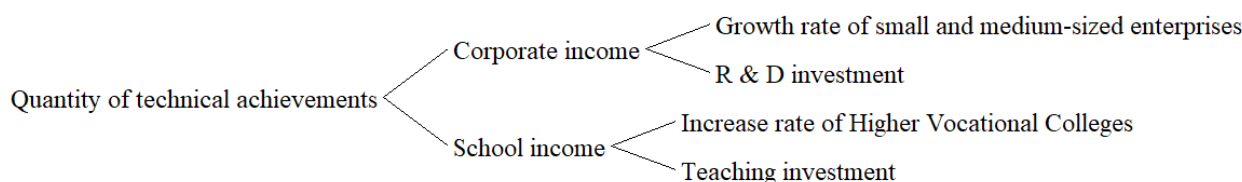


Fig. 3 Result tree of technical achievements

Under the condition that the government coordination level and intermediary service level remain unchanged, the greater the number of Higher Vocational Colleges and small and medium-sized enterprises participating in collaborative innovation, the greater the degree of synergy of the system, further improve the increase rate and number of achievements, and finally increase the number of technological achievements.

With the constant distribution coefficient, the increase of the number of technological achievements will increase the income of schools and enterprises. On the one hand, the income increase of the school will increase the teaching investment, further improve the construction level of teachers and teaching conditions, on the other hand, it will also attract more higher vocational colleges to participate in collaborative innovation, and improve the growth rate and number of colleges.

On the one hand, the increase of enterprise income will enable enterprises to increase R & D investment, thereby expanding R & D teams and improving R & D conditions. On the other hand, it will also attract more small and medium-sized enterprises to participate in collaborative innovation and improve the growth rate and number of enterprises.

Experience shows that the distribution of innovation income has a great impact on the enthusiasm of participants in collaborative innovation. Therefore, the operation characteristics of collaborative innovation system under different distribution coefficients are analyzed. In this model, the distribution coefficient is defined by the proportion allocated by higher vocational colleges, that is, when the distribution coefficient is set to 0.6, higher vocational colleges obtain 60% of innovation income, and small and medium-sized enterprises obtain 40% of innovation income.

It is advisable to set the initial number of Higher Vocational Colleges participating in collaborative innovation as 5 and the initial number of small and medium-sized enterprises participating in collaborative innovation as 10, and take the distribution coefficient as 0.3, 0.4, 0.5, 0.6 and 0.7 respectively. After the analysis, the results can be obtained as shown in Figure 4, figure 5 and Figure 6.

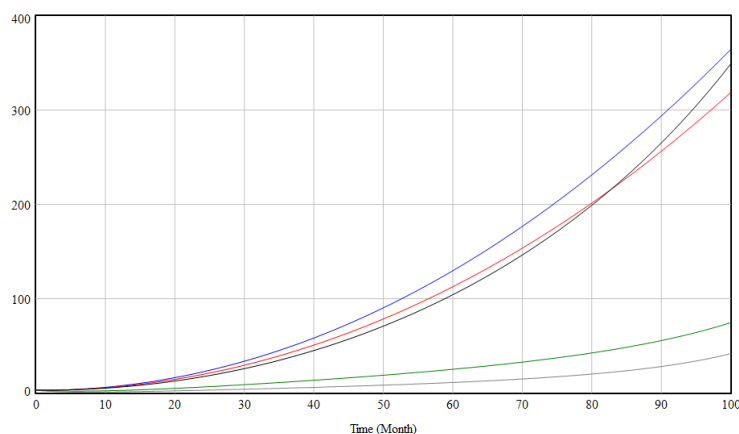


Fig. 4 Number of Higher Vocational Colleges participating in Collaborative Innovation

