

An Application of System Dynamics Approach to the Development Goals and Policies of the Animal Husbandry

Wang Hong-bin

Rural Development Research Center of Heilongjiang Provincial Government
27, Xuanxin Street, Harbin 150001, P.R. China

ABSTRACT

In this research, the system dynamics model for analysing the development goals and policies of the animal husbandry in Heilongjiang province is constructed by means of the theory and approach of system dynamics. In this model, the major relations of mutual effects and interactions existing in the processes of natural and economic reproduction of animal husbandry are described emphatically.

I. INTRODUCTION

In the research on the development of animal husbandry, the developing goals and the related policies are the core of the developmental research of animal husbandry. The developmental goal, however, and related developmental policies are interconnected and interacted in reality. Therefore, the work of researching and determining the goals and the policies should be repeated and circulated, that is, with certain goals, the related and possible policies will be researched and studied. In reality, policies used to realize the goals often can't be satisfied fully, and can only be satisfied partly. So the feasible goals should be studied by using the possible policies, and the process should be repeated until the demanded results are achieved. In this researching process, the actual difficulties are that of determining the general goal of developing the animal husbandry and the specific values of the sub-goals on various stage, as well as that of making the related policies and setting up the substantial relations between the policies and the goals. Take, for example, when the process of certain livestock products are set, what effects on the development of animal husbandry will be caused. This paper will show that the researches on the development of animal husbandry can forward only when the above problems are solved.

On the basis of analysing the advantages and disadvantages of various quantitative researches, this paper tries to solve the above problems, by means of system dynamic model which forms the structure of the problems. According to many years' experiences of studying the System Dynamic Approach we believe that the system dynamic model is likely to solve the problems, but the setting up of the model must be analysed and researched deeply.

II. ANALYSES ON THE DEVELOPMENTAL GOALS

In this research, according to the general developmental goal, put up by the provincial government, "that using the grain as the major project and using the animal husbandry and enterprises of towns and countries as the support, with the idea of grain, animal husbandry and enterprises as a whole so as bring other industries to develop coordinatively", we have determined the general goal of the development of the animal husbandry to "accelerate the development of animal husbandry and to make it the supporting enterprise." In this research, we have resolved the general goal of the development of the animal husbandry into subgoals in the different goal levels. The result of resolving goals is shown in Figure 1. In this paper, the output goal of livestock products, goal of output value of animal husbandry, goals of every herd of livestock on hand and the relations between them are emphatically analysed.

III. THE STRUCTURE OF DEVELOPMENTAL RESEARCH MODEL

The animal husbandry in Heilongjiang Province is an important element of the rural economic system and national economic system. From the point of system, the animal husbandry itself is a system, at the same time, it is also a subsystem within the whole national economic system and rural economic system. In the process of normally natural and economic reproduction, the animal husbandry system is connected with other subsystems within the national economic system, in the aspects of material objects, currency

and information. Concretely speaking, the development of animal husbandry depends on two aspects, that is, the structural characteristics of the animal husbandry system itself and the environmental conditions of the animal husbandry. In this sense, the structural characteristics of animal husbandry system refers to the structures and characteristics of a production-distribution-exchange link of the six kinds of animals and fowls which are pigs, milk-cows, cattles, horses, sheeps and fowls. For example, the development of milk-cows must be influenced by the breeding law, that is, if the animal group is small, it is very difficult to enlarge quickly the numbers. In addition, it can also be influenced by the practical process and effects. On the other hand, the environment and conditions of the animal husbandry refer to a collection of certain factors which influence the production, distribution and exchanges. The collection includes factors such as, supply amount of coarse fodder, energy fodder and protein fodder, fodder prices, demanded amount of various animal products, the amount of funds put into, the national and provincial policies on developing animal husbandry and the advances of techniques. All these factors directly or indirectly influence the developmant of animal husbandry.

