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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 farmers 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 an 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 indispensable 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 practical 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 de-

velop 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 Section 4. 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.

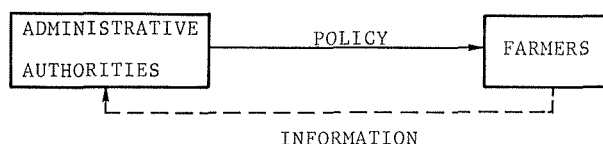


Fig. 1. Incomplete information system.

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 analyze, 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.

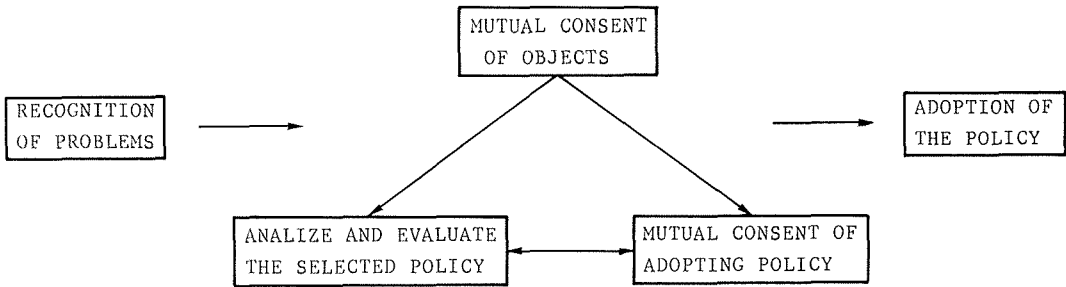


Fig. 2. Mutual consent.

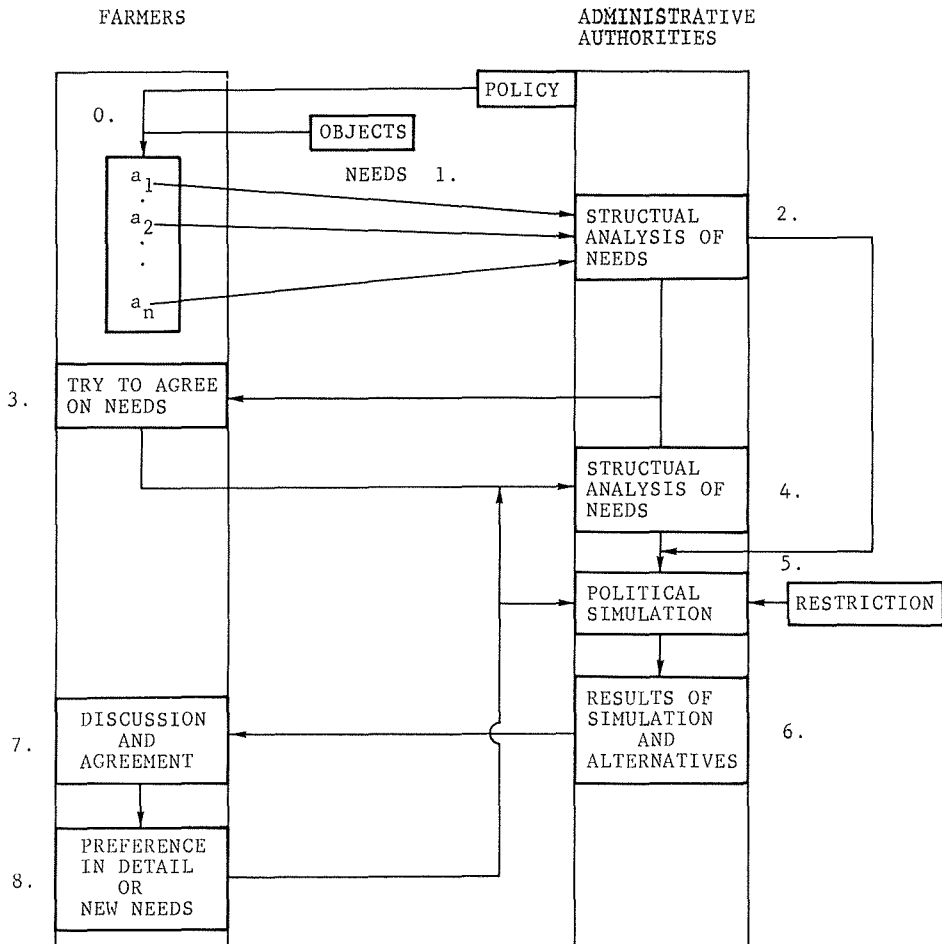


Fig. 3. Concept of the system.

