Changes in Science and Technology Policy for the Equipment Manufacturing Industry Collaborative Innovation Impact Prediction

Zhaoji Yu[1], Songtao Zhou[2*]

[1,2]School of Management, Shenyang University of Technology,Shenyang, 110870, China

Received 13 October 2014, www.cmnt.lv

Abstract:

This paper takes the Equipment Manufacturing Industrys the research object, drawing on the National Innovation System, building-science and technologypolicy-drivencollaborative innovationsystem model ofthe Equipment Manufacturing Industry. Throughmodeling and simulation, respectively forecasts under the existing conditions of Science and Technology Policy, Equipment Manufacturing Industry trend of patent applications 2012-2017; changes of different Science and Technology Policies, Equipment Manufacturing Industry collaborative innovation effect; changes of different combinations of Science and Technology Policies, Equipment Manufacturing Industry collaborative innovation effect. The results can provide scientific decision basis for improving the Equipment Manufacturing Industry innovation ability.

Keywords: Equipment Manufacturing Industry, collaborative innovation, Science and technology policy, system dynamics.

1 Introduction

Equipment manufacturing industry as a basic industry, as the country's pillars and strategic industry [1], on the development of China's industrialization and overall well-off society has a crucial role. In recent years, although China's Equipment Manufacturing Industry has developed rapidly, the total economic output has ranked first in the world, but still has higher degree of external dependence in the key, core technology, reaching more than 50%, compared with developed countries such as U.S. and Japan [2].To strengthen technological innovation, improve China's Equipment Manufacturing Industry core competitiveness, reduce the demand for foreign technology have become an urgent problem to solve.

How to improve innovation capability of Equipment Manufacturing Industry also launched a wide-ranging and in-depth study in academia. National Innovation System is an important area of current science and technology collaborative innovate on. This concept was firstly proposed by the British scholar Friedrich. He believed that in a country's economic leap in market economy with free competition alone is not enough and emphasized the importance of the national intervention to accelerate the establishment of national innovation system. The national innovation system includes innovation actors and innovation environment elements. The status and role of Innovation actors that include governments, businesses, universities and research institutions is different. Innovation environment elements are successful implementation and achieving results of national innovation system regulation and constraints, including innovation resources, and innovative mechanisms, innovation policy, innovation public infrastructure. This paper puts innovation resources and innovation policy into one category called fiscal policy element, puts innovative mechanisms and innovative public infrastructure into one category called environmental policy element, they are referred to as science and technology policy.

This paper draws on the national innovation system, building equipment manufacturing industry collaborative innovation system model, using system dynamics method, system modeling and simulation, to analyses the effect of the Equipment Manufacturing Industry under changes of different science and technology policy.

2 Relevant theoretical basis

Synergy theory was first proposed by the Federal University of Stuttgart, Germany, the famous physicist Haken in the 70's of the last century. The theory has been applied in Physics, Chemistry, Biology, Astronomy, Economics, Sociology, and Management Science[3]. Collaborative innovation is the synergy theory application in technological innovation field. Because of increasing competition, and the limitations and complementary of resources to Collaborative Innovation Subjects, cooperation among different subjects are becoming more and more common. That "Industry", "University", "Research institutions" compose of “IUR” cooperation innovation system has become a typical representative of collaborative innovation[4], and has great development potential, the model to be applied to the equipment manufacturing industry can more quickly improve its technology innovation ability.

System Dynamics method was first founded in 1956 by the Massachusetts Institute of Technology Professor Forrester, and in 1958 in the "Harvard Business Review" pub-

[*] ***Corresponding author’s*** *e-mail: shengchanjihua999@vip.sina.com*

lished foundation works [5]. System dynamics is a subject to sort out the relationships between multi factors in complex system, so as to reveal the structure and the dynamic behavior of complex systems. It can demonstrate the complex relationship between factors through causal loop diagram, flow chart of the model and other tools and methods, and Can use Vensim PLE Software Shadow variables, multi-level building system diagram to analyze problem sat the macro and micro levels, thus to describe the level and interaction of factors qualitatively and quantitatively[6]. The application of system dynamics and synergy theory ideas to collaborative innovation research of equipment manufacturing industry is an innovative point of this paper.