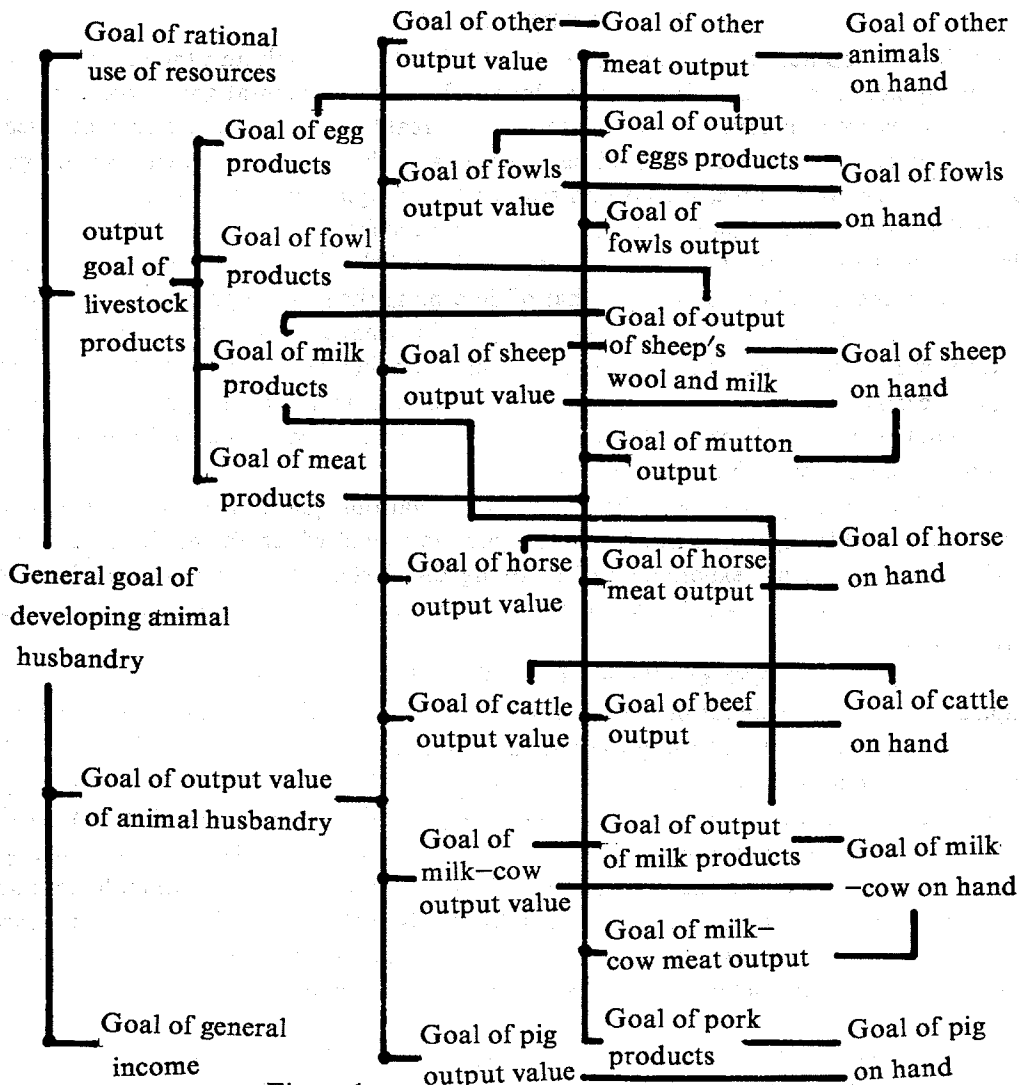


Figure 1.

In our research, we set up a model by means of system dynamic approach, so as to describe the procedures

of production, distribution and exchanges of the animal husbandry in Heilongjiang province, as well as the influential relations of the outer environmental factors such as policies, demands, resources and prices to the development of the animal husbandry. The basic structure is shown in Figure 2.

