An Application of System Dynamics to the Research on the Strategy of Rural Development in Heilongjiang Province

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ABSTRACT

By means of a study in the application of System Dynamics theory and approach,a quantitative analysis on the coordinative development of the main agricultural productions in Heilongjiang Province is made, constructing a simulation model of system dynamics which is composed of farming,forestry,animal husbandry fishery,land resoures and population.

The relationships between the various productions mentioned above, as well as between the internal variables within each production are correctly described in the model.Simulation analyses on the relationships between various productions and between the internal variables within each production,by using the model,are made and,at the same time,many programs which have advantages for the coordinative development of various productions result from these analyses.

1. INTRODUCTION

In researching the rural development strategy in 1987,Heilongjiang Provincial Government constructed a model for researching the coordinative development of the main agricultural productions in Heilongjiang Province by applying system dynamics theory and approach. The model is fundamentally based on the follwing ideas:

1.1 The key to the rural development,in terms of the actual situation in Heilongjiang Province,is rural economy and the development of rural economy is depended on agricultural productions,which,therefore, must be placed on the basic strategic position from now on.All the indices concerning agriculture development should be studied by using the method of combining qualitative analysis and quantitative research.

1.2 Agricultural production,which is a combination of natural reproduction and economic reproduction,is a giant and complex system. So factors affecting and restricting production development are numerous and relationships interacting each other are complicated. Therefore system dynamics theory and approach must be used to understand them and to find out ways to deal with them,so as to achieve an overall consideration,comprehensive analysis,complete understanding of primary and secondary and scientific rationalization.

1.3 In time of reforming at home and market–changing abroad,the modifications of policies,which have great influences on agriculture development,can not be avoided.In order to be fit to the changable situation,it is necessary for us to construct a model by applying system dynamics approach and to make a quick policy analysis according to the behavious of the model.This can enable Policy–designers to make quick reactions and revise the policy quickly.

1.4 In our researches on the developing strategy,comparisions between different programs were made to define many important indices. Being one part of a decision support system,the system dynamics model can make it puicker for system analysts to find out and identify a better program among numerous suggestions.As a result,it can provide dependable bases for the provincial government to make correct desisions.

The goal of our research is to understand the current situation, structure and coordinative relationships of various agricultural produtions in Heilongjiang povince better,by establishing a research model of coordinative development of the main agricultural production so that we can predict the developing trends of different productions and their effects on the whole production and can find out the reasonable production structures and serve as a scientific basis for designing production policies and development strategies with the help of computer simulation analysis comparing different policies and strategies.

2. SIMULATION MODEL AND ITS STRUCTURE

The coordinative development model of the main agricultural production contains six submodels which are farming,forestry,animal husbandry, fishrey,land resoures and population.The interacting relationships among these submodels are very complicated.The land resourse is the most important factor which determines the developing of other production; population is the sourse of labours and the consumers of material products,so the changes of population can influence directly the development of various productions.The relationships among these submodels and variables within each submodel have extremely important influence with the development of agricultural production.The fundamental structure of the specified internal and external relationships in this systematic modle are given in Figure 1.Figure 1 shows that each part in the system was its own principle and,at the same time,different parts also act and restrict each other.This restricting relationships can be seen in the following aspects:

2.1 In case of limited land resource,all types of land area can not extend arbitarily.Therefore,the formation of each type of land area has its own rational numerial value.

2.2 When there is a limited area of land to be use,the output of all kinds of crops,the growing stock of forest,and the output of livestock and fish products can also be increased by improving the intensive management.

2.3 The developing of animal husbandry and fishery requires a great increasing of fodder,since a balance between supply and demand is a fundamental condition for the developing of these two productions.In addition,animal hasbandry is the main source of organic fertilizer and its developing can make soil fertility enhancement so as to increase the outputs of crops.

2.4 The existance of human requirs a great deal of farming, animal husbandy and wood products,on the other band,the requiment can further give an impetus to these productions.

2.5 In order to keep the system running properly,the supplies and demands of all the products must be in the state of dynamic equilibrium.