3 Model design and analysis

3.1 MODEL DESIGN

3.1.1 Model construction

This paper builds science and technology policy-driven equipment manufacturing collaborative innovation system through drawing National Innovation System model. Science and Technology Policy as driving variables, patent applications as output variables (patent applications as industrial innovation capability index), tests the established coordination innovation system model of the equipment manufacturing industry, then uses the tested model for forecast and analysis.

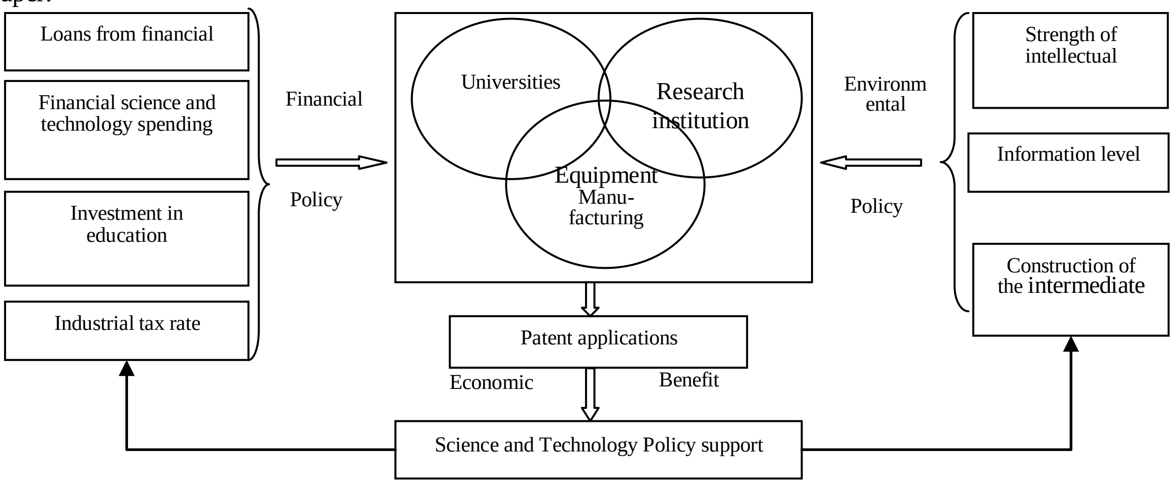

FIGURE 3.1 Equipment manufacturing collaborative innovation system model

3.1.2 The basic assumptions of system model

Do not consider the impact from natural disasters, war and other irresistible factors on the equipment manufacturing industry collaborative innovation system model; The operation of the system is a continuous, gradual process; Performance of the equipment manufacturing industry collaborative innovation expresses by the industry patent applications; Mainly consider the effect of Science and Technology Policy, other factors not considered and fixed.

3.2 MODEL ANALYSIS

3.2.1 Causal diagram

According to the basic assumptions, draw causal diagram of the equipment manufacturing industry collaborative innovation system, as shown in Figure 3.2. The causal diagram vividly reflects the mechanism and process of various elements under the action of Science and Technology Policy.

3.2.2 Analysis of flow chart

Due to the complexity of the system, using the text and mathematical equations is difficult to clearly describe the structure of the system and the mechanism of feedback loop. In order to facilitate to grasp the dynamic characteristics of the system, facilitate discussion and communication on system characteristics among managers, Can build the system structure chart of [6]. According to the causal diagram, construct the corresponding flow chart (Figure 3.3).

