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The Information System Model to Frame the Regional Dairy Farming Policy

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Abstract

In case of carrying out a regional agricultural policy, it is important for both administrative authorities and farmes lived in that region to reach an agreement on the adopting policy, but it has not been done sufficiently because of the lack of the information system and the methods to bring about an agreement. However, INS is expected to play a important role in constructing the information system. The purpose of this paper is to construct the system to frame the regional agricultural policy on the assumption that INS will be introduced. First, we present the concept of the system to bring about an agreement, next we give the method for the structural analysis of needs of the farmers and construct the regional model applied System Dynamics. Finally, we conduct a political simulation.

Key Words: agreement, INS, system, DEMATEL, MDS, SD, policy simulation.

1. Introduction

When the administrative authorities carry out the agricultural policy for a region or make a regional planning, it is indespensable to grasp the needs of farmers lived in that region in order to have their consensus to the policy. Nevertheless, that has not been done sufficiently because of the lack of communication and information system between them.

Accordingly, in many cases, the administrative authorities won't be able to lead their policy to any pratical result as they expected, even if the policy were come into operation. For the purpose of producing satisfactory result, striving to bring about mutual consent and furnishing the information about the adopting policy are very important. The introduction of Information Network System (INS) has been examined in the various fields lately and it will play an important part in filling information gap between them. In the existing circumstances, however, the discussion about introducing INS is abstract, not concrete as constructing a system.

The purpose of this paper is to construct the system for framing regional dairy farming policy on the assumption that INS is introduced to Nemuro dairy farming area where we will apply the system. The system which we construct is, so to speak, the supporting system for bringing about mutual consent and we develop a software for INS. Therefore, the measure and the property of mutual consent are not discussed in this paper.

The paper is organized as follows. In the next section the concept of the system is presented. The system composed of two main methods is discussed in the Section 3 and 4. The method for the structural analysis of needs is in Section 3 and as another one, the structure of dairy farming model for applied region is in Section4. In Section 5, some artificial data are given and discussed how the system is operated by combining two methods, and in Section 6, some concluding remarks are summerized and some implication to the future system are shown.

2. System

It does not always follow, so far, that agricultural policy for a certain region has been adopted after grasping the needs of farmers lived there sufficiently. So far as the policy is adopted under value judgement, we must recognize to a certain degree that the administrative authorities take priority the policy. But there is need to give farmers the information about adopted policy even under that conditions. Fig. 1 shows that an information system does not work sufficiently.

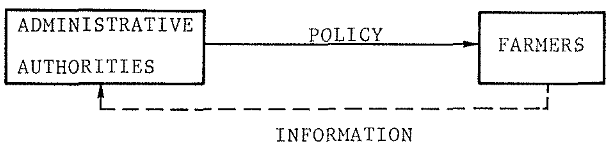

Fig. 1. Incomplete information system.

In case of taking a regional agricultural policy, for the purpose of making it effective, it is important that both administrative authotities and farmers will try to agree among themselves on the adopted policy. (Niwa and Shiba 1980) Fig. 2 shows the concept that the policy is adopted through agreement. On the assumption that this concept has been applied to the dairy farming region which we will analize, the concept would be shown as follows.

1) Recognition of present problem of Nemuro dairy farming region. (for example ; low income, large debt)

2) Agreement for the objects of regional dairy farming. (for example, increase of farm income, decrease of debt)

3) Agreement for the adopting policy which is selected through the adjustment between the needs of farmers and a possible policy of the administrative authorities, and for the measure fo policy evaluated.

4) Adoption of the policy.

Thus, a mutual consent must be attained to the objects and the policy to be adopted. The former is agreed easily, but the latter is difficult because of the difference of opinion among them. The reason why a management to bring about an agreement is not sufficient is pointed out as follows :

1) Lack of the methods to bring about an agreement as software.

2) Lack of the information system as hardware.

However, recently, some methods which are useful for agreement have been developed. If microcomputers are populized and INS (CATV) is introduced in the future, it seems that the problem on the information system as hardware would be solved. In this paper, mutual consent does not always mean unanimity.

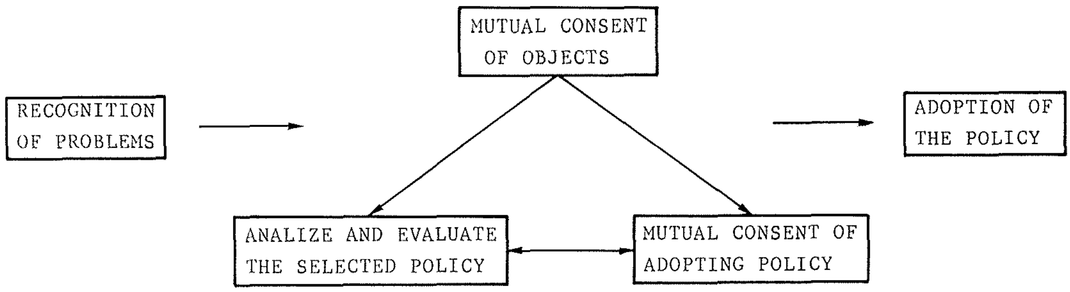

Fig. 2. Mutual consent.

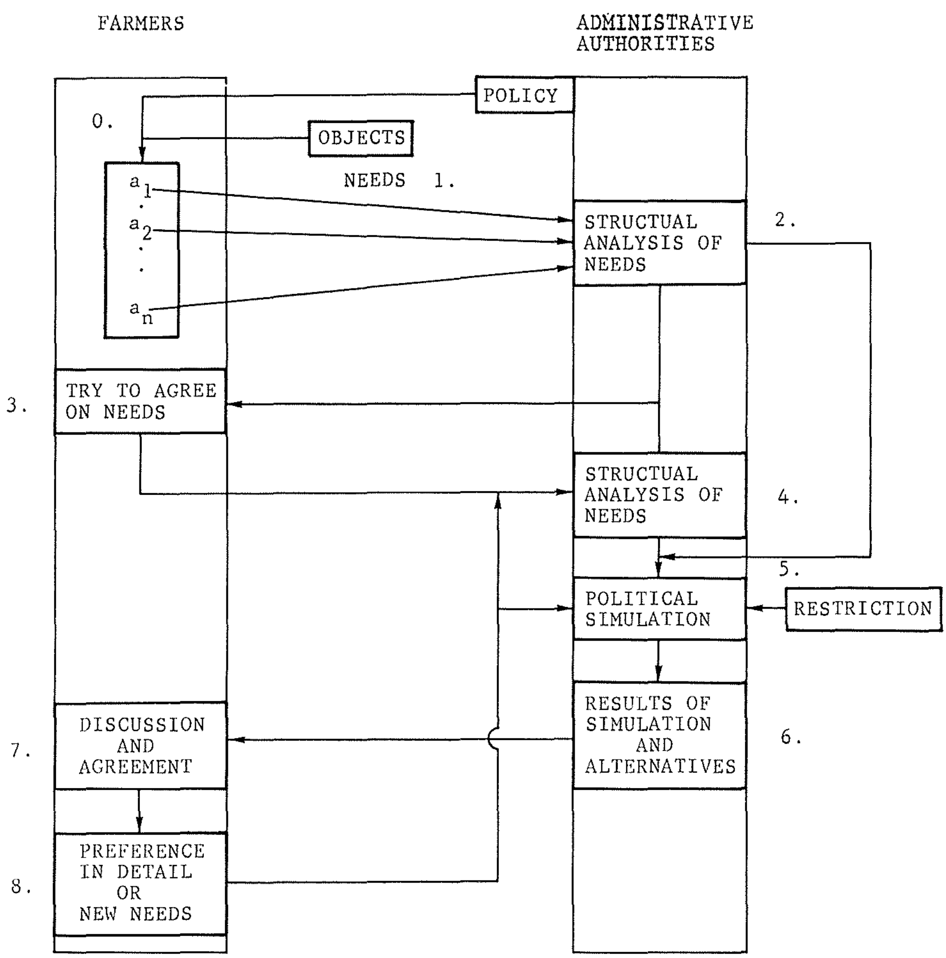

Fig. 3. Concept of the system.

Fig. 3 gives an outline of the system for framing a dairy farming policy which farmers participate. The framework of this system consists of the following procedure.

0) The start point is that the objects of the study region has already been decided, or the administrative authorities gives farmers some information of the adopted policy.

1) Investigation of the needs of farmers for agricultural policy.

2) Analysis of the structure of needs, and grasping the preferential structure of policy as a whole and each farmer. If the needs of each farmer are consistent, move to the 5th step (political simulation). However, usually there is a differrence of needs among farmers.

3) By giving each farmer the information about whole preferential structure and each preferential structure, farmers try to agree and inform their needs to administrative authorities again.

4) Analysis of the structure of needs agreed.

5) Simulation of the regional model by selected political variables.

When we simulate the regional model, some alternatives is presented, and assumed that administrative authorities may constrain.

6) Presentation of the results of simulation and alternatives.

7) Farmers discuss the results, and try to agree among themselves.

8) Presentation of the preference of policy in detail, move to the 5th step or the 4th step.

By repeating the feedback, farmers and administrative authorities try to agree on adopting policy.