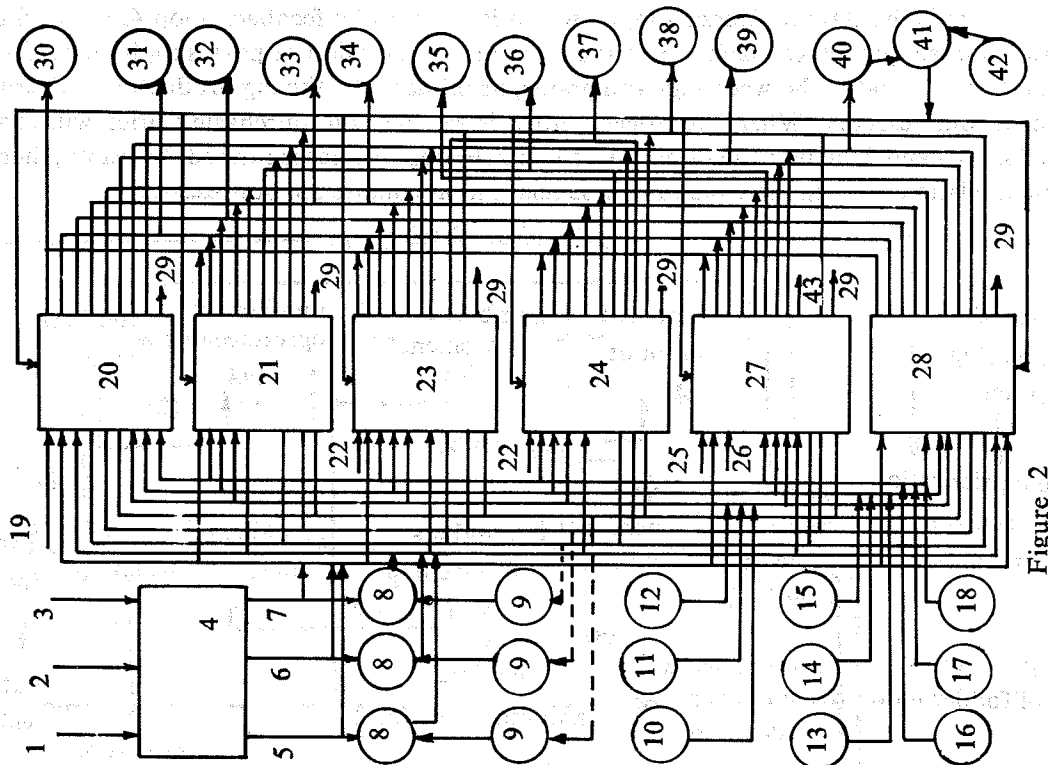


Figure 2

Notes: 1.funds of grass land,2.total amount of fodder,3.fodder straw,4.submodel of fodder production and supply, 5.supply amount of protein fodder,6.supply amount of energy fodder,7.supply amount of coarse fodder,8.ratio of supply and demand,9.total amount of demand,10.price of protein fodder,11.price of energy fodder,12.price of corase fodder,13.demand of meat ,14.demand of egg,15.demand of milk,16.meat prices,17.eggs prices,18.milks prices,19.demand of pork,20.sub-model of pig raising,21.sub-model of milk-cow raising,22.demand of ahimal power,23.sub-model of cattle raising,24.sub-model of horse raising,25.demand of wool,26.wool price,27.sub-modle of sheep raising,28.sub-modelof fowls raising,29.on sale,30.amount of manure produced,21.net income,32.total output value,33.cost of total materials,34.meat output,35.egg output,36.milk output,37.animal power supplied,38.unit of cattle ,39.net output value,40.total income,41.cost of production,42.funds invested outside,43.wool output.

IV. THE SYSTEM DYNAMIC MODEL

In this research, the system dynamic model, organically formulated, consists of a number of sub-models which are fodder production and supply, pig raising, milk-cow raising, cattle raising, horse raising, sheep raising, fowls raising and economic accounting. within the above model, all kinds of the raising models, emphatically, describe the changing procedures of the production of all knids of animals under the influences of these factors. In reality, the factors influencing the production are of great numbers and the differences between the factors are also great. However, a detailed analysis can show that the structures of these sub-models are basically the same and can be described with a similiar model structure. Now, take the pig model as an example to show the structure.

When we set up the submodel to describe the production of pigs, we put the stress on the five factors

,which are the supply and demand of funds,supply and demand of fodders,supply and demand of pork and the self-breeding law of pigs.all of these factors influenc the pig production. The influential relations of these factors to the pig production are shown in Figure 3. Among the influencing factors, the first one is the natural breeding process and law of the pig population which is described by feedback loop 2 and 3;the second one is the state of fodder supply, which is described by feedback loop 4,the third one is the state of the fund supply by feedback loop 5;the fourth is the situation of pork supply by feedback 6;and the fifth is the proces ration between pigs and grains, its influence to the pig production is deccribed by an open loop in our research. When the price-control is set free, the purchasing price will change with changes of supply and demand state of pork,so a control-loop of price is formed. In reality, there are also interactional relations among these factors, these relations are omitted in our research.