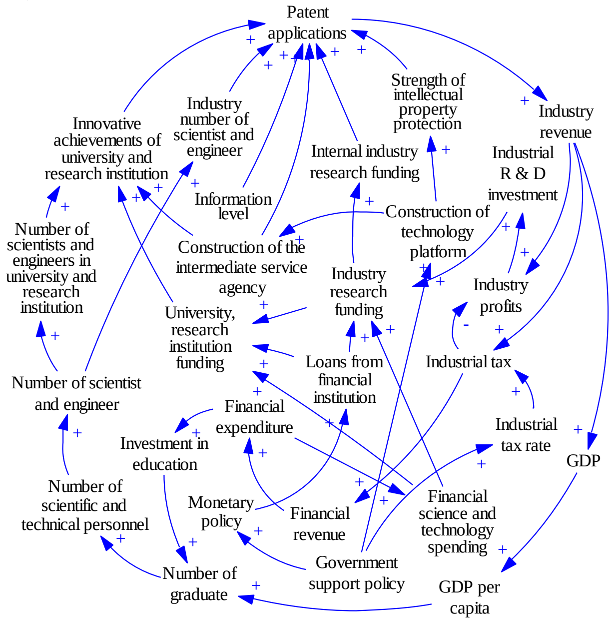

FIGURE 3.2 Causal diagram

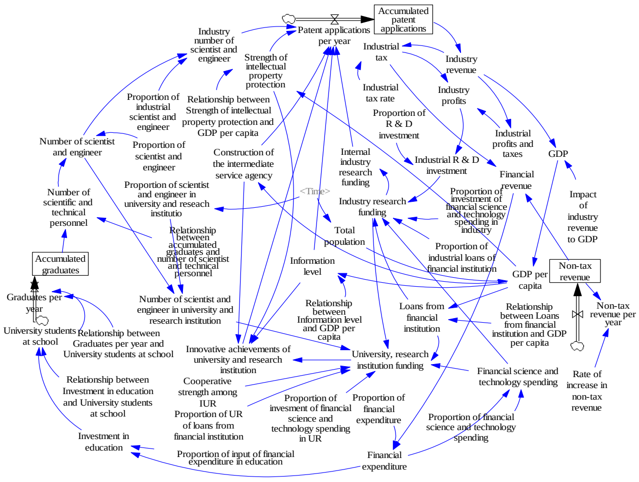

FIGURE 3.3 Flow chart

4 Model simulation and test

4.1 MODEL SIMULATION

With Vensim PLE software model simulation, simulation start time 2004, the termination date is 2011, a total of eight years, DT = 1 years. Science and technology data discussed in this paper are from the "China Statistical Yearbook on science and technology 2004-2011" and "2004-2011" statistical yearbook of china. The intensity of intellectual property protection and information level data are from the Xu Chunming [7,8] and Yang Jingying [9] documents respectively.

Variables related to funds with "100million" as a unit; Variables related to staff with "million" as a unit; Variables related to a patent with the "item" as a unit.

4.2 MODEL TEST

After completing the simulation model, need to test the feasibility of the model demonstrating whether the main variable data in the model are consistent with a true value. This article takes some main variables and calculates their fitting degree. As shown in table 4.1, the fitting degree between actual value and simulated value of the main variables are all above 0.9. This shows that, this model is effective.

TABLE 4.1 The main variable fitting degree

Variables	R	Variables	R
Patent applications	0.993	Industry research funding	0.980
Number of scientist and engineer	0.982	Financial science and technology spending	0.990
Investment in education	0.932	Financial revenue	0.974
Information level	0.923	Innovative achievements of university and research institution	0.930
Strength of intellectual property protection	0.933	Industry revenue	0.988
Construction of the intermediate service agency	0.979	University, research institution funding	0.989
Loans from financial institution	0.978	Industrial tax	0.993

5. Effective prediction of science and technology policy change

5.1 2012-2017 EQUIPMENT MANUFACTURING INDUSTRY PATENT APPLICATION FORECAST

Using the system model to predict the equipment manufacturing patent applications from 2012-2017,the results as shown in figure 5.1.

5.2 SCIENCE AND TECHNOLOGY POLICY CHANGE EXPERIMENT

5.2.1 Fiscal policy experiment

Because fiscal policies are easily received constraints from many external factors (such as natural disasters, financial crisis and so on),and difficult to sustain investment intensity, So the study respectively adds 10% Multi-pulse function in the simulation value of "Proportion of financial science and technology spending", "Proportion of input of financial expenditure in education ", "Industrial tax rate" and "Loans from financial institution "in 2013 and 2015, to compare impact strength from four different variables to the equipment manufacturing patent applications, as shown in figure 5.2.(Note: "industrial tax rate" to reduce the corresponding simulation value of 10%).