The system has two main methods used for structual analysis of needs and political simulation. Then, we apply DEMATEL method and Multi-Dimensional Scaling (MDS) to the former, System Dynamics method (SD) to the latter and assume that INS (CATV) is introduced as a means of giving and receiving information. If the program of these methods are ready, it seems that they can agree soon with the information of structual analysis and simulation that are shown on CATV. In this paper, we simulate only from the 1st step to the 6th step of the system.

3. Structural Analysis of needs

In this section, two methods used for structural analysis of needs are explained. We explain each method by giving artificial data, but a theoretical part is omitted.

3-1. DEMATEL method

DEMATEL method is explained as follows: First, as shown Table 1, direct influence matrix is made. A-F present the item of policy, and element x_{ij} presents the degree of influence that ith item has on jth item directly. The row sum D express the degree of influence that each item has on others and the column sum R express the degree that each item is under influence of the others. D-R present the degree of influence and D+R present the degree of importance.

Table 1. Direct Influence Matrix

	A	B	C	D	E	F	D	D−R	D+R
A. production adjustment		2	0	0	3	3	8	3	13
B. price of raw milk	2		0	0	3	4	9	1	7
C. price of feed	0	2		0	3	2	7	7	7
D. price of materials	0	1	0		2	0	3	3	3
E. maximum amount of loans	1	2	0	0		2	5	−9	19
F. information	2	1	0	0	3		7	−4	18
R	5	8	0	0	14	11			

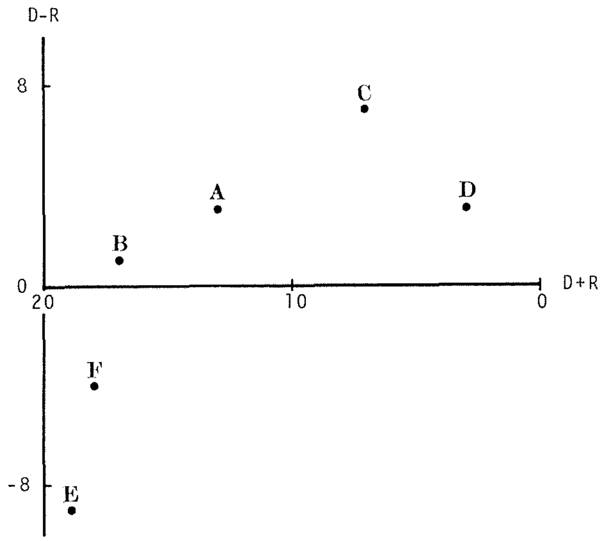

Fig. 4. Configuration of DEMATEL.

By plotting D−R and D+R, we recognize the preferential structure of farmers to these policies. As shown Fig. 4, E and F are important policies to deal with the influences from other policies. C and D are less important, but have influence on others.

3-2. MDS (Multi-Dimensional Scaling) method

The method MDS is one of Multivariate Analysis that represent objects by the points plotted in the multi-space when similarity data between objects are given, and clarify the structure of factors and attributions of objects by investigation of derived configuration. (Takane 1980, Kruskal and Wish 1978) In this part, we clarify the preferential structure of agricultural policies, giving a similarity data between agricultural policies.

Table 2 presents preference order of each farmer to agricultural policies as artificial data. By transforming this data into profiel similarity data, we obtain the profiel distance matrix as shown Table 3. We apply nonmetric MDS used SMA-COF algorithm this profiel distance matrix as input data. Fig. 5 shows the plots

Table 2. Preference order of each farmer to agricultural policy

	A	B	C	D	E	F
farmer 1	6	3	2	1	5	4
2	5	6	1	2	4	3
3	4	5	3	1	6	2
4	3	5	2	1	6	4
5	6	4	2	1	5	3
6	4	6	2	1	5	3

Table 3. Profile distance matrix

	A	B	C	D	E	F
A						
B	5.0					
C	7.4	7.7				
D	9.0	9.3	3.0			
E	4.1	3.2	7.8	10.1		
F	4.8	5.5	3.9	5.3	5.5	

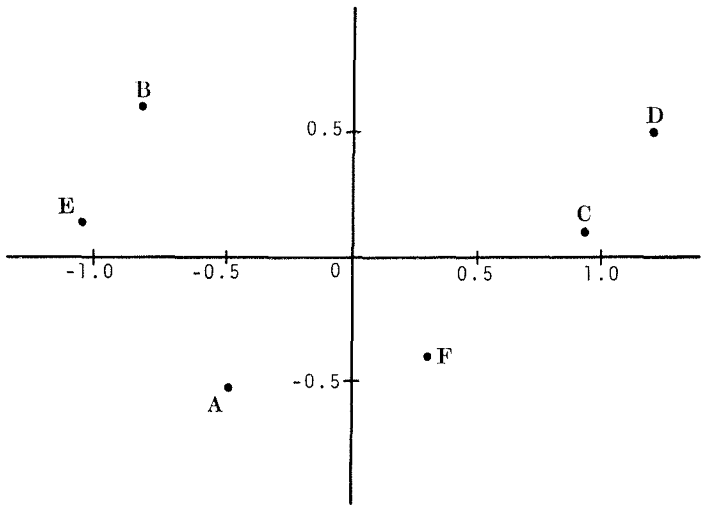

Fig. 5. Derived configuration by M. D. S.

of the derived configulation in 2-dimensional space. The viewpoint of farmers for each policy is shown as the relationship of the plotted points. (E, F) and (C, D) forms a group respectively, but A and F is plotted separately. The horizontal axis shows the degree of preference.

Next, we consider this result and the result of DEMATEL. R, F and A have importance and needs. C and D have influence on the others. E is a policy to deal with the effects of A, B, C, D. F is a more important policy to deal with the effects of A, B, C, D, BUT prefered separately. C and D have a much influence on the others, but rather low in importance and needs, and are recognized as difficult ones to deal with. As the result of artifitial data, in 5th step we make some scenarios by means of fixing political variables in order from low degree to high degree of importance and needs. Using these scenarios, we simulate the regional model, i. e., first, political variables for C and D are fixed and next, some scenarios combined A, B, E, F are made, and then simulated. Section 5 shows the detail.

The artifitial data in this section are assumed data which is agreed in the 4th step in the system. The difference of opinion among farmers are presented when the 2nd step to the 3rd step in the system moves as follows. The difference among results of DEAMTEL will be shown to each farmer as given in Fig. 4. The direct influence matrix as given Table 1 are transformed into the distance matrix among farmers by defining the distance between a and b as $d_{ab}=\sum_i \sum_j (x_{ij}(a)-x_{ij}(b))^2/n^2$, and using this distance matrix as input data, MDS presents the derived configuration that shows the difference of opinion among farmers. As for Table 2, by transforming Table 2 into profile distance matrix among farmers and using it as input data, MDS presents the derived configuration that shows the difference of viewpoint between farmers. And then we can also apply these methods to grouped data. Especially, Individual Difference MDS (INDSCAL) assumed weighted model presents the derived configulation that shows the difference among groups.

So, we can show each farmer the results of these methods as information to bring about agreement.

4. Structure of the Regional Dairy-farming Model

4-1. Outline of the analyzed area

As the area to be analyzed, we selected the Nemuro district in Hokkaido (under administration of the branch office of the Hokkaido Government Office). This Nemuro district has a total land area of 356,000 hectares. As of 1983, its cultivated-land ratio was 29.4% and is a grassland-type dairy-farming area of a large scale whose principal crop is the pasturage grown on the pastureland that accounts for 95% of the cultivated land.

At present, the Nemuro district has a total of 2,484 farm households, of which 81.2% are full-time farm households, 12.9% are Class-I Part-time farm households and 5.9%, Class-II Part-time farm households. Thus, most of the farm households in this district are full-time farm households.

The ratio of farm households raising dairy cows has been increasing yearly; it was 90% in 1975, 92% in 1980 and 94% in 1983. Meanwhile, the per-household number of the cattle raised also has been similarly increasing; 40 in 1975, 57 in 1980 and 63 in 1983. A number of different conditions may be pointed out as those that have made it possible for the farm households to raise and manage the dairy cows that kept on increasing every year. Among such conditions are, the rapid progress of mechanization, the expansion and improvement of barn facilities, the comparative ease for the farmers to acquire farmland and the resultant feasibility for them in expanding the foundation for the steady supply of feed. There also have been such factors as, that the Nemuro district was designated as the 'area on which a large-scale stock-farming base is to be constructed' under the New National Overall Development Plan of the Japanese Government and that, in 1973, a series of projects to construct new dairy-farming villages was commenced under the leadership of the Development Corporation for the lands for farming use under operation by the national or the Nemuro district authorities.

On the other hand, however, such expansion of farmlands, rapid increase in investments into machinery and facilities as mentioned above, coupled with the intensifying efforts made for farmland acquisition, have in recent years been causing a sharp increase in the amounts of farm households' debts, thereby applying much pressure on the management of farm households. Furthermore, the production adjustment of milk and the soaring of the costs of materials have been giving added pressure on the farm households' operations.

4-2. Construction of a regional dairy-farming model

In constructing the Nemuro regional dairy-farming model, we have used the existing results of studies on the dairy production system as the basis (Kisimoto 1978, Ikeda, *et al.* 1980, Honma 1980) and have done our best to construct a model suited as much as possible to the present situation by supplementing and revising our own studies making use of the results of the survey made by the Hokkaido Government on the actual conditions of dairy-farming operations, the content of the Bekkai Farm Cooperative's regional agriculture promotion plan and the opinions given by the knowledgeable people such as those of the farm cooperatives.