When the interacting relationships described above are specified,the causal relationship diagrams and system flow diagrams can be drawn and consequently the equiations, which express the system in detail,can be established. In this paper,only one submodel showing the increasing variations of dairy cattle in the animal husbandry subsystem is described which serves as a example to illustrate the idea of establishing the model.The flow diagram showing the variations of amount of dairy cattle is given in Fiqure 2. The amount of dairy cattle on hand in the Fiqure 2 is level variables.The equations for it are given below:

1L X2.K = X2.J+DT * (X21.Jk−X22.JK)

X2 in the equation is the amount of dairy cattle on hand;X21 is the increasing rate of dairy cattle;X22 represents the decreasing rate of dairy cattle.The equation for calculating X21 is

2R X21.KL = X2.K * 0.62 * 0.35 * PCX2.K+GX21.K

X2 in the equation 2 is the amount of dairy cattle on hand at the end of the year;0.62 is the ratio of calver;0.35 is the ratio of female calves born;and PCX2 is the controlling coefficient.The product

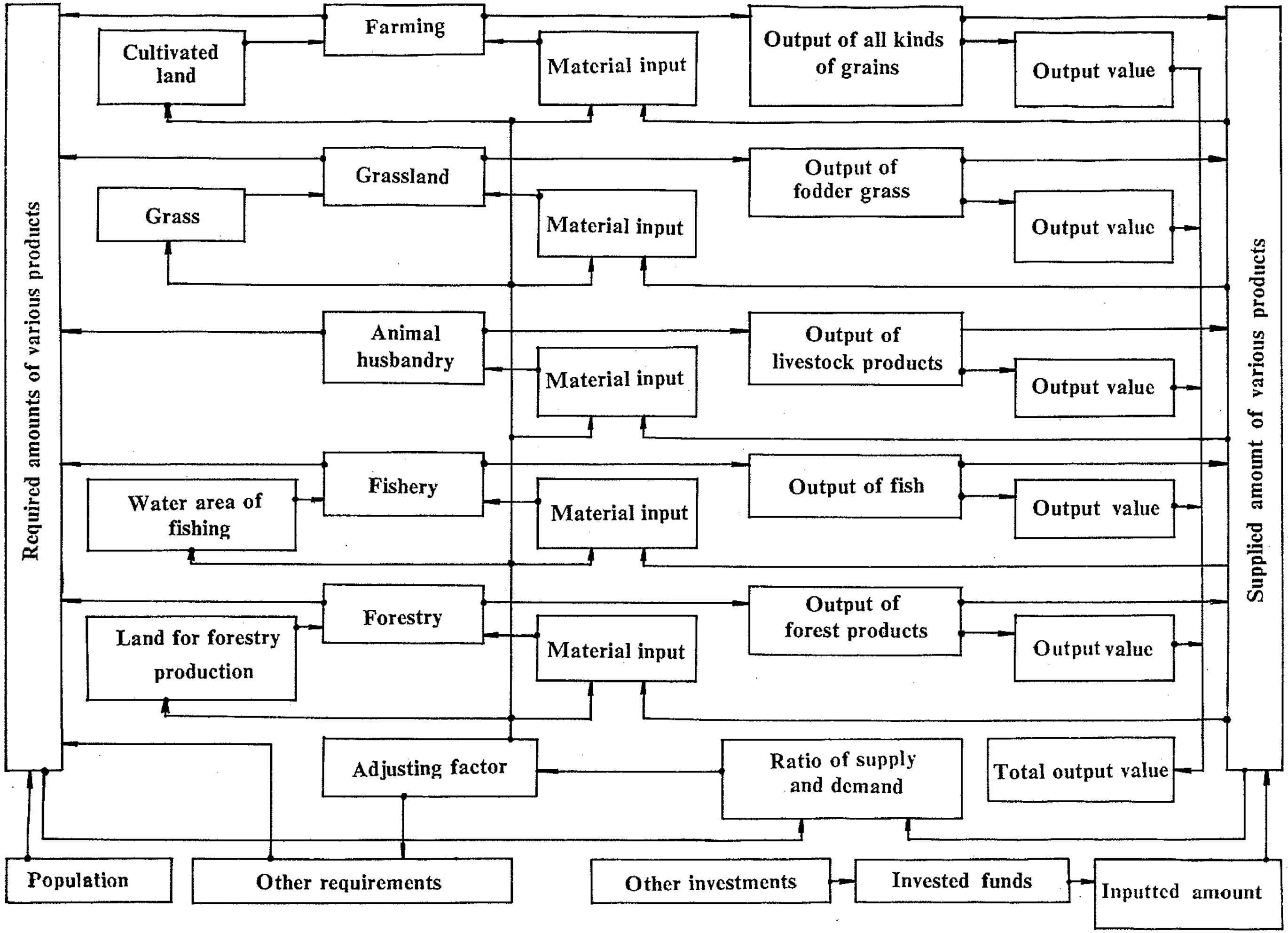

Figure 1 Diagram of Structure Relations of System Model

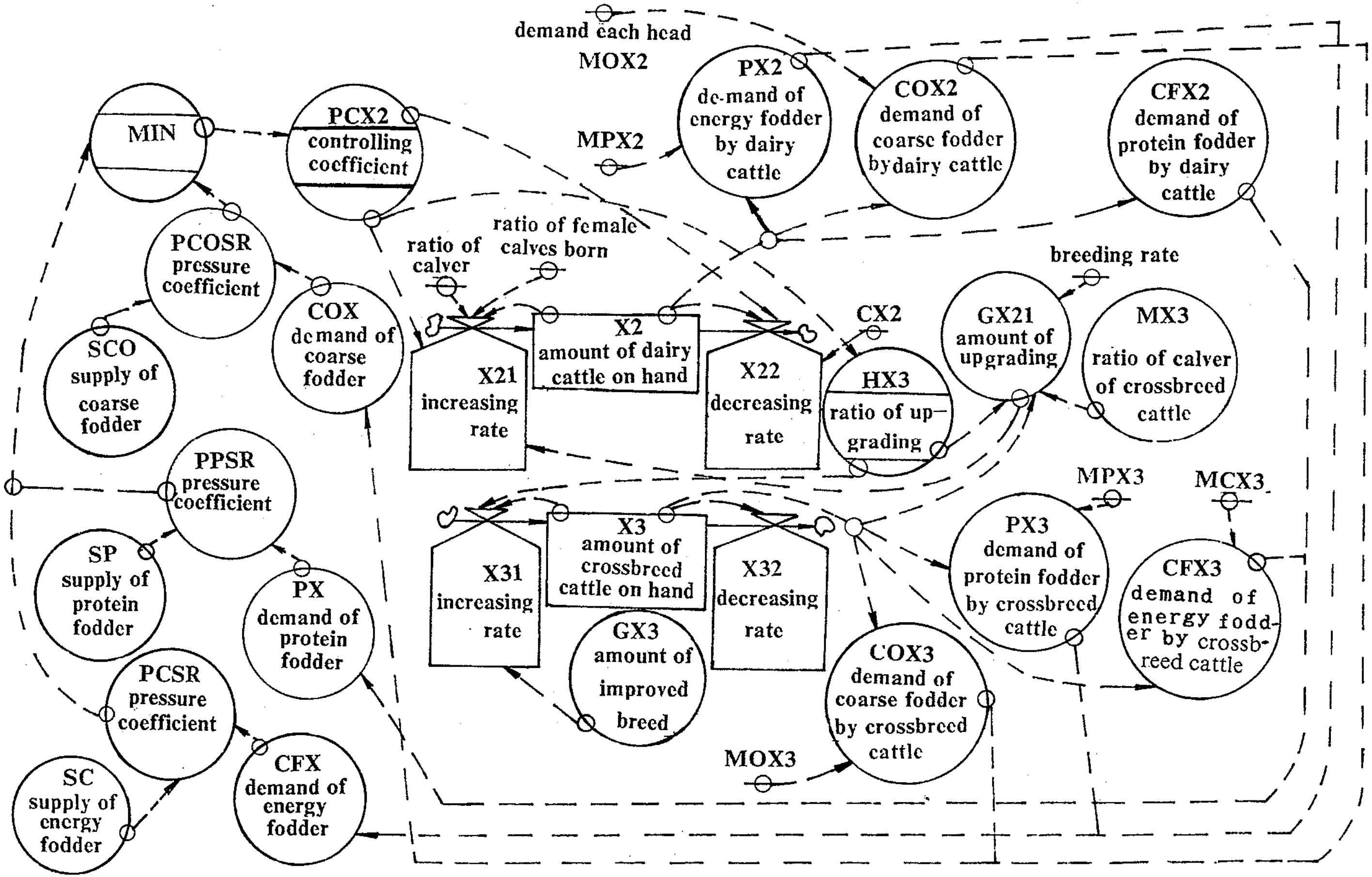

Figure 2. Submodel of dairy cattle

multiplied by these variables is the amount of dairy cattle self–breed.GX21 represents the number of upgrading crossbreed cattle caused by crossbreeding.The equiation for GX21 is

3A   GX21.K = X3.K * HX3.K * M3.K * 0.43

X3 in equiation 3 represents the amount of crossbreed cattle on hand;MX3 is the ratio of calver of crossbreed cattle; 0.43 is the breeding rate;HX3 is the ratio of upgrading.X22 in equation 1 is the decreasing rate of dairy cattle.The calculating equation is given b~low.