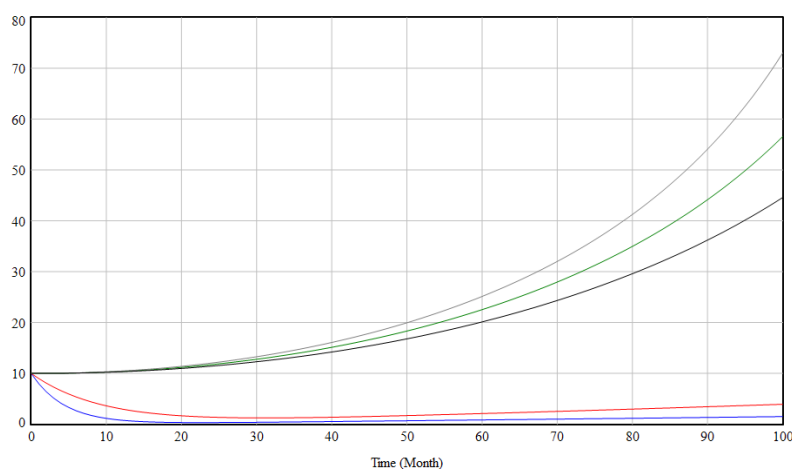


Fig. 5 Number of SMEs participating in Collaborative Innovation

When the distribution coefficient is equal to 0.5, higher vocational colleges and enterprises distribute the innovation income equally. Both of them have high enthusiasm to participate in collaborative innovation, and the number of both and the number of technological achievements have increased greatly.

When the distribution coefficient is less than 0.5, enterprises gain more income and have stronger enthusiasm, and their increase is more significant. The income of higher vocational colleges has decreased, their enthusiasm has weakened, and the range of increase has decreased significantly.

When the distribution coefficient is greater than 0.5, higher vocational colleges get more benefits and have stronger enthusiasm, and their increase is more significant. Enterprises' income decreases and their enthusiasm decreases. Instead of increasing, the number of enterprises decreases. This shows that enterprises pay more attention to income and withdraw from the collaborative innovation system when the income decreases

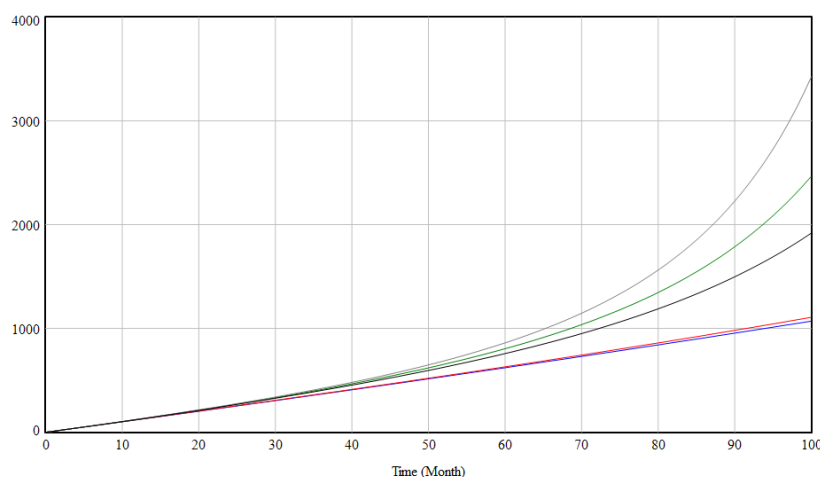


Fig. 6 Number of collaborative innovation achievements

4. Summary

Based on system dynamics, the model of collaborative innovation system between small and medium-sized enterprises and higher vocational colleges is constructed, and simulation analysis is carried out. The research shows that how to reasonably distribute the benefits of collaborative innovation is an important factor to determine whether the innovation system can continue to develop. Therefore, it is necessary to have a third-party organization to carry out achievement appraisal, scientifically quantify the achievement income, and reasonably distribute it according to the contribution rate of both parties, so as to ensure the sustainable development of collaborative innovation.

Acknowledgments

This work is supported by the following three project funds.

- 1). Guangzhou philosophy and Social Sciences "13th five-year plan" project (No.: 2020GZGJ223)
- 2). The 13th five-year plan of philosophy and Social Sciences in Guangdong Province (No.: GD20XJY36).
- 3). The 13th five-year plan of Educational Science in Guangdong Province (No.: 2020GXJK 222).

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