In constructing the system model, we adopted the System Dynamic method (SD), as this method was believed to enable us to grasp dairy-farming production system, the regional employment, living environment and land problems.

Listed below are the characteristics of the 'SD' which is a method that deals with the dynamic behaviors of a system including the information feedback. (Forrester 1961 a)

(1) It enables us to find out the dynamic expression of a regional dairy-farming production system, that is, a series of feedback loops with a time-lag, as shown in the Fig. 6. 1.

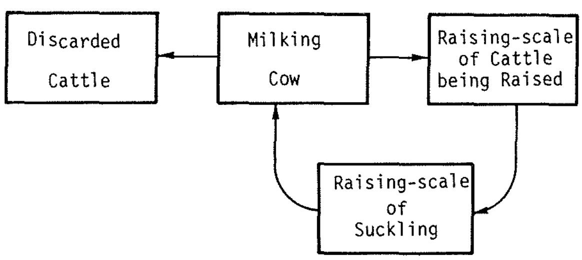

Fig. 6. 1. Flow Chart and Feedback Loops among Cattle Individuals at the Cycle of the Year.

(2) It enables us to conduct an overall model construction, because, using it, the expression of many factors and of complex cause-effect chain relationship (including the non-linear beings) is feasible.

(3) It enables us to eaily conduct a simulation for various kinds of policy variables.

(4) Because of its being structure-dependent type and not parameter-dependent type (a representative example being the econometrics model), there is little restriction resulting from the observation data (that is, the need of statistical and probability verifications).

4-3. Outline of the model

As can be seen from the flow diagram shown in the Fig. 6.2.-6.4. this model consists of four sub sectors ; the production sector, the farm-household population sector, the farm-household income sector and the land sector. And its structure is such that the entire system is made to function dynamically with each sector affecting the others.

Basically, it is a series of feedback systems in which the raising-scale of the dairy cows controls the raising-scale of sucklings which, in turn, controls the raising-scale of the cattle being raised. And further, the rasing-scale of the cattle being raised, with some time lag, controls the raising-scale of the milking cows itself.

It is of a structure in which, based on the feedback loop system, the multiple information on such matters as the production of raw milk, the shipping ratio of sucklings and that of cattle being raised are controlled through their relations with the price sector. Here, a consideration has been given so that the model will as much as possible become a closed model. The variables were made internally-generated so that they may be determined within the system. But as for the price sector, the variables were processed in relation to the functions of time, since they cannot be determined internally within the area.

It is also of a structure in which an analysis can be made, through the multiple feedback loop and based on the number of head of the cattle being raised, the volume of feed required by those cattle, the area of the land required to be utilized, the amount of loans and the structure of the expenses required in developing the farmlands.

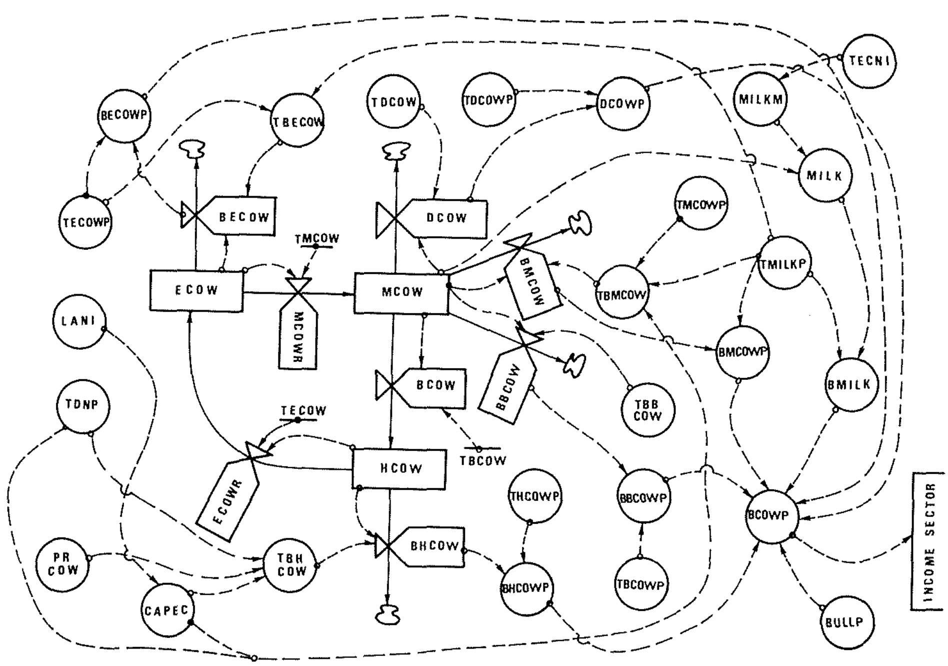

Fig. 6. 2. Flow diagram of production sector.

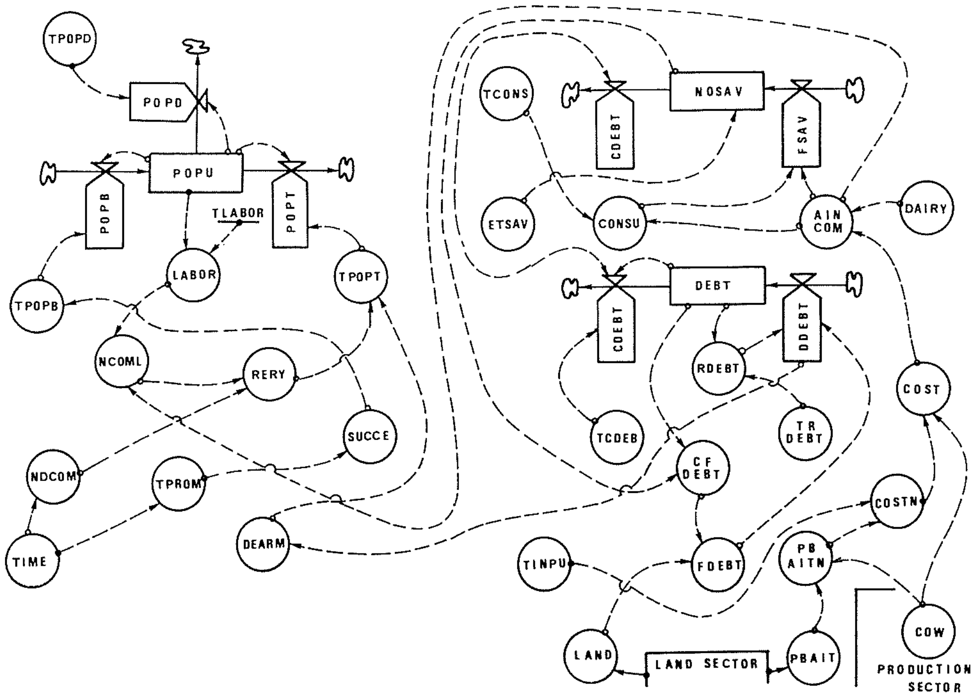

Fig. 6. 3. Flow diagram of farm-household population sector, farm-household income sector.

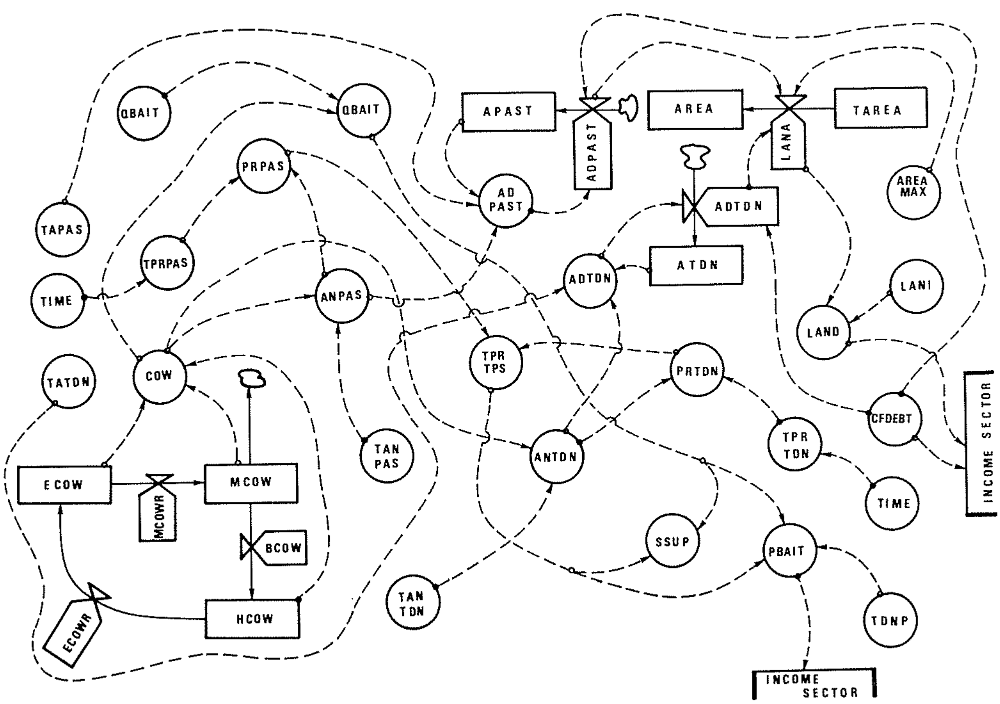

Fig. 6. 4. Flow diagram of land sector.