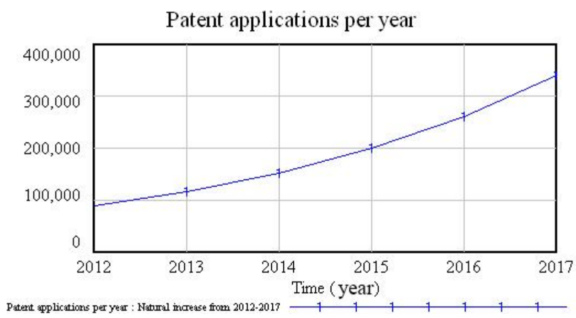

FIGURE 5.1 2012-2017 forecast of patent applications

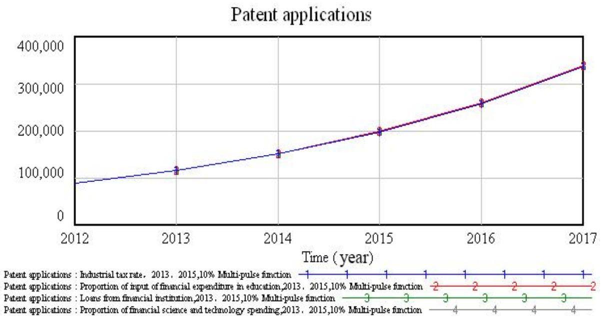

FIGURE 5.2 Effect of changes in fiscal policy forecast

Since the numerical gap relative to a coordinate scale is too small, exhibition is not ideal, so to display the data in tabular form, as shown in table 5.1.

As can be seen from the table that in 2013 just four variables input intensity changes," Proportion of financial science and technology spending" and "Loans of financial institution" on the industry of patent application have better significant effect, demonstrating that the input of them can be relatively quickly improving the equipment manufacturing industry patent applications."Proportion of input of financial expenditure in education" variable in the beginning is not as effective as other variables, there is some lag, but then better than "Proportion of financial science and technology spending" and "Loans from financial institution". "Industrial tax rate" has a similar effect with "Proportion of input of financial expenditure in education", also slightly lagging at begin, but late effect is prominent, better than "Proportion of input of financial expenditure in education" variable.

TABLE 5.1 Effect of changes in fiscal policy forecast

Year	Industrial tax rate, 2013 and 2015, 10%Multi-pulse function	Proportion of input of financial expenditure in education, 2013and 2015, 10% Multi-pulse function	Loans from financial institution, 2013 and 2015, 10% Multi-pulse function	Proportion of financial science and technology spending, 2013and 2015, 10% Multi-pulse function
2012	88030	88030	88030	88030
2013	115796	115383	115904	115917
2014	151440	151372	151317	151321
2015	198983	198237	198757	198996
2016	259892	259666	259436	259505
2017	339803	339523	339172	339261

5.2.2 Platform policy experiment

Platform policy is different from the fiscal policy, because of the little influence from the outside world, the government can continue to maintain the strength, So the study respectively adds 10%step function for the simulation value of "Construction of the intermediate service agency", "Information level" and "Strength of intellectual property protection", to compare impact strength from three different variables to the equipment manufacturing industry patent applications, as shown in figure 5.3.

As shown from figure 5.3, "Strength of intellectual property protection" has greatest effect on patent applications, smallest is "Construction of the intermediate service agency", middle is "Information level".

5.2.3 Fiscal policy combination experiment

This study puts "Proportion of financial science and technology spending", "Proportion of input of financial expenditure in education ", "Industrial tax rate" and "Loans from financial institution" combined into six groups. (To freely choose two from the four variables), Analyzing the following two situations:

(1) Adding 10% single pulse function for corresponding simulation value of above combinations from 2013 to 2014, as shown in figure 5.4.

(2) Adding 10% multi-pulse function for corresponding simulation value of above combinations in 2013 and 2015, as shown in figure5.5. (Note: "Industrial tax rate" to reduce the corresponding simulation value of 10%).

Since the numerical gap relative to a coordinate scale is too small, exhibition is not ideal, so to display the data in tabular form, as shown in table 5.2 and 5.3.

TABLE 5.2 Effect of changes in fiscal policy combined forecast (Adding 10% single pulse function from 2013 to 2014)

Year	Industrial tax rate and Proportion of financial science and technology spending,2013-2014, 10%Single pulse function	Industrial tax rate and Loans from financial institution, 2013-2014, 10%Single pulse function	Industrial tax rate and Proportion of input of financial expenditure in education,2013-2014, 10%Single pulse function	Proportion of input of financial expenditure in education and Proportion of financial science and technology spending,2013-2014, 10%Single pulse function,	Proportion of input of financial expenditure in education and Loans from financial institution,2013-2014, 10%Single pulse function	Loans from financial institution and Proportion of financial science and technology spending,2013-2014, 10%Single pulse function
2012	88030	88030	88030	88030	88030	88030
2013	116371	116317	115796	115917	115904	116438
2014	152839	152663	152156	152185	152073	152693
2015	199026	198964	199131	198822	198789	198659
2016	260444	260365	260630	260193	260150	259932
2017	340512	340409	340807	340201	340146	339810