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 difference 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 structural 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 structural 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  $i$ th item has on  $j$ th 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 |   |     |     |

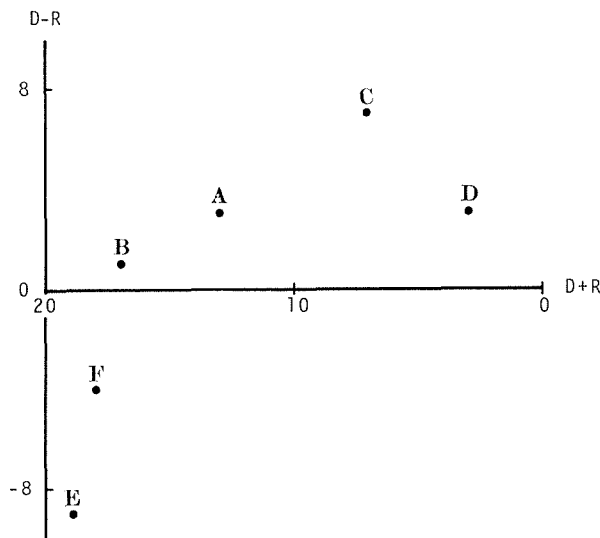


Fig. 4. Configuration of DEMATEL.

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.

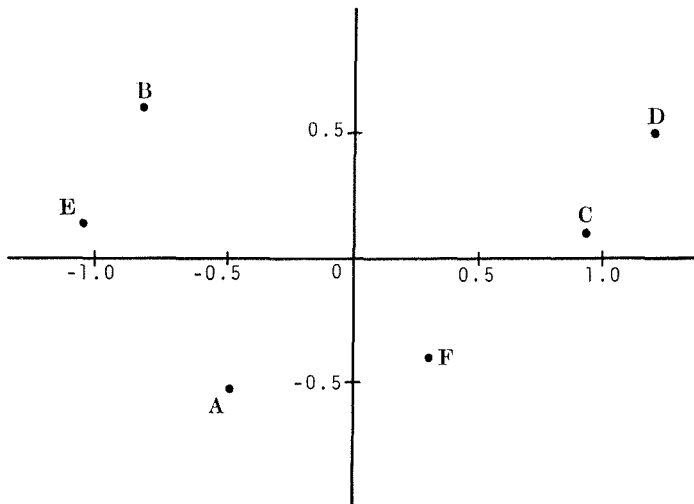
Table 2 presents preference order of each farmer to agricultural policies as artificial data. By transforming this data into profil similarity data, we obtain the profil distance matrix as shown Table 3. We apply nonmetric MDS used SMA-COF algorithm this profil distance matrix as input data. Fig. 5 shows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

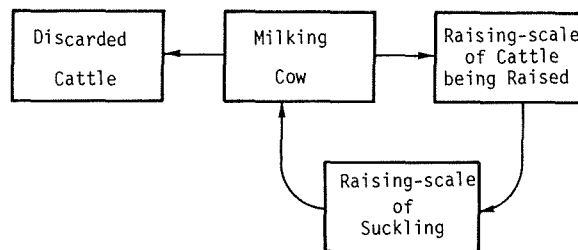


Fig. 6.1. Flow Chart and Feedback Loops among Cattle Individuals at the Cycle of the Year.

- (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 easily 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 raising-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.