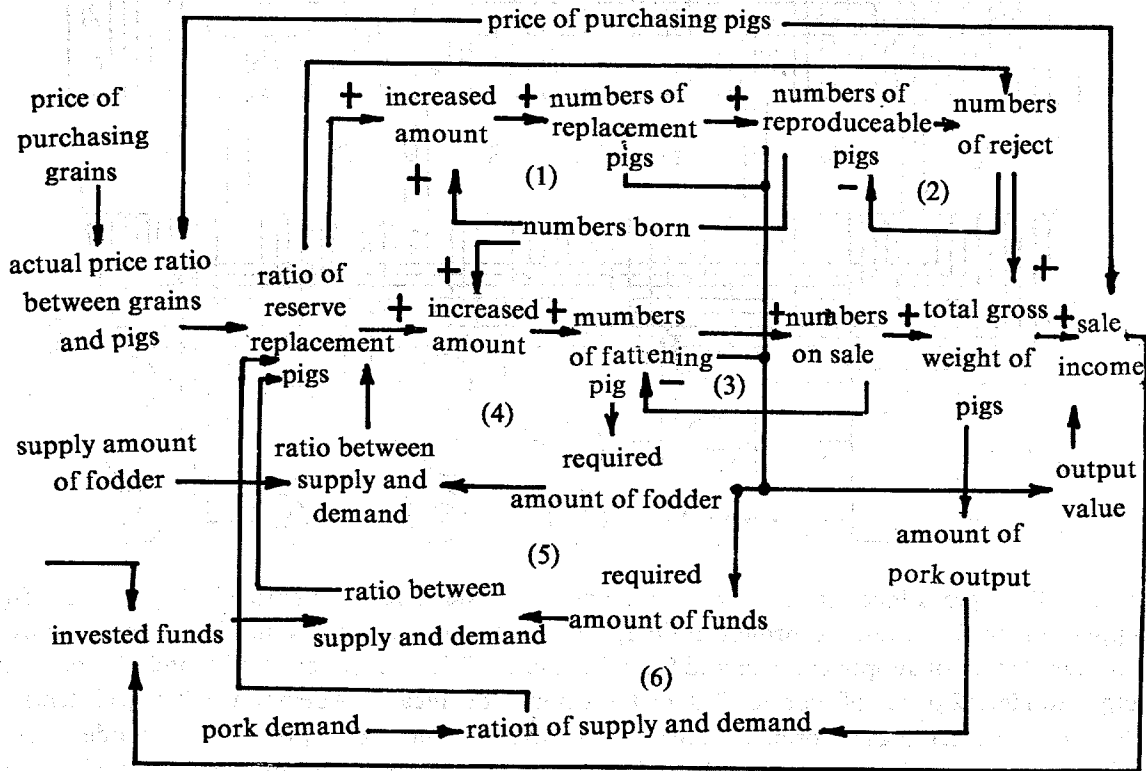


Figure 3.

With the analysis given above,we can form the flow diagram of the pig production model after specializing the factors which affect the pig production. The flow diagram is shown in Figure 4.In the diagram, the variable ration of reserve replacement pigs is the major one affecting the pig production.When the ration is high, the numbers of pig can increase greatly after a period of time; When the value is low, the number of pigs will decre ase greatly. Among the factors affecting the ratio of reserve replacement pig, the benefit of raising pigs shown by the relation of price ration between pigs and grains is one of the most important one ,it not only has effects over the ratio of reserve replacement pigs, but also has effects on the years the femals pigs are made use of .In addition, the average numbers of pigs farrowed by each pig,which can give birth, once is also an important factors influencing the raising level of pigs. In our research, the function of the advancing of science and techiques is mainly shown in rising of the transforming ratio of fodder, and of numbers of pigs on sale and the economic benefit of raising pigs.

In terms of the relations shown in Figure 4, the mathematical simulation model describing the pig production can achieved by giving the relations numerical value. There are 3 major level equations and 5 rate equations which are used in the mathematical simulation model which can describe the pig produc-

tion. The level equations are comparatively simple. In the paper, we mainly analyse the two rate equations, which are used to analyse quantitatively the relations of various influencing factors of the increased amount of reserve replacement pigs and the fattening pigs.

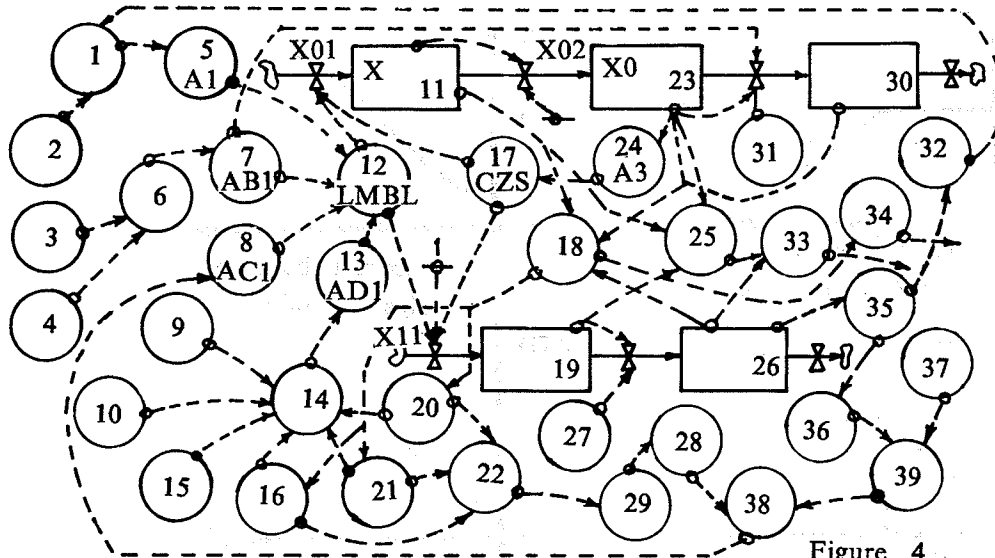


Figure 4.