4R   X22.KL = X2.K / (CX2.K * PCX2.K)

CX2 in equation 4 is the ordinary time–length over Which the cattle are kept on hand,while PCX2 is the controlling coefficient related to the relationship of fodder supply and demand.The supply and demand relationship of the three kinds of fodder is expressed by the ratio of available amount of supply and demand.when the amount of supply is more than that of demand,the ratio is over 1;when supply and demand is in balance,the ratio is equal to 1;and when supply is less than demand, the ratio is below 1. In fact,ratios of supply and demand relationsheps of the three kinds of fodder can not be equal under existing conditions.It is the short supply relation of supply anddemand that,in practice,restricts the number growth of dairy cattle. Therefore,MINX,which is the minimum value of the three kinds of supply and demand ratio mentioned above is used to determine the value of PCX2.The possible relation between PCX2 and MINX is expressed with the following equation.

5A   PCX2.K = TABHL(TPCX2,MINX • K,0,1.2,0.2)
6T   TPCX2 = 0.2 / 0.2 / 0.4 / 0.6 / 0.8 / 1 / 1

This equation,together with the equations of dairy cattle increasing and decreasing rate,shows that when the fodder supply fails to meet demand,it will restrict the increasing of dairy cattle;while the development of dairy cattle production mainly depands on the breeding capacity of cattle when fodder supply exceeds demand. However,there are also,in reality,other types of relationships between PCX2 and MINX.These different relationships are representatives of different controlling polices on the developing of dairy cattle produetion.In addition to the restriction caused by fodder supply and demand,the capacity for processing fresh milk is also considered as a controlling factor on the developing of dairy cattle in this model.Being located in the zone suitable for dairy cattle life in the world,Heilongjiang Province possesses many advantages for dairy cattle production so that it can provide milk product all over the country and export milk product to other countrries.Therefore,the milk processing capacity in the model is assumed to be a productive force which can be raised in pace with the growing of dairy cattle production.The fresh milk processing capacity in Heilongjiang Province at present is larger than the output of fresh milk.

3 SIMULATION ANALYSIS

Based on the analyses and establishments of various submodels,a complete research model for coordinatuve development of the main agricultural production in Heilongjiang Procince can be constructed by combining,organically,the submodels. The model was tested before policy simulations or strategy simulations.The results show that this model is suitable for policy simulation or developing strategy simulation.

During the simulation analyses,we focus on the production subsystem, as well as the possible developing trends and interrelations between submodels in case of using different developing strategies and policies. By simulating and analyzing the developing strategies and policies,we considered several programs.The results of these programs are given below briefly.

3.1 A program speeding up the developing of animal husbandry by increasing material inputin farming and ensuring export of grain.

This program is one of the coordinative development of farming and animal husbandry.It requires that the amount of chemical fertilizer input,which will increase to 1.7 million tons(net measure), should be tripled that of 1983 by 2000 and the investment for building grassland after 1990 should be keeping in 180 million yuan(RMB).The seeded area of soybean will increase to 2.275 million hectare.Some of the condition parameters are given in Table 1 and the main data of simulation results can be seen in Table 2.

Table 1 condition parameters

years \ units \ items	Chemical fertilizer (net measure)	Seeded area of soybean	Investment for million man–made grassland	Export amount of soybean	Export amount of grain.
	10000 tons	10000 hectare	millon yuan	million kilogram	million kilogram
1990	110	227.5	180	2000	2000
1995	130	227.5	180	2000	2500
2000	170	227.5	180	2000	2500

3.2 A program speeding up the developmlnf of animel husbandry by reducing gradually the exported soybean by 0.5 billion kilogram after 1993.

This program is a better coordinative development of farming and animal husbandry production.It requires that o.5 billion kilogram of soybean to be exported should be cut down and the investment for grassland building should be speeded up.The result of simulations are given in Table 3.

The first program stresses on the increasing of chemical fertilizer input,the enlarging of the seeded area of soybean and the extending of the man–made grassland,so as to increase the output of grain and soybean to 24.25 billion kilogram by 2000.In other words,Ensuring the grain consumption by people and industry,the first program can maintain 2 billion kilogram soybean to be exported,supply 3 billion kilogram commodity grain and increase slightly the fodder for animal husbandry.After providing meat,egg and fur,this program can speed up somewhat the dairy cattle production (1.168 million head of cattle by 2000). However,a potential of increasing still exists.Based on the first program, the second program suggested reducing 0.5 billion kilogram of soybean in export and 0.5 billion kilogram of commodity grain by the end of 2000. On one hand,the program can meet the demands of meat,egg and fur,on the other hand,the dairy cattle production can expand a great deal and the amount of dairy cattle on hand can amount to 2.578 million by 2000. caused by the repid development of animal husbandry,the total output value of the farming and animal husbandry can be 2.1 billion yuan more than that of the first program,and the yield of grain,soybean and potato can an increase by 0.4 billion kilogram over the first program.In addition,the reducing of organic matter in soil can be slowed down.