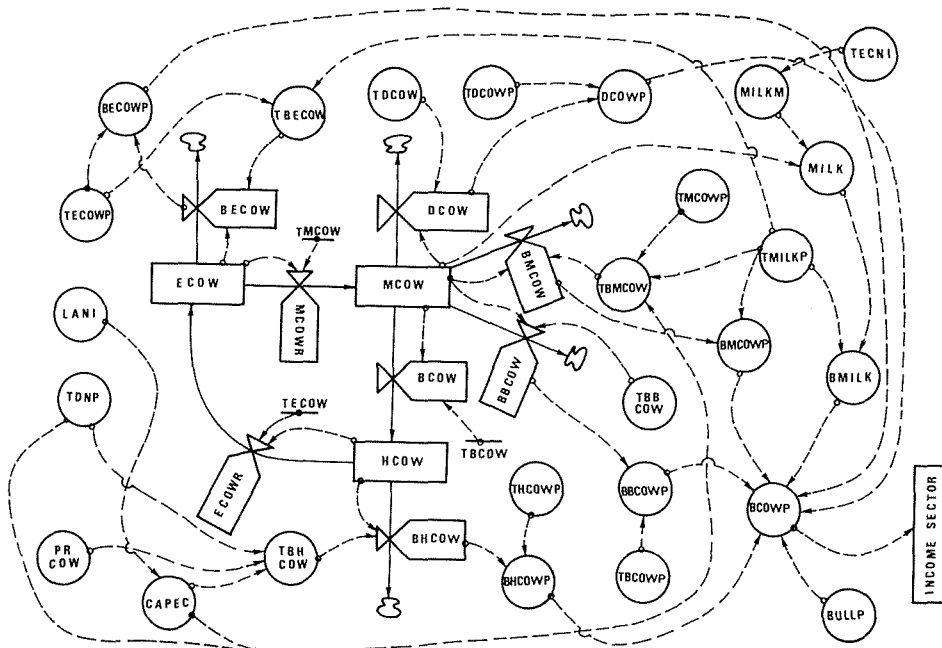


Fig. 6.2. Flow diagram of production sector.

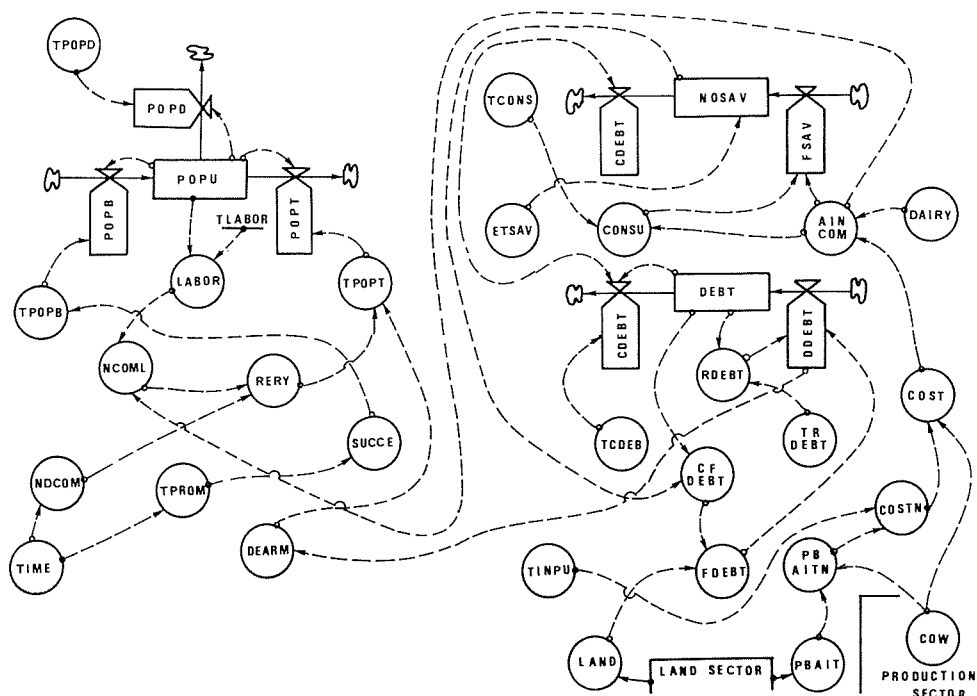


Fig. 6. 3. Flow diagram of farm-household population sector, farm-household income sector.