As outlined above, the model as a whole consists of 10 Level equations, 17 Rate equations, 72 Auxiliary equations and 4 other equations, totalling 103 equation systems. The following is a brief explanation on the cause & effect flow of the main variables in each sector, given by means of an expression method using a DYNAMO language.

a) Production sector

The production sector shows the behaviors of such factors as the variation of the number of head of the cattle raised within the area, the quantity of raw milk produced and the number of dairy cows (MCOW) shipped. First, the changes in the number of milking cows are determined by the number of milking cows (MCOWR), that of discarded cattle (DCOW) and that of the dairy cows shipped (BCOW), in the next term. (Formula (1))

$$\text{L} \quad \text{MCOW.K} = \text{MCOW.J} + (\text{DT})\ (\text{MCOWR.JK} - \text{BCOW.JK}) \tag{1}$$

$$\text{R} \quad \text{MCOWR.KL} = \text{ECOW.K} * \text{TMCOW.K} \tag{2}$$

$$\text{R} \quad \text{DCOW.KL} = \text{MCOW.K} * \text{TDCOW.K} \tag{3}$$

$$\text{A} \quad \text{TMCOW.K} = \text{STMCOW.K} * 0.78 \tag{4}$$

$$\text{A} \quad \text{TDCOW.K} = \text{STDCOW} * 0.118 \tag{5}$$

$$\text{R} \quad \text{BMCOW.KL} = \text{MCOW.K} * \text{TGMCOW.K} \tag{6}$$

$$\begin{aligned} \text{A} \quad \text{TBMCOW.K} &= 0.0028 * \text{LAN1.k} + 0.2122 * (\text{TMCOWP.K}/\text{TMILKP.K}) \\ &\quad + 0.0012 * \text{TDNP.K} + 0.0001 * \text{PRCOW.K} + 0.0634 \end{aligned} \tag{7}$$

Here, the number of the milking cows in the next term (MCOWR) was obtained by multiplying the number of the suckling cattle (ECOW) by the rate of cattle being raised turning into milking cows in the next term (TMCOW), (Formula (2)) and the number of the discarded cattle (DCOW) was obtained by multiplying the number of milking cows (MCOW) by the discarded-cattle rate (TDCOW). (Formula (3)) Furthermore, the number of dairy cows shipped was (MCOW) obtained by multiplying the number of milking cows (MCOW) by the shipping rate of dairy cows (TBMCOW). (Formula (6)) In this case, in order to show the mechanism (Forester 1961 b) of how the farm households make their decisions on the shipment of their dairy cows, the relationship of functions as shown in the formula (8) was assumed and the rate of shipment of dairy cows was determined. (Formula (7))

$$\begin{aligned} \text{TBMCOW} &= \underset{(3.443)}{0.0028 * \text{LAN1}} + \underset{(3.163)}{0.2122 * (\text{TMCOWP}/\text{TMILKP})} \\ &\quad + \underset{(3.382)}{0.0012 * \text{TDNP}} + \underset{(4.693)}{0.0001 * \text{PRCOW}} + \underset{(2.007)}{0.0634} \qquad R^2 = 0.930 \\ &\qquad \text{D, W} = 2.413 \end{aligned} \tag{8}$$

The estimation period of the structure equation is 8 year from 1975 to 1982, and the Ordinaly Least Squares method is employed as the estimation method. The values within parentheses of the equation are t values of parameters, R^2 is decision coefficient, D, W is Durbin=Watson statistic and Log is common logarithms. In a similar way, we would like to show the relations of movement of cattle individuals with the numbers of suckling and with that of cattle being raised. (Formula (9)-(14))

$$\text{L} \quad \text{HCOW.K} = \text{HCOW.J} + (\text{DT})(\text{BCOW.JK} - \text{ECOW.JK} - \text{BHCOW.JK}) \tag{9}$$

$$\text{R} \quad \text{ECOWR.KL} = \text{HCOW.K} * \text{TECOW} \tag{10}$$

$$\text{R} \quad \text{BCOW.KL} = \text{MCOW.K} * \text{TBCOW} \tag{11}$$

$$\text{R} \quad \text{BHCOW.KL} = \text{HCOW.K} * \text{TBHCOW.K} \tag{12}$$

$$\text{L} \quad \text{BECOW.KL} = \text{ECOW.J} + (\text{DT})\ (\text{ECOW.JK} - \text{MCOWR.JK} - \text{BECOW.JK}) \tag{13}$$

$$\text{R} \quad \text{BCOW.KL} = \text{ECOW.K} * \text{TBECOW.K} \tag{14}$$

Here, in showing the mechanism of how a decision is made on whether or not to stop the shipment of sucklings or cattle being raised, we assumed the function relations as shown in the formulas (15)-(16) and determined the shipment rate for each.

$$\begin{aligned} \text{TBHCOW.K} = & \underset{(3.353)}{-1.6592} + \underset{(1.964)}{0.0143} * \text{LAN1.K} + \underset{(1.565)}{0.0055} * \text{TDNP.K} \\ & + \underset{(4.372)}{0.0012} * \text{PRCOW.K} \qquad R^2 = 0.912 \quad \text{D, W} = 1.586 \end{aligned} \tag{15}$$

$$\begin{aligned} \text{TBCOW.K} = & \underset{(5.936)}{-0.3061} * ((\text{TMILKP.J} * \text{TECOWP.K})/(\text{TMILK.K} * \text{TECOWP.J})) \\ & \underset{(5.346)}{-0.06201} * \text{DMYP.K} + \underset{(7.793)}{0.3826} \qquad R^2 = 0.950 \quad \text{D, W} = 1.795 \end{aligned} \tag{16}$$

When the transfer relations among the cattle individuals are determined, the output amount of the regional dairy-farming perations (DAIRY) will be determined according to the output of the raw milk (BMILK), the shipping amounts of dairy cows (BCOWP), calves (BBCOWP), cattle being raised (BHCOWP) and suckling (BECOWP), the shipping amount of the discarded cattle (DCOWP) and the total output of beef cattle (BULLP). (Formula (17)-(18))

$$\text{A} \quad \text{DAIRY.K} = \text{BCOWP.K} + \text{BULLP.K} \tag{17}$$

$$\text{A} \quad \text{BCOWP.K} = \text{BMILK} + \text{BMCOWP.K} + \text{DCOWP.K} + \text{BECOWP.K} + \text{BHCOWPK} + \text{BBCOMP.K} \tag{18}$$

In this case, each shipping amount can be obtained by multiplying the shipping volume by the price of each cattle individual. (Formula (20)-(24)) Also, the output volume of raw milk (MILK) is determined by multiplying the number of milking cows (MCOW) by the quantity of milk produced per head (MILKM). (Formula

(25)) And the output of the raw milk (BMILK) is obtained by multiplying the output volume of raw milk (MILK) by the price of the raw milk (TMILKP). (Formula (19))

A BMILK.K = MILK.K*TMILKP.K (19)

A BMCOWP.K = BMCOW.K*TMCOWP.K (20)

A DCOW.K = DCOW.K*TDCOWP.K (21)

A BECOWP.K = BECOW.K*TECOWP.K (22)

A BHCOWP.K = BHCOW.K*THCOWP.K (23)

A BBCOWP.K = BBCOW.K*TBCOWP.K (24)

A MILK.K = MCOW.K*MILKM.K (25)

As to the volume of milk per head of cattle, a formula was established in terms of functions of time, taking the current trend into account. (Formula (26), Fig. 6.5.)

A MILKM.K = TABHL(MILKMT, TIME.K, 50, 57, 1)
T MILKMT = 4.89, 4.91, 5.44, 5.45, 5.33, 5.23, 5.07, 5.20 (26)

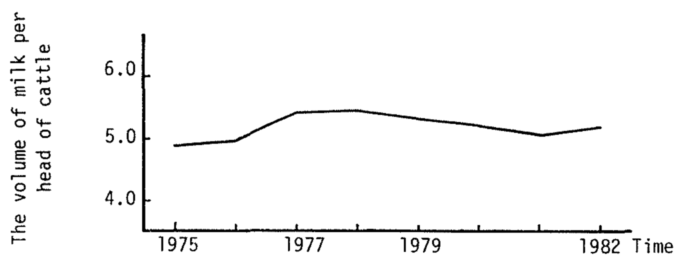

Fig. 6. 5. The relation between TIME and the volume of milk per head of cattle.