In the coordinative dvelopment program,the coordinative developments of forestry and fishery are dealt with separatly and both of the results are satisfactory.

4 CONCLUSION

Of these two simulated programs,we prefer the second one.The second program requires that the

Table 2 Index table of main prodctions,economic benefit and equilibrium parameters

Items \ Units \ Years		1990	1995	2000	Items \ Unit \ Year		1900	1995	2000
Total output of grains,soybean and potato	million kilogram	19920	21850	24250	Equilibrium of egg supply and demand	%	79.4	90.7	94.5
Output value of farming production	million yuan	13030	14510	16130	Equilibrium of milk processing	%	88.5	90.9	92.3
Output value of animal hus-bandry	million yuan	3481	4650	5650	Investment for milk processing each year	million yuan	63	79	101
Output value of farming and a n i m a l hushandry	million yuan	16510	19160	21780	Equilibrium of wool supply and demand	%	101.7	97.1	101.4
Equilibrium of meat supply and demand	%	114.9	115.6	110.1	Equilibrium of pork supply and demand	%	101.3	105.1	99.4
Export of soybean	million kilogram	2000	2000	2000					

Table 3 Index table of the main production,economicbenefit and equilibrium parameters

Items \ Unit \ Year		1990	1995	2000	Items \ Unit \ Year		1900	1995	2000
Total output of grain soybean and potato	million kilogram	19940	21880	24150	Output value of farming	millon yuan	13040	14590	16380
Output value of animal hus-bandry	million yuan	3590	5330	7460	Output value of farming and animal hus-bandry	million yuan	16630	19920	23840
Equilibrium coefficient of meat	%	115.2	116.4	111.9	Equilibrium of pork suplly and demand	%	101.3	105.1	99.4
Equilibrium of egg supply and demand	%	79.4	90.7	94.5	Common ox unit	10000 head	639.2	841.3	1149
Investment for milk processing eaeh year	million yuan	100	199	365	Export of soybean	million kilogra m	2000	1700	1500

chemical fertilizer input should amount to 1.7 million tons by 2000 and the exported amount of soybean should be decreasing from 2 billion kilogram in 1990 to 1.5 billion kilogram in 1995 which should be maintained after 1995,while the total output of soybean keeps growing.As a result,the output value of animal husbandry can amount to 7.45 billion yuan.

By using system dynamics theory and approach,our research constructed a coordinative development model of the main agricultural productions. Using the model,we quantitatively analyses the relationships of coordinative development from the view points of time and space.This method is superior to other traditional ways and the research has practical significance in reality.

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THE DYNAMIC RELATIONSHIP BETWEEN TRANSPORTATION AND OTHER INDUSTRIES IN CHINA

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ABSTRACT

This paper analyses the dynamic relationship between transportation and other industries with system dynamics theory and method. We develop a system dynamics model to protray how the transportability influences other indistries, and have made some computer simulation in which we simulated the dynamic characteristics of the system at different alternatives of investment.

In the simulation, we properly reduced the investment in heavy industry and increase the investment in transportation, while the total amount of the investment is the same. The output value of heavy industry didn't decrease, on the contrary, it increased. At the same time, the output value of other industries and national income increased too. This indicates that the transportability directly influences the output value of other industries.

From the simulation result we also see that the investment in transportation of China is too small and this leads to the situation that the development of transportation can't meet the demand of national economics in China.

This paper is a application example of how system dynamics is used to solve problems of social economics. This research will help people to know the importance of transportation in national economics and government to make policies.

1. PROBLEM AND PURPOSE

Transportation is a major one basis of national economic. It's very important in linking production circulation and distribution as well.

For nearly fourty yrars, transportation in China has developed quickly. However it doesn't meet the demand of industrial and agricultural production and people's life. For a long time transpotation in China is in a passive state, to which economic development is subject.

There are a lot of objective causes for the passive state of transportation in China. But wrong decisions caused by subjective element are primary. That is, strategy position and precursory affect of transportation were not fully realised, systematic and quantitative analysis are seldom used to study the relationship between transportation and other industries. Therefore the alternative of investment didn't include improving the transportation first. And it was even neglected. Especially during the period of fifth and sixth five-year economic plan, the investment in transportation of China is not sufficient at all . Other policies for developing transportation are not adequate also.

According to the fundamental concept of system engineering—the concept of system and using system dynamics methods,we put transportat-