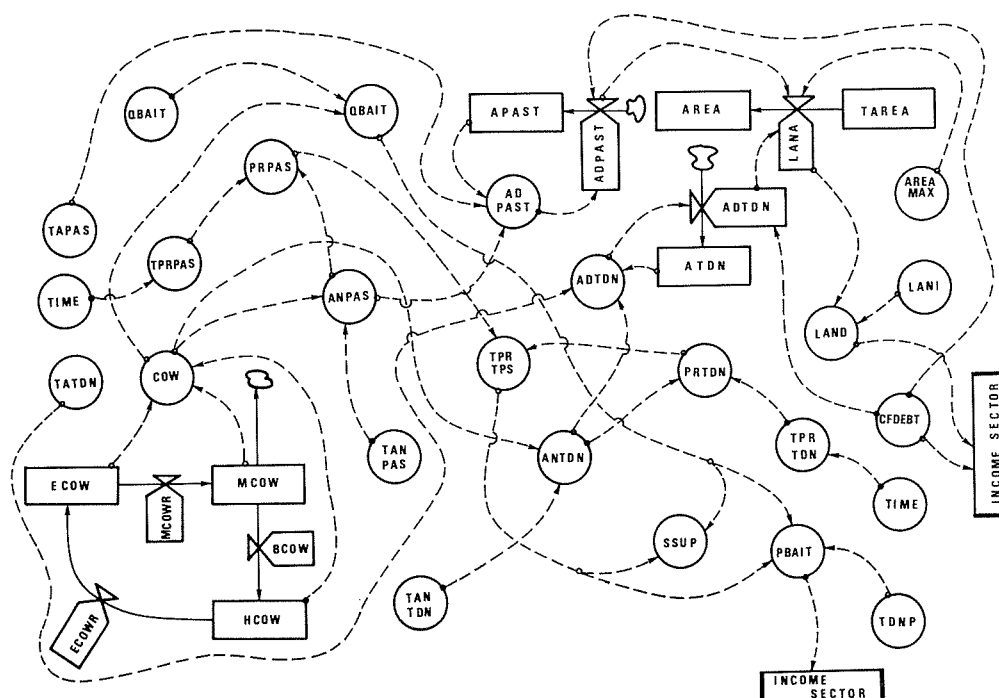


Fig. 6. 4. Flow diagram of land sector.

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))

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

$$R \quad MCOWR.KL = ECOW.K * TMCOW.K \quad (2)$$

$$R \quad DCOW.KL = MCOW.K * TDCOW.K \quad (3)$$

$$A \quad TMCOW.K = STMOW.K * 0.78 \quad (4)$$

$$A \quad TDCOW.K = STDCOW * 0.118 \quad (5)$$

$$R \quad BMCOW.KL = MCOW.K * TGMOW.K \quad (6)$$

$$A \quad TBMOW.K = 0.0028 * LAN1.k + 0.2122 * (TMCOWP.K / TMILKP.K) \\ + 0.0012 * TDNP.K + 0.0001 * PRCOW.K + 0.0634 \quad (7)$$

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 (TBMOW). (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))

$$TBMOW = 0.0028 * LAN1 + 0.2122 * (TMCOWP / TMILKP) \\ (3.443) \quad (3.163) \\ + 0.0012 * TDNP + 0.0001 * PRCOW + 0.0634 \quad R^2 = 0.930 \quad (8) \\ (3.382) \quad (4.693) \quad (2.007)$$

$$D, W = 2.413$$

The estimation period of the structure equation is 8 year from 1975 to 1982, and the Ordinal 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))

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

$$R \quad ECOWR.KL = HCOW.K * TECOW \quad (10)$$

$$R \quad BCOW.KL = MCOW.K * TBCOW \quad (11)$$

$$R \quad BHCOW.KL = HCOW.K * TBHCOW.K \quad (12)$$

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

$$R \quad BCOW.KL = ECOW.K * TBECOW.K \quad (14)$$

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.

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

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

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))

$$A \quad DAIRY.K = BCOWP.K + BULLP.K \quad (17)$$

$$\begin{aligned} A \quad BCOWP.K = & BMILK + BMCOWP.K + DCOWP.K \\ & + BECOWP.K + BHCOWPK + BBCOMP.K \quad (18) \end{aligned}$$

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))

$$A \quad \text{BMILK.K} = \text{MILK.K} * \text{TMILKP.K} \quad (19)$$

$$A \quad \text{BMCOWP.K} = \text{BMCOW.K} * \text{TMCOWP.K} \quad (20)$$

$$A \quad \text{DCOW.K} = \text{DCOW.K} * \text{TDCOWP.K} \quad (21)$$

$$A \quad \text{BECOWP.K} = \text{BECOW.K} * \text{TECOWP.K} \quad (22)$$

$$A \quad \text{BHCOWP.K} = \text{BHCOW.K} * \text{THCOWP.K} \quad (23)$$

$$A \quad \text{BBCOWP.K} = \text{BBCOW.K} * \text{TBCOWP.K} \quad (24)$$

$$A \quad \text{MILK.K} = \text{MCOW.K} * \text{MILKM.K} \quad (25)$$

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.)