Notes: 1.ratio between pork supply and demand,2.amount of pork demand,3.price of purchasing pigs,4.price of purchasing gains,5.adjusting factor,6.price ratio of pigs and grains,7.affecting factors, 8.affecting factors,9.supply amount of protein fodder,10.Supply amount of coarse fadder,11.numbers of replacement pigs,12.ratio of reserve replacement pigs,13.affecting factor,14.minimal ratio between supply and demand,15.supply amount of energy fodder,16.demand amount of protein fodder,17.numbers born,18.numbers raised,19.fattening pigs,20.amount of demanded enery fodder,21.amount of demanded coarse fodder,22.demanded cost of fodder,23.numbers of reproduceable pigs,24.numbers of breeding sow,25.numbers on hand,26.numbers on sale,27.ratio on sale,28.required production cost,29.material cost,30.numbers of reject pigs each year,31.numbers of years for normal use,32.amount of meat produced,33.output value,34.amount of manure produced,35.total weight of gross pigs,36.sale income,37.other investments,38.ratio between funds supply and demand,39.possible production cost.

The increasing rate equations of reserve replacement pigs and fattening pigs are:

$$R X01.KL = CZS.K * LMBL.K$$

$$R X11.KL = CZS.K * (1-LMBL.K)$$

X01---The increased numbers of reserve replacement pig (head / year)

X11---The increased numbers of fattening pigs (head / year)

CZS---Numbers born (head / year)

LMBL---Ratio of reserve replacement pig

In the equations, LMBL is an important factor having effects ON the pig production, and the basic form of its equation is as following:

$$LMBL.K = (\text{ratio between fadder demand and supply, ratio between pigs and grains, ratio between pork demand and supply, ratio between funds demand and supply})$$

In this particular research, on the basis of the actual situation in Heilongjiang province, the specialized equations are shown as following:

$$A LMBL.K = C5.K * A1.K * AB1.K * AC1.K * AD1.K$$

A1---affecting coefficient of the ratio between pork demand and supply

AB1---affecting coefficient of the price ratio between pigs and grains

AC1---affecting coefficient of the ratio between demand and supply of funds

AD1—affecting coefficient of the minimal fodder demand and supply

C5—LMBL keeping the raising scale stable

The basic influence relation of the above factor to LMBL are shown in Figure 5. In developing model, correct descriptions of the above factors is very important for the development of pig production.