In establishing the formula for the structure to determine the prices, a formula was established for price changes basically in terms of functions of time, since it was considered that the prices are determined by policy-oriented or externally-generated factors, rather than through the price-determining structure within the area concerned. The main results of measurements are shown below. (Formula (27)-(32))

A TINPU.K = $-622.688+179.937*\mathrm{Log}$ (TIME.K)
(6.875) (7.906) $R^2=0.912$ (27)
D, W = 1.257

A TDCOWP.K = $-2268.51+620.875*\mathrm{Log}$ (TIME.K)
(9.963) (10.851) $R^2=0.952$ (28)
D, W = 1.751

A TMCOWP.K = $-3325.53+910.321*\mathrm{Log}$ (TIME.K)
(9.889) (10.768) $R^2=0.951$ (29)
D, W = 1.774

$$\text{A} \quad \text{TECOWP.K} = \underset{(9.799)}{-1831.38} + \underset{(10.44)}{489.531} * \text{Log}(\text{TIME.K}) \qquad R^2=0.948 \quad D, W=2.920 \tag{30}$$

$$\text{A} \quad \text{THCOWP.K} = \underset{(9.761)}{-545.75} + \underset{(10.382)}{145.898} * \text{Log}(\text{TIME.K}) \qquad R^2=0.947 \quad D, W=1.902 \tag{31}$$

$$\text{A} \quad \text{TBCOWP.K} = \underset{(10.005)}{-2714.25} + \underset{(10.894)}{742.719} * \text{Log}(\text{TIME.K}) \qquad R^2=0.952 \quad D, W=1.748 \tag{32}$$

b) Farm-household income sector

This sector mainly shows the mechanism relating to the operational division of dairy-farming including the tremnds of farm incomes within the area, the amounts of consumption, savings deposits, investments and debts resulting from the production activities. Here, the farm incom (AINCOM) is obtained by excluding the production costs (COST) from the dairy-farming output (DAIRY), and the amount of consumption (COSU) is determined by multiplying the farm income by the table of propensity to consume (TCONS). (Formula (34))

In this case, when determining the amount of farm production costs on which the increase or decrease of the farm income depends, we assumed the function relations of the amount of feed purchased (TDNP) and the prices of materials (TINPU), and established a formula of calculation. (Formula (36)-(37))

$$\text{A} \quad \text{AINCOM.K} = \text{DAIRY.K} - \text{COST.K} \tag{33}$$

$$\text{A} \quad \text{CONSU.K} = \text{AINCOM.K} * \text{TCONS.K} \tag{34}$$

$$\text{A} \quad \text{TCONS.K} = \text{TABHL(TCONST, TIME.K, 50, 57, 1)} \tag{35}$$

$$\text{A} \quad \text{COST.K} = \text{COSTN.K} * \text{COW.K} \tag{36}$$

$$\text{CONSTN.K} = \underset{(1.039)}{-0.53760} + \underset{(1.863)}{0.053612} * \text{Log(PABIT.K/COW.K} * \text{TDNP.K)} + \underset{(1.513)}{0.0783} * \text{Log}(\text{TINPU.K}) \qquad R^2=0.873 \quad D, W=2.337 \tag{37}$$

Furthermore, the mechanism ensures that the amount of funds to be loaned (FDEBT) for investments (LAND) is monitered from a policy viewpoint and that the debtor balance (DEBT) of farm households is controlled constatly so that it may not substatially exeed the farm household'income. Incidentally, since this type of control mechanism has been derived so that it may function when a simulation is conducted to predict future values, we at present adopt a system in which the limit to the MIN functions. (Formula (38)-(39))

As to the MIN function, the value of CFDEBT will be adopted if CFDEBT LAND, and the value of LAND, if CFDEBT LAND.

$$\text{R} \quad \text{FDEBT.KL} = \text{MIN}(\text{CFDEBT.K, LAND.K}) \tag{38}$$

$$\text{L} \quad \text{DEBT.K} = \text{DEBT.J} + (\text{DT})(\text{RDEBT.JK} - \text{CDEBT.JK} + \text{FDEBT.JK}) \tag{39}$$

c) Farm-household population sector

The farm-household population is determined by the number of births (POPB), the number of deaths (POPD) and the number of people moving out into other occupational categories (POPT). (Formula (40)) The net number of move-out (POPT) can be obtained by multiplying the farm-household population (POPU) by the net move-out ratio. (TPOPT) (Formula (41)) Theformula for the net move-out ratio (TPOPT) was established by assuming the function relations between the relative income (RERY) (Formula (42)), which can be expressed as a ratio of per-head farm income (NCOML) against the per-head non-farm income (NDCOM), and the increase rate of farm households' debt (DDEBT). (Formula (43))

$$\text{L} \quad \text{POPU.K} = \text{POPU.J} + (\text{DT})(\text{POPB.JK} - \text{POPD.JK} + \text{POPT.JK}) \qquad (40)$$

$$\text{R} \quad \text{POPT.KL} = \text{POPU.K} * \text{TPOPT.K} \qquad (41)$$

$$\text{A} \quad \text{RERY.K} = \text{NCOML.K/NDCOM.K} \qquad (42)$$

$$\begin{aligned}\text{TPOPT.K} = & -\underset{(2.415)}{8.70792} * \text{Log}(\text{DDEBT}) + \underset{(3.074)}{3.65792} * \text{Log}(\text{RERY.K}) \\ & + \underset{(2.535)}{2.0918} * \text{DMYP2.K} + \underset{(0.114)}{0.08265} \qquad R^2 = 0.860 \quad \text{D, W} = 1.173\end{aligned} \qquad (43)$$

Meanwhile, the population engaged in agriculture (LABOR) was obtained by multiplying the farm-household population (POPU) as determined by the formula (40) by the employment ratio (TLABOR). In this case, the formula for the employment ratio was established by means of the function of time in order to explain the behavior in each year. (Formula (45), Fig. 6. 6.)

$$\text{A} \quad \text{LABOR.K} = \text{POPU.K} * \text{TLABOR.K} \qquad (44)$$

$$\text{A} \quad \text{TLABOR.K} = \text{TABHHL}(\text{TLABORT, TIME.K, 50, 57, 1}) \qquad (45)$$

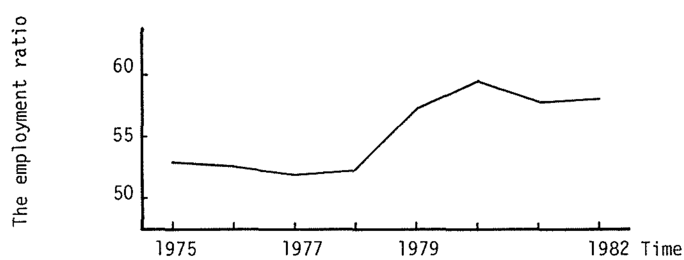

Fig. 6. 6. The relation between TIME and the employment ratio.

d) Land sector

The land sector determines the behaviors of the areas of feed farms and pastureland owed by the raw-milk producing farm households. The area of feed farms (ATDN) is determined by adding the area of feed farms for which the need of development (ADTDN) arose in the current term to the area of feed farms as at the end of the preceding term. (Formula (46)) Similary, the area of pastureland (APAST) is determined by adding the area of pasturage that needs to be developed

(ADPAST) to the area of pastureland as at the end of the preceding term. (Formula (47))

L ATDN.K = ATDN.J + (DT) (ADTDN.JK) (46)

L APAST.K = APAST.J + (DT) (ADPAST.JK) (47)

The area F feed farm that needs to be developed (ADTDN) is determined by multiplying the area needed in planting the feed (ANTDN) enough to raise the dairy cows for one year by areciprocal number of the ratio of conversion of the land into feed farms (TATDN), that become necessary in order to plant the feed mentioned above and, further, by subtracting, from the figure resulting from the foregoing calculation, the area of the feed farm that existed as at the end of the preceding term. (Formula (48)) The area of the pasturage that needs to be developed (ADPAST) is also determined through a similar logic. (Formula (49))

R ADTDN.KL = ANTDN.K/TATDN.K − ATDN.J (48)

R ADPAST.KL = ANPAS.K/TAPAS.K − APAST.J (49)

The quantity of crop of the feed (PRTDN) can be obtained by multiplying the quantity of crop per one hectare (TPRDN) by the feed acreage. (Formula (50)) Incidetally, the growth of yield of the feed per one hectare over the years up to the present has been most remarkable as a result of the fertilization, the technological progress including the pasturrage made for the purpose of maintaining the productive strength of the earth. And such a growth of yield can be expected to continue into the future. Thus, we have shown the per-hectare yield of the feed in term of the function relations with time and have established the formula for the future value by means of the logarithmic regression. (Formula (51), Fig. 6. 7.)

A PRTDN.K = TPRTDN.K*ANTDN.K (50)

$$\underset{(3.864)}{\mathrm{TPRTDN} = -212.406} + \underset{(4.479)}{61.875} * \mathrm{Log}\,(\mathrm{PTIM.K}) \qquad R^2 = 0.780 \quad D, W = 1.351 \qquad (51)$$

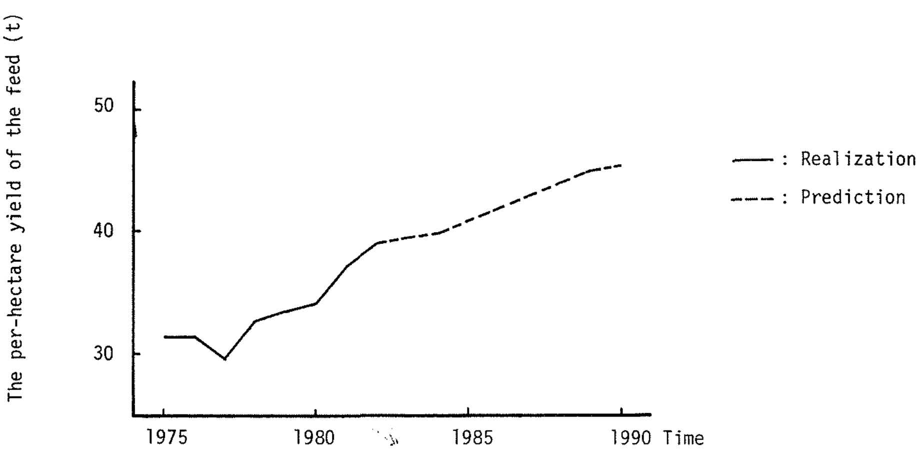

Fig. 6. 7. The relation between TIME and the per-hectare yield of the feed.