$$A \quad \text{MILKM.K} = \text{TABHL}(\text{MILKMT}, \text{TIME.K}, 50, 57, 1) \quad (26)$$

$$T \quad \text{MILKMT} = 4.89, 4.91, 5.44, 5.45, 5.33, 5.23, 5.07, 5.20$$

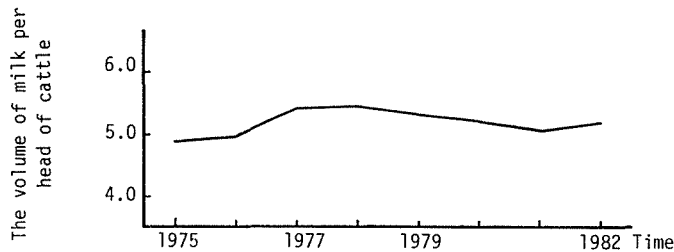


Fig. 6.5. The relation between TIME and the volume of milk per head of cattle.

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))

$$A \quad \text{TINPU.K} = -622.688 + 179.937 * \text{Log}(\text{TIME.K}) \quad (27)$$

(6.875)      (7.906)       $R^2 = 0.912$   
D, W = 1.257

$$A \quad \text{TDCOWP.K} = -2268.51 + 620.875 * \text{Log}(\text{TIME.K}) \quad (28)$$

(9.963)      (10.851)       $R^2 = 0.952$   
D, W = 1.751

$$A \quad \text{TMCOWP.K} = -3325.53 + 910.321 * \text{Log}(\text{TIME.K}) \quad (29)$$

(9.889)      (10.768)       $R^2 = 0.951$   
D, W = 1.774

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

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

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

b) Farm-household income sector

This sector mainly shows the mechanism relating to the operational division of dairy-farming including the trends of farm incomes within the area, the amounts of consumption, savings deposits, investments and debts resulting from the production activities. Here, the farm income (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))

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

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

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

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

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

Furthermore, the mechanism ensures that the amount of funds to be loaned (FDEBT) for investments (LAND) is monitored from a policy viewpoint and that the debtor balance (DEBT) of farm households is controlled constantly so that it may not substantially exceed the farm household's 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.

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

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

## 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)) The formula 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))

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

$$R \quad POPT.KL = POPU.K * TPOPT.K \quad (41)$$

$$A \quad RERY.K = NCOML.K / NDCOM.K \quad (42)$$

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

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.)

$$A \quad LABOR.K = POPU.K * TLABOR.K \quad (44)$$

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

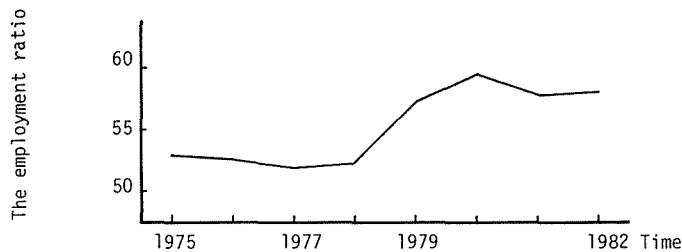


Fig. 6. 6. The relation between TIME and the employment ratio.

## 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)) Similarly, 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))

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

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

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))

$$R \quad ADTDN.KL = ANTDN.K / TATDN.K - ATDN.J \quad (48)$$

$$R \quad ADPAST.KL = ANPAS.K / TAPAS.K - APAST.J \quad (49)$$

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 pasturage 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.)