TABLE 5.3 Effect of changes in the fiscal policy combined forecast (Adding 10% multi-pulse function in 2013 and 2015)

Year	Industrial tax rate and Proportion of financial science and technology spending,2013,2015,10%Multi-pulse function	Industrial tax rate and Loans from financial institution,2013and 2015,10%Multi-pulse function	Industrial tax rate and Proportion of input of financial expenditure in education,2013and 2015,10%Multi-pulse function	Proportion of input of financial expenditure in education and Proportion of financial science and technology spending,2013and 2015,10%Multi-pulse function	Proportion of input of financial expenditure in education and Loans from financial institution,2013and 2015,10%Multi-pulse function	Loans from financial institution and Proportion of financial science and technology spending,2013and 2015,10%Multi-pulse function
2012	88030	88030	88030	880230	88030	88030
2013	116371	116317	115796	115917	115904	116438
2014	151594	151580	151635	151515	151511	151460
2015	200097	199163	199257	199269	198416	199177
2016	260395	260123	260523	260131	259896	259735
2017	340448	340100	340668	340121	339820	339557

Two table datas show following results:

1) The most effective combination is "Loans from financial institution and Proportion of financial science and technology spending" in short term.
2) Because of a certain lag, the three combinations including "Proportion of input of financial expenditure in education" variable have a relatively small increase in short term, but has the trend of rapid growth in the late. In the long term, the combination of "Industrial tax rate and Proportion of input of financial expenditure in education" has greatest influence in patent applications.
2) According to comparison of two input methods, can know a continuous input is better than separate in effect.
4) Platform policy combination test

This study Put "information level", "intensity of intellectual property protection" and "construction of the intermediate service agency" combined into three groups, then put 10% single step function on the simulation value of three groups from 2012 to observe the different influence on patent applications, the results as shown in figure 5.6.

Can be seen from Figure 5.6, the "intensity of intellecttual property protection" and "information level" combination works best, second is "construction of the intermediate service agency" and "intensity of intellectual property protection" combination. From the contrast of first group and second, that first group is better than second in effect shows that "information level" variable has a better effect to patent applications than "construction of the intermediate service agency" variable, similarly, from the contrast of second group and third, can know "intensity of intellectual property protection" has a better effect than "information level".

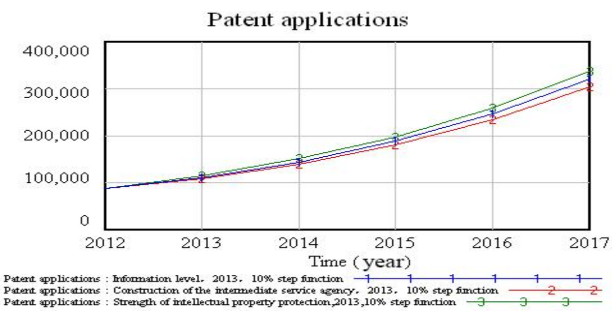

FIGURE 5.3 Effect of changes in platform policy forecast

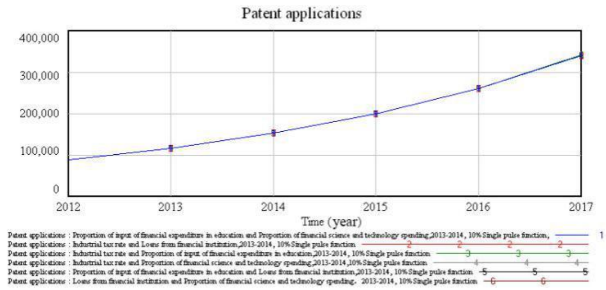

FIGURE 5.4 Effect of changes in fiscal policy combined forecast (Adding 10% single pulse function from 2013 to 2014)

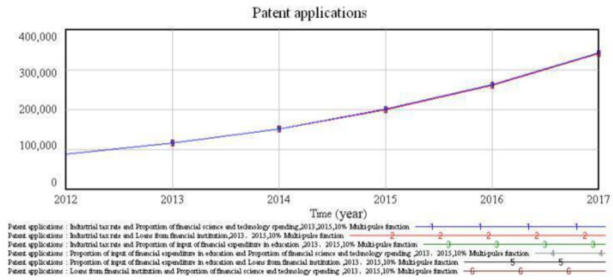

FIGURE 5.5 Effect of changes in the platform policy combined forecast (Adding 10% multi-pulse function in 2013 and 2015)