4-4. Test on the predictive power of the model

Before conducting the policy simulation, a series of final tests to prove the properiety of the model was made for a period of eight years from 1975 to 1982. In this series of tests, the appraisal of the degree of adaptability of the model to the reality was done based on the coefficient of disagreement.

As aresult of the test, it has been found that all the variables reproduce the actual behaviors well and that all the coefficients of disagreement are close to zero. Hence, it appears that the model is capable of conducting prediction analyses of high reliability. The Table 4.1. shows the degree of adaptability of the main variables in term of coefficients of disagreement.

Table 4. 1. Fitness of the Final Test adopted to the Inequality Coefficient

Variable	Tile-U	Variable	Tile-U	Variable	Tile-U	Variable	Tile-U
MCOW	0.00048	NOSAV	0.00067	ECOW	0.00422	DEBT	0.00319
DCOW	0.00113	DAIRY	0.00068	HCOW	0.00578	POPU	0.00093
COW	0.00170	LABOR	0.00095	MILK	0.00046	ATDN	0.00893
COST	0.00206	APAST	0.00034	AINCOM	0.00271	AREA	0.00069

5. Policy Simulations

In this Section, we simulate the regional model made in Section 4 based on the results of structural analysis of needs in Section 3.

Here, we have established five scenario-cases for the policy variables of the total of seven items of policy variables, viz., production adjustment (for A), price of raw milk (for B), price of feed (for C), price of materials (for D), maximum amount of loans (for E), volume of milk per head of cattle (for F), and production-adjustment measures. A simulation analysis was conducted to find out what sort of influences these policies have given to the production structure of the regional dairy-farming, and also what kinds of effects were brought about as a result of the implementation of these policies.

Five scenario-cases which were made by means of fixing political variables

Table 4. 2. Simulation scenario

Items of Policy	Case-1	Case-2	Case-3	Case-4	Case-5
1. Production-adjustment	1.5	1.5	C	C	C
2. Price of raw milk	1	1	1	0	0
3. Price of feed	1	1	1	1	1
4. Price of materials	1	1	1	1	1
5. Maximum amount of loans	1	0	0	0	0
6. Volume of milk per head of cattle	I	I	C	C	U
7. Production-adjustment measures	S	S	N	N	S

for C and D, and combing political variables for A, B, E, F are shown in Table 4. 2. and the content of the prediction scenario is given below.

1. Production adjustment

1.5 : The case where the maximum total quantity of raw milk to be produced within the region is increased by 1.5% in 1983 and onwards in accordance with the decision made by the recent central dairy farming conference at which the target quantity of the raw milk to be shipped from Hokkaido during the fiscal 1984 was determined (1.5% more that the total quantity actually shipped in the previous fiscal year).

C : The case where the maximum total quantity of raw milk to be produced within the region will become constant in 1983 and onwards.

0 : The case where no ristriction is placed on the production of raw milk by means of production adjustment.

2. Price of raw milk

1 : The case where the rate of increase of guaranteed price of milk is to be kept constant at the annual rate of 0.98% in 1983 and onwards, in accordance with the rate of increase (0.98% in annual rate) of the guaranteed price which was maintained from 1975 to 1982.

0 : The case where the price is left unchanged at the level of fiscal 1982.

3. Price of feed 4. Price of materials

1 : The case where the future price is to be set in accordance with the current trend.

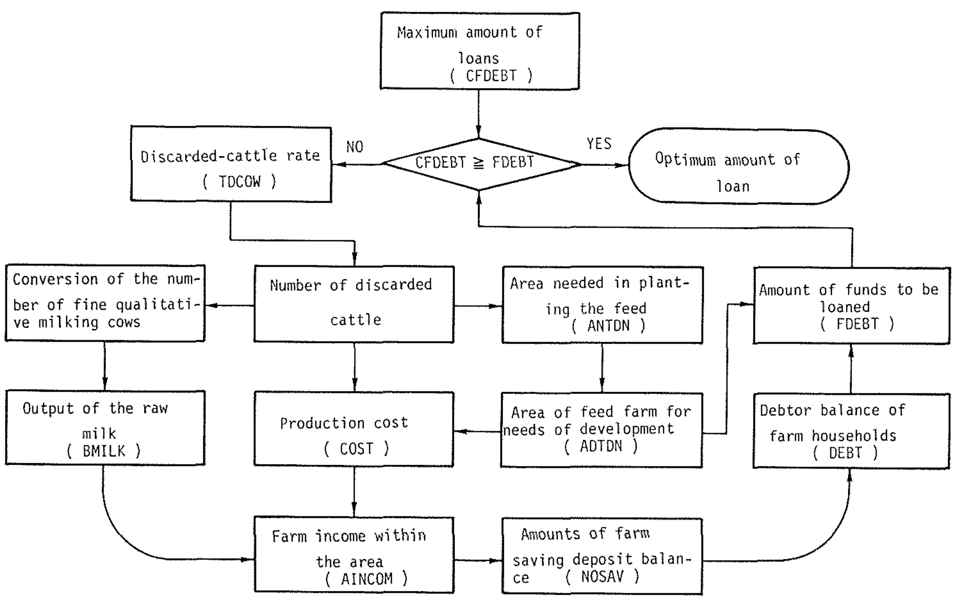

Fig. 7. 1. Flowchart of the cause-effect chain relationship of the casewhere the maximum amount of funds that can be obtained by loan is Set by a policy.

0 : The case where afixed price is assumed as being maintained since 1982.

5. Maximum amount of loans

1 : This is the case where the maximum amount of funds that can be obtained by loan is set by a policy. In other words, the mechanism structure is such that, when the amount secured by loan exceeds the maximum amount of loan permitted, the discarded-cattle rate within the model is controlled and, through the cause &

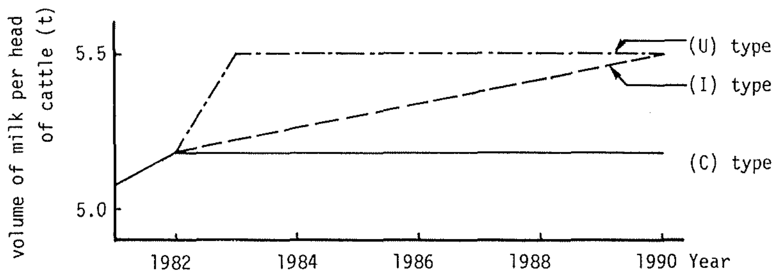

Fig. 7. 2. Policy table of volume of milk per head of cattle.

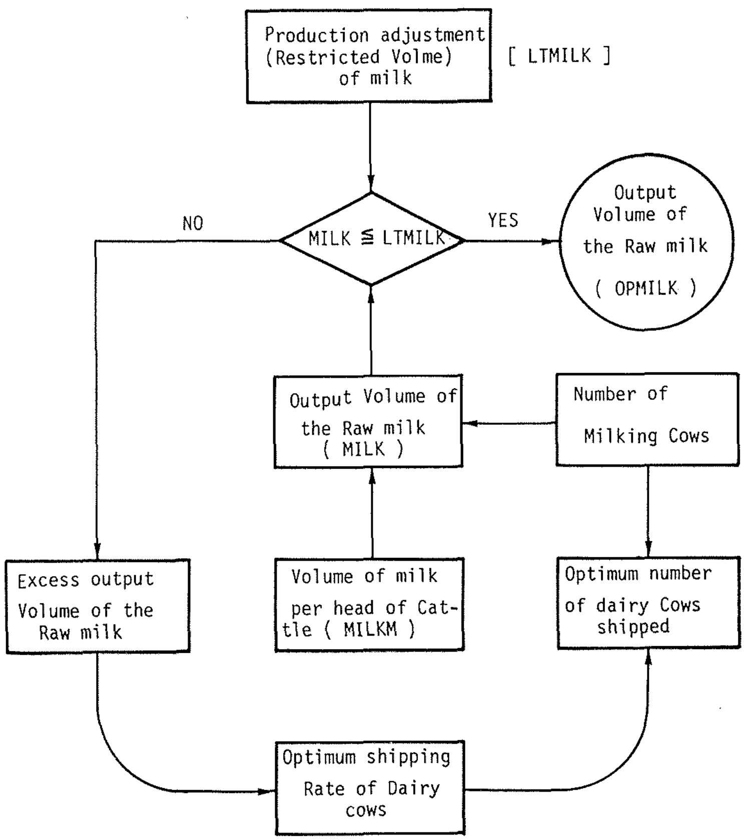

Fig. 7. 3. The structure of strategically control mechanism under the production adjustment policy.