$$A \quad PRTDN.K = TPRDN.K * ANTDN.K \quad (50)$$

$$TPRDN = -212.406 + 61.875 * \text{Log} (PTIM.K) \quad R^2 = 0.780 \quad (51)$$

(3.864)      (4.479)      D, W = 1.351

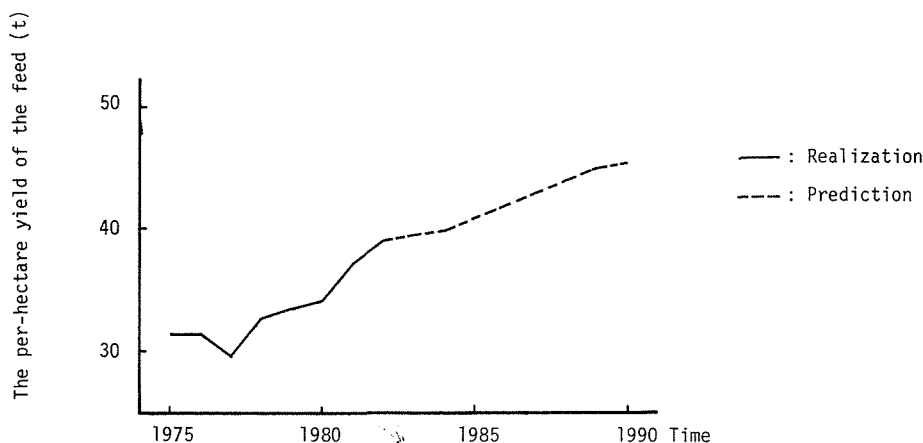


Fig. 6.7. The relation between TIME and the per-hectare yield of the feed.

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

Before conducting the policy simulation, a series of final tests to prove the propriety 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 a result 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 combining 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 than 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 restriction 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.

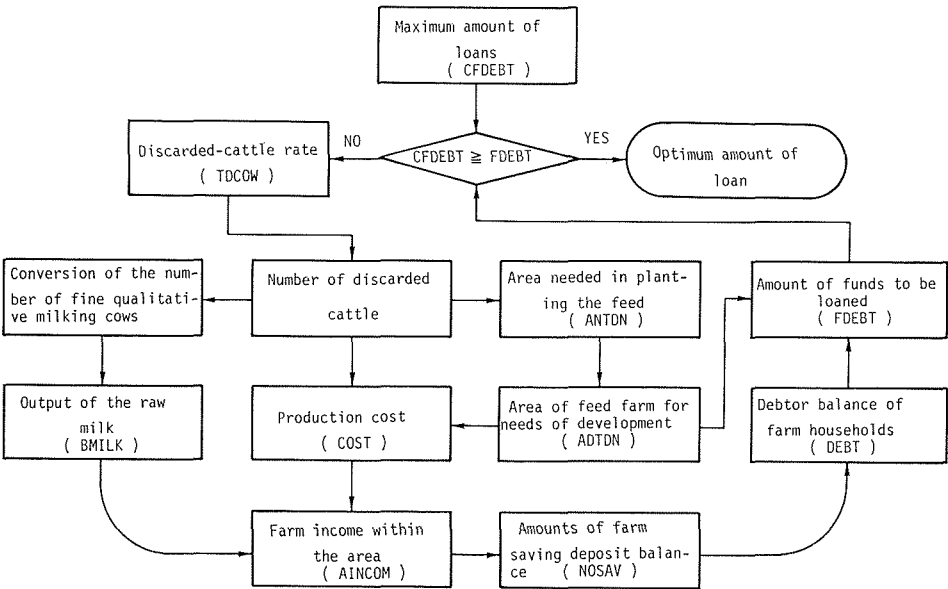


Fig. 7.1. Flowchart of the cause-effect chain relationship of the case where the maximum amount of funds that can be obtained by loan is set by a policy.

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 &

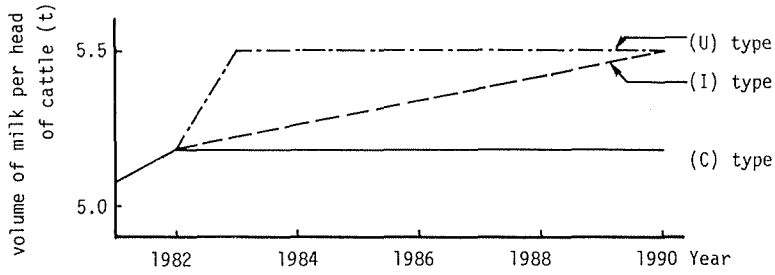


Fig. 7.2. Policy table of volume of milk per head of cattle.