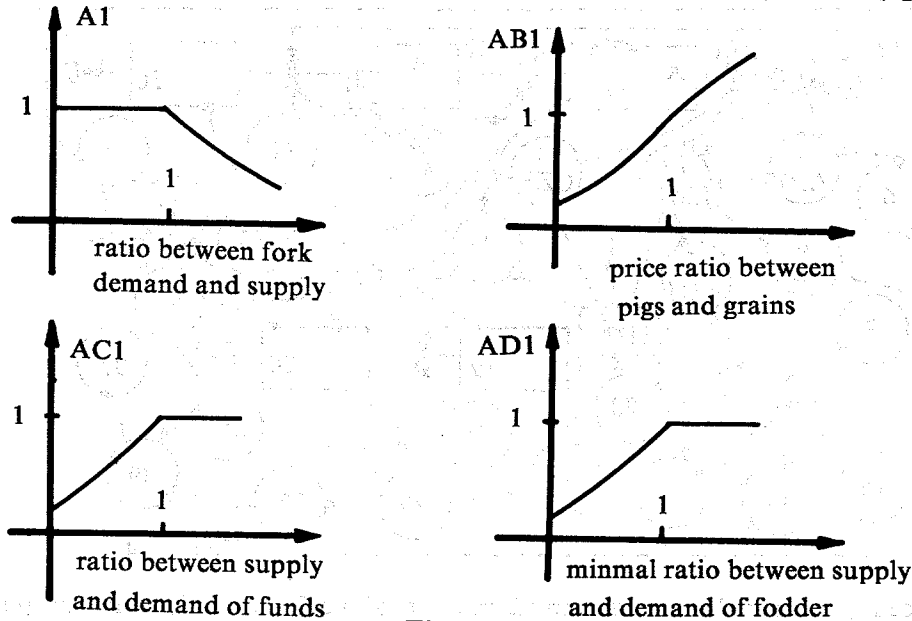


Figure 5

Viewing the analysis of the above system dynamic model, we can see that when the whole structure of the system dynamic model has been determined, the system dynamic model, which is comparatively conformed to reality, can only be done after a great deal of works. However, correct and quantitative description of the process of making decisions by people according to the actual situation is the most difficult one, but also the most important one. Works and documents concerning such things are rather few. In our research, we have made a few attempts and made a little progress, but more works must be done for it practically, since it is a critical problem for improving the quality of model study.

V. SIMULATION ANALYSIS AND POLICIES SUGGESTIONS

On the basis of the researchs and developmental model of animal husbandry and according to the requirements of the reseaching and developmental goals of the animal husbandry, we use the software, PD puls and DYSMAP2, for simulating and analysing three potential developmetal goals. The results of the simulation analysis of the three programmes, drawn up in terms of the three principles, are given in Table 1. The goal values in the table don't consist of other domestic animals, since the production of those animals only take a small portion in animal husbandry.

The low-goals programme for developing animal husbandry are made according to the present developmental tendency of animal husbandry; the medium-goals programme is a plan for developing animal husbandry faster by putting into more matei rals and by enhancing the functions of modern science and techniques; and the high-goal programme is a plan of devoting major efforts to the development of animal husbandry by doing every thing to put into materials and, at the same time, enhancing ,further, the function of mdrn science and techniques.

From Table 1, we can see that when the low-goal programme is used, the output value of animal husbandry (in terms of the unchanged prices of 1980) will amount to 1,863 million yuan in 1900, 2504 million yuan in 1995 and 3,514 million yuan in 2000. The average developing rate will be 6.1% for the first five years and 7.0% for the second five years. The meats output, on the other hand, will respectively, 428 million kg, 547 million kg and 710 million kg; The total output of eggs will, respectively, amount to 256 mil-

Table 1 Some of the major goals of animal husbandry

item	unit	year	1990			1995			2000		
		plans	low	medium	high	low	medium	high	low	medium	high
Total output value (current price)	100 Million yuan		33.34	34.14	34.91	44.40	50.02	59.03	60.61	74.68	95.28
Total output value	100 Million yuan		18.63	19.00	19.39	25.04	27.90	32.23	35.14	42.28	52.31
output value of pigs	100 Million yuan		5.166	5.270	5.26	6.824	7.329	8.052	8.444	9.953	13.09
output value of milk-cow	100 Million yuan		5.137	5.214	5.291	9.046	9.857	10.71	15.82	18.18	20.88
output value of cattle	100 Million yuan		0.937	0.937	0.937	0.953	0.953	0.953	1.101	1.101	1.101
output value of horse	100 Million yuan		1.213	1.213	1.213	0.946	0.946	0.946	0.731	0.731	0.731
output value of sheep	100 Million yuan		0.47	0.47	0.483	0.627	0.627	0.783	0.840	0.840	1.257
output value of fowl	100 Million yuan		5.71	5.896	6.212	6.647	8.192	10.79	8.20	11.48	15.26
pigs on hand	10,000 head		533.0	500.2	504.9	686.6	745.7	835.6	849.2	834.3	1092.0
milk-cow on hand	10,000 head		54.8	54.8	54.8	96.7	96.7	96.7	169.1	169.1	169.1
cattle on hand	10,000 head		164.8	164.8	162.8	132.0	122.7	122.7	135.0	121.2	121.2
horse on hand	10,000 head		102.7	102.7	102.7	79.3	79.3	79.3	61.2	61.2	61.2
sheep on hand	10,000 head		255.1	259.1	261.8	354.3	354.3	387.6	485.7	485.7	575.4
fowls on hand	10,000 head		6684	6684	6790	7708	7871	8764	9369	6911	10390
egg output	100 million kg		2.56	2.66	2.79	2.77	3.44	4.33	3.00	4.31	5.86
wool output	ton		8389	8389	8842	11460	11460	15920	15710	15710	27260
milk output	100 million kg		8.84	9.01	9.19	15.43	17.26	19.19	26.84	32.15	38.28
meat output	100 million kg		4.28	4.34	4.38	5.47	5.91	6.98	7.10	7.35	10.77
pork output	100 million kg		2.62	2.69	2.69	3.47	3.65	4.05	4.29	5.30	6.77
beef output	100 million kg		0.583	0.583	0.583	0.650	0.717	0.717	0.783	0.795	0.795
horse meat output	100 million kg		0.384	0.384	0.384	0.294	0.294	0.294	0.227	0.227	0.227
mutton output	100 million kg		0.0576	0.058	0.058	0.078	0.078	0.078	0.107	0.107	0.116
fowls meat output	100 million kg		0.632	0.635	0.676	0.975	1.176	1.805	1.686	2.243	2.862

Note: The output value, apart from those that are given current prices, are the unchanged price value in 1980.