Table 4. 3. Results of the policy simulation

Variables	Year / Case	1982	1984 Realization	84'/82'	1986 Realization	86'/82'	1988 Realization	88'/82'	1990 Realization	90'/82'
Output volume of the raw milk (MILK)	1	424928	437410	1.029	449195	1.057	465894	1.096	478050	1.125
	2		444989	1.047	464109	1.092	467794	1.101	475478	1.119
	3		438690	1.032	442022	1.040	438705	1.032	438482	1.032
	4		441091	1.038	443880	1.045	440070	1.036	442318	1.041
	5		438167	1.031	444340	1.046	443938	1.045	442990	1.043
Output amount of the regional dairy farming (DAIRY)	1	50556	54943	1.087	58212	1.151	61750	1.221	64951	1.285
	2		55445	1.097	59566	1.178	62121	1.229	64970	1.285
	3		54871	1.085	57513	1.138	59364	1.174	61396	1.214
	4		54282	1.074	56102	1.110	57016	1.128	58417	1.155
	5		54063	1.069	56432	1.116	58383	1.155	59368	1.174
Farm incomes within the area (AINCOM)	1	18233	22826	1.252	26859	1.473	31697	1.738	37266	2.044
	2		22729	1.247	27141	1.489	30745	1.686	35810	1.964
	3		22155	1.215	25088	1.376	27989	1.535	32235	1.768
	4		21238	1.165	23268	1.276	25091	1.376	28397	1.557
	5		21383	1.173	24021	1.317	27277	1.496	31079	1.705
Amount of farm saving deposit balance (NOSAV)	1	24398	28826	1.182	34948	1.433	42697	1.751	52376	2.148
	2		28716	1.177	34527	1.416	41397	1.697	49860	2.044
	3		28556	1.171	33644	1.379	39530	1.621	46703	1.915
	4		28261	1.159	32687	1.340	37598	1.542	43353	1.778
	5		28344	1.162	33190	1.361	38848	1.593	45885	1.881
Debtor balence of farm households (DEBT)	1	73791	73978	1.003	74232	1.006	75560	1.024	75385	1.022
	2		79651	1.079	85628	1.160	90727	1.230	94207	1.277
	3		79651	1.079	85628	1.160	90727	1.230	94207	1.277
	4		80633	1.093	85543	1.159	90377	1.225	96072	1.302
	5		79294	1.075	85573	1.160	86961	1.178	81384	1.103

Table 4.4. Results of the policy simulation

Variables	Case (Year →)	1982	1984 Realization	84'/82'	1986 Realization	86'/82'	1988 Realization	88'/82'	1990 Realization	90'/82'
Farm-household population (POPU)	1	12783	12970	1.015	12988	1.016	13060	1.022	13187	1.032
	2		12928	1.011	12869	1.007	12889	1.008	12975	1.015
	3		12922	1.011	12819	1.003	12767	0.999	12773	0.999
	4		12898	1.009	12753	0.998	12648	0.989	12532	0.980
	5		12915	1.010	12797	1.001	12712	0.994	12787	1.000
Population engaged in agriculture (LABOR)	1	7325	7236	0.988	7246	0.989	7286	0.995	7357	1.004
	2		7212	0.985	7179	0.980	7191	0.982	7239	0.988
	3		7209	0.984	7151	0.976	7123	0.972	7126	0.973
	4		7196	0.982	7115	0.971	7056	0.963	6992	0.955
	5		7205	0.984	7139	0.975	7092	0.968	7134	0.974
Number of head of raising dairy cows (COW)	1	148271	150726	1.017	152941	1.031	155271	1.047	156867	1.058
	2		153538	1.036	158171	1.067	162105	1.093	165228	1.114
	3		153538	1.036	158171	1.067	162105	1.093	165228	1.114
	4		154042	1.039	158234	1.067	162049	1.093	165926	1.119
	5		153363	1.034	158104	1.066	160712	1.084	160292	1.081
Area of feed farms (ATDN)	1	1643	6143	1.000	6143	1.000	6191	1.008	6255	1.018
	2		6143	1.000	6307	1.027	6464	1.052	6588	1.072
	3		6143	1.000	6307	1.027	6464	1.052	6588	1.072
	4		6143	1.000	6309	1.027	6461	1.052	6166	1.077
	5		6143	1.000	6304	1.026	6408	1.043	6408	1.043
Area of pasture land (APAST)	1	98698	100332	1.017	101806	1.031	103357	1.047	104420	1.058
	2		102204	1.036	105288	1.067	107907	1.093	109986	1.114
	3		102204	1.036	105288	1.067	107907	1.093	109986	1.114
	4		102539	1.039	105330	1.067	107870	1.093	110450	1.119
	5		102087	1.034	105243	1.066	106979	1.084	106979	1.084

effect process as shown in Fig. 7. 1., the optimum amount of loan is again determined.

This would mean that the maximum amount of funds that the farm cooperatives and associated organizations can make available in loans is controlled and the attempts are made to stabilize the management of farming operations, so that the growth rate of debt may not constantly exceed the growth rate farm incomes.

0 : The case where there is no limit to the amount of funds available in loan.

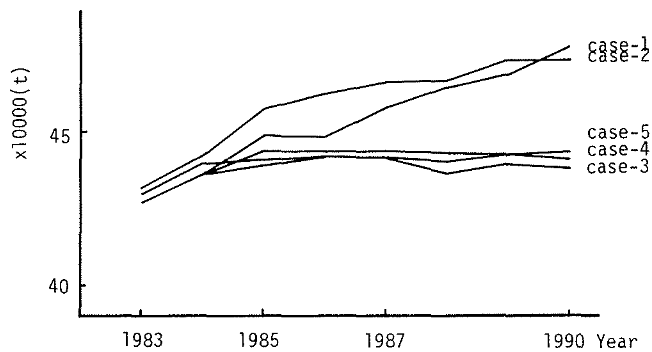

Fig. 8. 1. The output volume of the raw milk.

Fig. 8. 2. The output amount of the regional dairy farming operations.

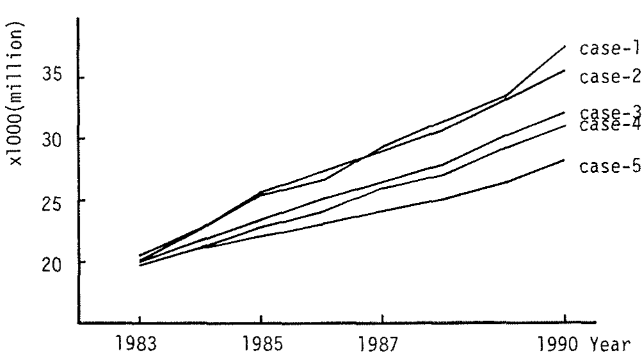

Fig. 8. 3. Farm incomes within the area.

6. Volume of milk per head of cattle

C: The case where the current value is continued into the future without a change.

U: The case where the quantity of milk produced per head of cattle increase to 5.5 tons in 1987 and thereafter.

I: The case where a target value is set according to the Hokkaido Long-term Dairy-farming Plan which calls for an annual increase of milk output to 5.5 tons per head of cattle, with 1990 as the ultimate target year. (Fig. 7. 2)

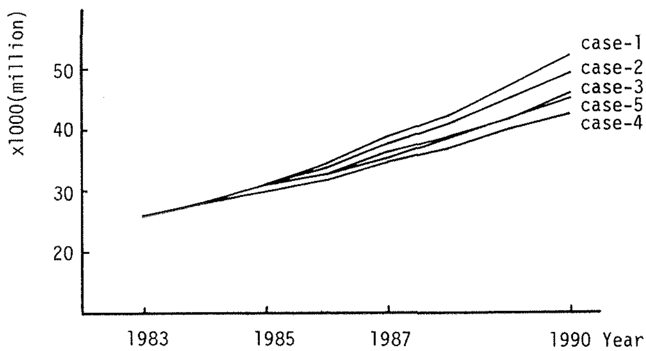

Fig. 8. 4. The amounts of farm savings deposit balance.

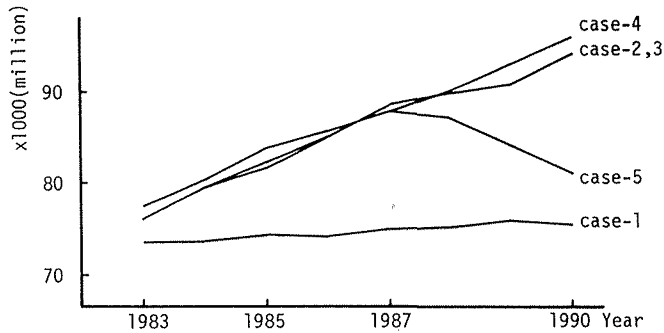

Fig. 8. 5. The debtor balance of farm households.

Fig. 8. 6. The farm-household population.

7. Production-adjustment measures

S: The case where the number of milking cows is strategically controlled under the existing production adjustment policy so as to cope with the restrictions placed on the volume of milk produced the area. The structure of control mechanism in this case is shown in Fig. 7. 3.

N: The case where, instead of conducting strategic control on the number of milking cows, the restriction is applied only on the volume of milk produced per

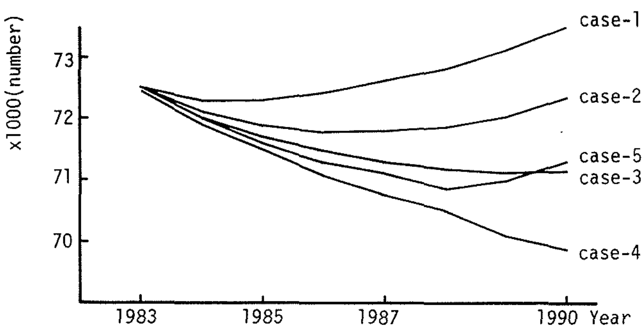

Fig. 8. 7. The population engaged in agriculture.