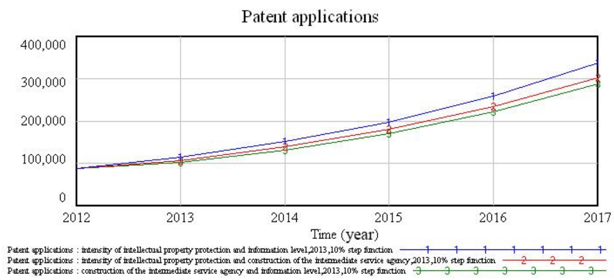

FIGURE 5.6 Effect of changes in the platform policy combined forecast (Adding 10% multi-pulse function in 2013 and 2015)

6 Conclusion

Through the analysis of the paper, the following conclusions can be drawn:

1) In science and technology policy conditions remaining unchanged, patent applications of the equipment manufacturing rise steadily, has an accelerating trend. 2017 patent applications in 2012 are expected to reach 4 times.

2) In the fiscal policy experiment, can get "Industry rate" variable in the long term run the best for improving the patent applications, “Loans from financial institution” and “Proportion of financial science and technology spending” variables in the short term run better than the others. In the platform policy experiment, can know “intensity of intellectual property protection” has the most significant effect in patent applications.
3) In the fiscal policy combination experiment, can know in the long term "Industry tax rate" and " Proportion of input of financial expenditure in education "combination either in the form of a continuous increase in single pulse or intermittently increase in multiple pulses is best to enhance the amount of patent applications, single pulse increase was better than the multi-pulse increase; in the platform policy combination test, can know “intensity of intellectual property protection” and "information level" combined the best, followed by “construction of the intermediate service agency” and “intensity of intellectual property protection” combination.

Due to the complexity of the equipment manufacturing collaborative innovation system, this article just to put science and technology policy as driving variable to examine the impact of the changes on innovation capability, however, factors affecting the innovation capability of equipment manufacturing there are many, the article do not list them all, the future should be to collect relevant literature to make the model more perfect.

Acknowledgements

This paper is supported by the National Soft Science Research Program (2012GXS4D078), supported by Program for Liaoning Excellent Talents in University (WR2012003)

References

[1] Miao Li, role of system dynamics in collaborative innovation Higher Education Development and Evaluation, 2013 (1): 18-22.
[2] Yang Jingying, Jiang Shu, He Qiang. 2012 China Information Technology Development Index (Ⅱ) International comparative study research in the world, 2013, 1: 002.
[3] Jiang Xianchen.Status of the equipment manufacturing industry in Liaoning Province On the technological innovation capability Economic Research Guide, 2013 (5): 39-40.
[4] Li Jinhai, Cui Jie, Liu Lei.Research conceptual structure model based on collaborative innovation Hebei University of Technology, 2013 (1): 112-118.
[5] Forrester J W. Industrial dynamics: A breakthrough for decision makers. Harvard Business Review,1958,36(4) : 37-66.
[6] Li Jinhua, Li Cangshu.Chinese manufacturing under the new international context: policy paradox and predicament of Shanghai Economic Research, 2010, 04:3-11.
[7] Feng Feng. Collaborative research Situation and Countermeasures Innovative Technology and Enterprise Development, 2013, 08: 217-218.
[8] Zhu Xiaoxia.The driving force of RIS innovation based on SD model Scientific Research, 2008, 06: 1300-1309.
[9] Xu Chunming, Chen Min,Determination and validation of the strength of IPR protection in China Intellectual Property, 2008, 01: 27-36
[10] Xu Chunming, Dan Xiaoguang, Construction of China's IPR protection strength index system and verification ,Scientific Research, 2008, 04: 715-723

Authors

Yu Zhaoji , Born in March, 1975, Liaoyang city, China

Current position, grades: Associate Professor of Shenyang University of Technoloyg.
University studies: Northeastern University Ph.D.
Scientific interest: Management Science and Engineering, Strategic Management.
Publications: more than 40 papers published in various journals.
Experience: teaching experience of 8 years, 30 scientific research projects.

Zhou Songtao , Born in September, 1989, Shaoxing city, China

Current position, grades: Researcher.
University studies: Bachelor of Shenyang University of Technology, Graduate student.
Scientific interest: Management Science and Engineering, Strategic Management.
Publications: more than 5 papers published in various journals.