Table 2. The Supply and Demand Situation of the major Livestock Products, and

the Proportion of Animal Husbandry output value in agriculture output value

item	unit	year		1990		1995		2000	
		plans	medium	high	medium	high	medium	high	
total output value of agriculture	100 million yuan		120.10	128.19	138.57	157.23	161.38	192.21	
total output value of animal husbandry	100 million yuan		19.00	19.39	27.97	32.23	42.28	52.31	
proportion in agriculture output value	%		15.8	15.1	20.2	20.5	26.2	27.2	
total output value of planting	100 million yuan		88.8	95.9	95.9	108.2	101.7	118.0	
total output value of fishery	100 million yuan		2.0	2.0	3.4	4.0	4.9	6.2	
total output value of forestry	100 million yuan		5.3	5.7	5.8	6.5	6.4	8.0	
total output value of sideline products	100 million yuan		5.0	5.2	5.5	6.3	6.1	7.7	
demand amount of meat	10 thousand tons		51	51	72	72	101	101	
supply amount of meat	10 thousand tons		43.4	43.8	59.1	69.8	73.5	107.7	
ratio of supply and demand	%		85	85	82	97	72	106	
demand amount of eggs	100 million kg		2.6	2.6	4.0	4.0	6.0	6.0	
supply amount of eggs	100 million kg		2.66	2.79	3.44	4.33	4.31	5.86	
ratio of supply and demand	%		102	107	86	108	71	98	
demand amount of milk	100 million kg		9.1	9.1	24.41	24.41	38.82	38.82	
supply amount of milk	100 million kg		9.01	9.19	17.26	19.22	32.15	38.58	
ratio of supply and demand	%		99	100	70	79	83	99	

lion kg, 277 million kg and 300 million kg; and the total output of milk will amount to, respectively, 884 million kg, 1543 million kg and 2,684 million kg.

When the medium-goal programme is adopted, the total output value, calculated in terms of the unchanged prices in 1980, will amount to 1,900 million yuan in 1990, 2,790 million yuan in 1995 and 4,228 million yuan in 2000, with an average increasing rate of 7.8% for the first five years and 8.7% for the second five years. The total output of meat will be, respectively, 434 million kg in 1990, 591 million kg in 1995 and 735 million kg in 2000; the total output of eggs will be, respectively, 256 million kg, 344 million kg and 431 million kg; and the total output of milk will be 901 million kg, 1726 million kg and 3215 million kg.

If the high-goal programme is used, the total output value of animal husbandry, calculated according to unchanged prices of 1980, will reach 1,939 million yuan, in 1990, 3223 million yuan in 1995 and 5,231 million yuan in 2000, with an average increasing rate of 10% for the first five years and 10.2% for the second five years. Correspondingly, the total output of meats will be 438 million kg, 698 million kg and 1077 million kg, respectively, for 1990, 1995 and 2000; the total output of eggs will be 279 million kg, 433 million kg and 586 million kg; and the total output of milk be 919 million, 1919 million kg and 3828 million kg.

In this paper, we put stresses on analyses of the rationalities of these three programme from viewpoint of supply and demand relations of livestock products and relations between agriculture and animal husbandry, and put forward the goal of developing the animal husbandry which should be given priority. In addition, by means of the conditions and results of the simulation given above, corresponding policies and measures for realizing the developmental goal are also given.

For convenience sake, the data in Table 2 are only the demanded amount and the potentially supplied amount, which are comprehensive analysing results of the model simulation, for major livestock products in Heilongjiang province of the medium and high goals programme. We have predicted the demand amount of livestock products with the help of some other research achievements. When predicting the data of demand amount given in Table 2, we have considered the factors such as population, the growth rate of the gross national product, the developing rate of industry, the growth rate of purchasing power, the amount of livestock products, that are to be transferred to other provinces, and so on. In reality, the supply amount of the livestock products are also affected by various factors, which have been partly explained above. Therefore, we only put in the major supply and demand relations of livestock products in Table 2. In addition, Table two also gives the possible changes of proportion of the total output value of livestock products of medium and high goals in the output value of agriculture. The output value of agriculture and other industries in Table 2 are drawn from other research results.