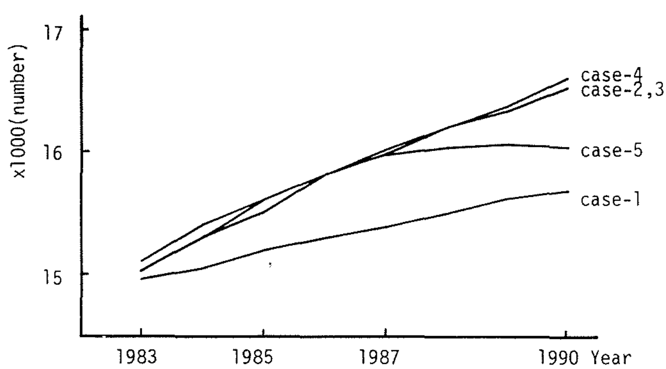

Fig. 8. 8. The number of head of raising dairy cows.

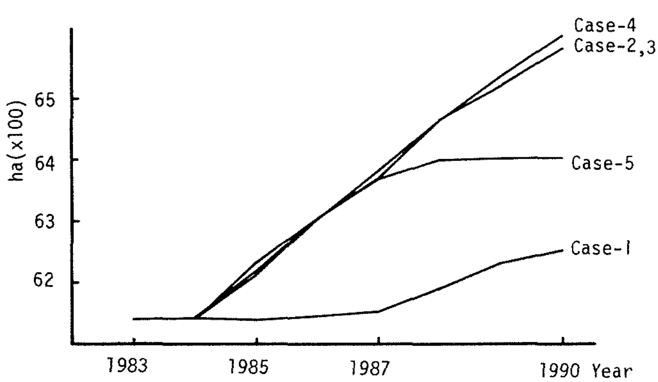

Fig. 8. 9. The area of feed for needs of development.

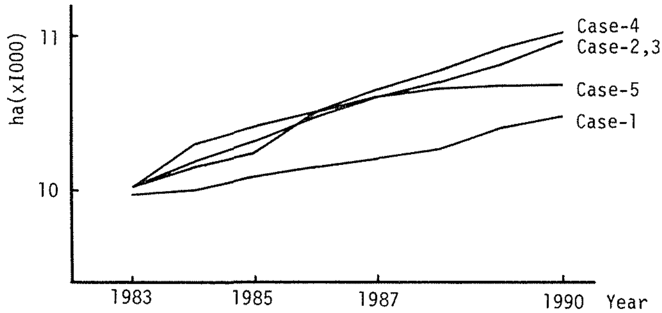

Fig. 8. 10. The area of pasturage for needs of development.

head of cattle so as to cope with the prediction adjustment (restricted volume of milk within the area).

According to the combinations of scenarios as shown in the Table 4. 2. a simulation was conducted for each case. The results of the simulations of the main variables are show in the Table 4. 3–4. 4. and their behavior patterns in the Fig. 8. 1.–8. 10.

At the 6th step in the system, five scenarios shown in the Table 4. 2. are presented to farmers as the alternatives, and these results of the simulations are given to farmers for the evaluation of the alternatives.

6. Conclusion

In this paper, we constructed the system to frame an agricultural policy on the assumption that INS will be introduced as a means of giving and receiving information. This system includes the procedure that a regional policy is adopted through farmers who participate in framing it. Supposing that this system is introduced to Nemuro dairy farming area, we developed two main methods ; structural analysis of needs and regional model. Especially, we applied System Dynamics method to the latter so as to conduct a policy simulation. And then, we explained the process of the system by giving artifitial data which will be needed for the farmers.

The feature of this system are as follows. 1) To shape democratic process. 2) To include the methods which bring about a mutual consent easily. 3) To conduct the policy simulation.

However, we cannot discuss the problems of carrying out the system because INS is not introduced and there is no complete information system under the existing circumstance. Accordingly, we made first trial to construct an ideal system to frame the regional agricultural policy.

For the purpose of making the system better, the points which we must consider are shown as follows.

1) Development of the methods for agreeing on objects.
2) Development of the methods for evaluation of alternatives.
3) Inprovement of the regional model for the detailed simulations.

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Materials 1. List of Variables

Variables		Variable Names
ADPAST	:	Area of pasturage for need of development (ha)
ADTDN	:	Area of feed farm for needs of development (ha)
AINCOM	:	Farm incomes within the area (million yen)
ANPAS	:	Area needed in planting the pasturage (ha)
ANTDN	:	Area needed in planting the feed (ha)
APAST	:	Area of pastureland (ha)
AREA	:	Total area of dairy farm (ha)
AREAMAX	:	Maximum ratio for area of development
ATDN	:	Area of feed farms (ha)
BBCOW	:	Number of calves shipped
BBCOWP	:	Shipping amounts of calves (million yen)
BCOW	:	Number of calves
BECOW	:	Number of suckling cattle shipped
BECOWP	:	Shipping amounts of suckling cattle (million yen)
BHCOW	:	Number of cattle being raised for shipped
BHCOWP	:	Shipping amounts of cattle being raised (million yen)
BMCOW	:	Number dairy cows shipped
BMCOWP	:	Shipping amounts of dairy cows (million yen)
BMILK	:	Output of the raw milk (million yen)
BULLP	:	Total output of beef cattle (million yen)
CAPEC	:	Capacity of the suckling cattle
CDEBT	:	Amounts of repayments (million yen)
CFDEBT	:	Maximum amount of loand (million yen)
CONSU	:	Amounts of farm consumption (million yen)
COST	:	Production costs (million yen)
COSTN	:	Production costs per head of cattle
COW	:	Number of head of raising dairy cows
DAIRY	:	Output amount of the regional dairy farming operations (million yen)
DCOW	:	Number of discarded cattle
DCOWP	:	Shipping amounts of the discarded cattle (million yen)
DDEBT	:	Amount increased of debtor balance (million yen)
DEARM	:	Rate of increased of debtor balance
DEBT	:	Debtor balance of farm households (million yen)
ECOW	:	Number of suckling cattle
ECOWR	:	Number of cattle being raised turning into suckling cattle in the next term
ETSAV	:	Rate of farm saving deposits
FDEBT	:	Amounts of funds to be loaned (million yen)
FSAV	:	Amount of farm savings deposits (million yen)
HCOW	:	Number of cattle being raised

Variables		Variable Names
LABOR	:	Population engaged in agriculture
LAN1	:	Investment into expansion of farmlands per-hectare
LANA	:	Area of farms for the need of development
LAND	:	Investments into expansion of farmlands (million yen)
MCOW	:	Number of milking cows
MCOWR	:	Number of milking cows in the next term
MILK	:	Output volume of the raw milk (t)
MILKM	:	Volume of milk per head of cattle
NOSAV	:	Amount of farm savings deposit balance (million yen)
NCOML	:	Per-head farm income
NDCOM	:	Per-head non-farm income
PBAIT	:	Amount of feed purchased (million yen)
POPB	:	Number of births
POPD	:	Number of deaths
POPT	:	Number of people moving out into other occupational categories
POPU	:	Farm-household population
PRPAS	:	Quantity of crop of the pasturage
PRCOW	:	Price of beef cattle
PRTDN	:	Quantity of crop of the feed
QBAIT	:	Quantity of feed for needs of raising dairy cows
QBAIT1	:	Quantity of feed per-head of cattle
RDEBT	:	Amount of interest of farm households debts (million yen)
RERY	:	Relative income
SSUP	:	Self-sufficing feed
SUCCE	:	Number of the ratio of successor
TANPAS	:	Area in planting the pasturage per-head of cattle
TANTDN	:	Area in planting the feed per-head of cattle
TAPAS	:	Number of the ratio of conversion of land into pasturage
TATDN	:	Number of the ratio of conversion of land into feed
TBBCOW	:	Shipping ratio of calves
TBCOWP	:	Price of calves
TBECOW	:	Shipping ratio of suckling cattle
TBHCOW	:	Shipping ratio of cattle being raised
TBMCOW	:	Shipping ratio of dairy cows
TBULP	:	Total output of beef cattle
TCDEB	:	Number of the ratio of repayments
TCPNS	:	Table of propensity to consume
TDCOW	:	Discarded-cattle ratio
TDCOWP	:	Price of Discarded-cattle
TDNP	:	Price of feed
TECOW	:	Rate of cattle being raised turning into suckling cattle in the next term

Variables		Variable Names
TECOWP	:	Price of suckling cattle
TECNI	:	Rate of milk per-head of milking cows
THCOWP	:	Price of cattle being raised
TINPU	:	Price of materials
TLABOR	:	Employment ratio
TMCOW	:	Rate of cattle being raised turning into milking cows in the next term
TMCOWP	:	Price of dairy cows
TMILKP	:	Price of milk
TPOPB	:	Birth ratio
TPOPD	:	Death ratio
TPOPT	:	Net move-out ratio
TPROM	:	Rate of entrance into a school of high grade
TPRPAS	:	Quantity of crop of the pasturage per hectare
TPRTDN	:	Quantity of crop of the feed per hectare
TRDEBT	:	Rate of the interest of farm households debts

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