From Table 2, we can see that we should make use of high-goal programme, so that we can make the goal of the animal husbandry products meet the demands of people. The high-goal programme is better than the medium-goal programme in the aspect of satisfying the people's demands for livestock products.

Table 2 shows that with continuous growth of output value of agriculture, the proportion of livestock output value in agriculture output value will increase, in the medium goal programme, 0.88% each year during the first five years, and 1.2% during the second five years; and the proportion of livestock output value in agriculture output value will increase 1.08% during the first five years and 1.34% during the second five years in the high-goal programme. So the high-goal programme is superior than the medium-goal programme in view of growth proportion of animal husbandry production in agriculture and bring about the coordinative development.

Moreover, we have also considered the rational use of resources and rational investments in our analysis. Viewing the results of comprehensive analysis, the choosing the values of the major variables in simulation results of the high-goal programme as the goal of animal husbandry is more rational.

In order to realize the developing goals determined in the high-goal programme, we should put our stress on performing the following policies and measures concerned.

1. Ensure the rational benefit of animal husbandry production and enhance the power of accumulating funds by the animal husbandry itself. The rational benefit refers to the corresponding rational beneficial results between the animal husbandry production and other industrial productions, as well as the produc-

tions of various breedings within the animal husbandry. The rational benefit changes as time goes on. Therefore for the purpose of ensuring the animal husbandry to develop faster, national and provincial government should continuously adjust the prices of livestock products according to the relatively-changed situation so as to make the animal husbandry benefit rational.

2. With the growth of grains yield, the proportion of grain used as fodder should be increases greatly, The fine fodder should be more than 5,000 million kg for 1990, 7,300 million kg for 1995 and 9,800 million kg for 2000.

3. Under the circumstance of devoting great efforts to develop the fodder grass, the contradictory between supply and demand for coarse fodder will be protruding continuously. The grass land must be, therefore, enlarged during the years later. And while overall disposing the firewood in countryside, we should rise the proportion of straws used as fodder. The aim of the proportion is 30% in 2000.

4. Speed up the development of fodder industry, The proportion of mixed fodder and the transformation ratio of fodder must be continuously increased. The aim of rising proportion of the mixed fodder is up to 80%.

5. Speed up the development of milk-processing industry. It has been analysed that the milk-processing industry will be a main factor restricting the development of milk production for a very long period of time. It is quite necessary to set up the milk-cow industry in a planned way in accordance with the developing programme.

6. The function of science and techniques in the production of animal husbandry production should be further strengthened and hard techniques and soft works should be stressed, so as to rise the transforming rate of input-output in animal husbandry.

The result of this research will play an important role in establishing the developmental goals and policies for the animal husbandry in Heilongjiang Province. Speaking concretely, the result of this research is a solution to the problem of non-coordinative development of general goal and the subgoals of different levels, which results from the research of the developmental goal of animal husbandry by traditional approach. For example, using the traditional approach in the past, the proportion of the output value of animal husbandry in agriculture production is 1 percent more than the year before; while the corresponding output of meat in the locality should increase 16 million kg, eggs output should increase 5 million kg, milk increases 20 million kg, wool increases 0.3 million kg. However the result of the model research show that the proportion of livestock output value in agriculture output value is one percent more than the year before when the high-goal programme is adopted; while the corresponding output of livestock products increased will be twice as much as that by traditional approach, and output of some livestock products are several times higher. The research results also show that the original goal is equal in the high-goal programme in our research, but its actual goal put forward in, in fact, rather low. Therefore the policy-makers may mistaken and think that the goal can be realized easily, so that they may not work as hard as they should. As a result, the goal will not be fulfilled. This research tells us that the high-goal programme in our research can be realized in practice, and the realization needs policies and measures to ensure. After analysing the above causes for the difference, people, generally, admit the correctness of the research result of the model and, in addition, further understand the necessity of using the modern science and technology as well as modern approaches to research the present economic problems.

REFERENCES

1. Forrester, Jay w., Principles of System, MIT, Press 1980.
2. Goodman, Michael R., Study Notes in System Dynamics, MIT, Press 1980.
3. Hongbin, Wang., Demin, Yao., System Dynamics Approach for the Developing Strategies Study of Forest Industry, Forest Science, 3, 1986.
4. Wenhua, Zhao., Hongbin, Wang., Linming, Gu., An Application of System Dynamics to the Research on the Strategy of Rural Development in Heilongjiang Province, Computer-Based Management of Complex System, Springer-Verlag, 1989.