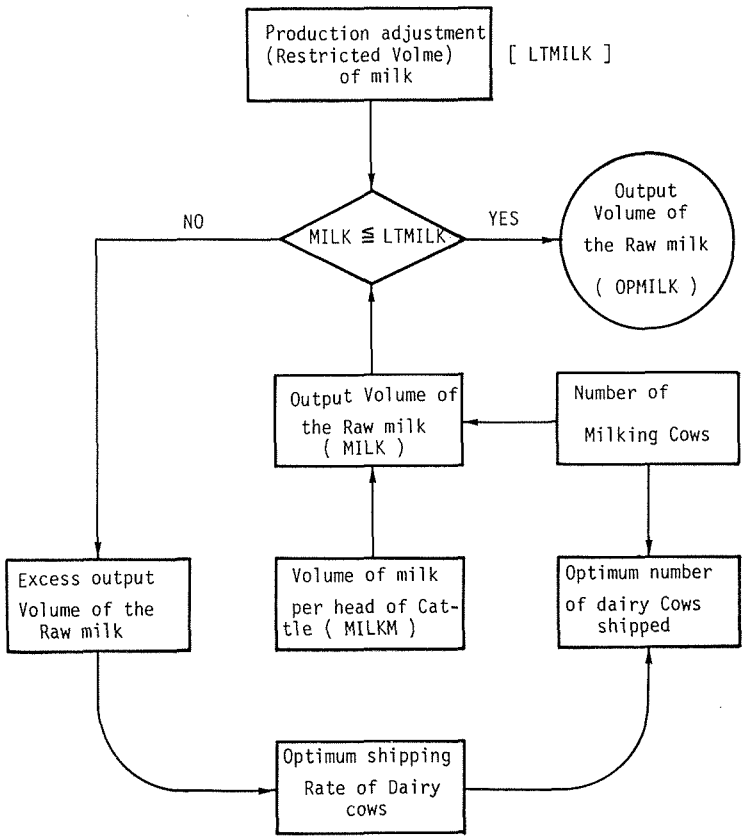


Fig. 7.3. The structure of strategically control mechanism under the production adjustment policy.

Table 4. 3. Results of the policy simulation

| Variables                                                    | Year | 1982   | 1984        |         | 1986        |         | 1988        |         | 1990        |         |
|--------------------------------------------------------------|------|--------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|
|                                                              | Case |        | Realization | 84'/82' | Realization | 86'/82' | Realization | 88'/82' | Realization | 90'/82' |
| Output volume of the<br>raw milk<br>(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<br>regional dairy<br>farming<br>(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<br>the area<br>(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<br>deposit balance<br>(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 balance of farm<br>households<br>(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                                        | Year | 1982   | 1984        |         | 1986        |         | 1988        |         | 1990        |         |
|--------------------------------------------------|------|--------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|
|                                                  | Case |        | Realization | 84'/82' | Realization | 86'/82' | Realization | 88'/82' | Realization | 90'/82' |
| Farm-household<br>population<br>(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<br>agriculture<br>(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<br>raising dairy cows<br>(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<br>(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<br>(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.

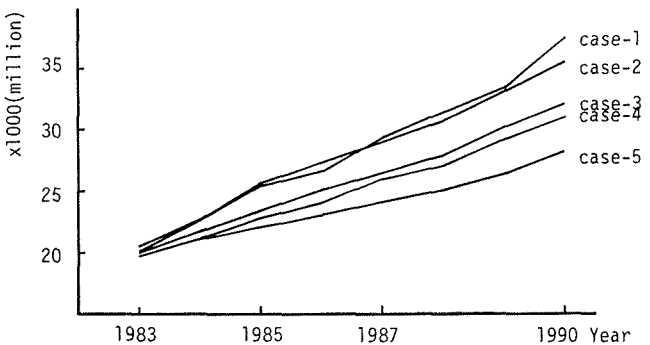


Fig. 8.3. Farm incomes within the area.

## 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)

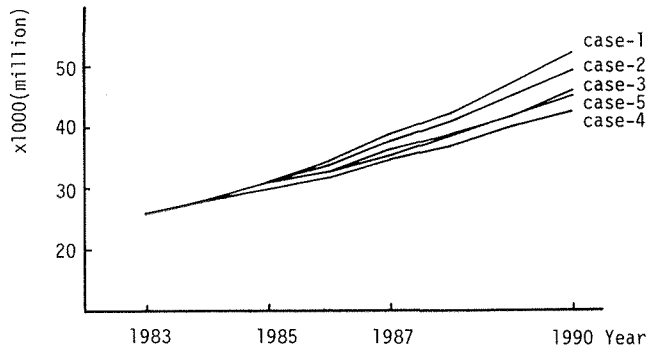


Fig. 8.4. The amounts of farm savings deposit balance.

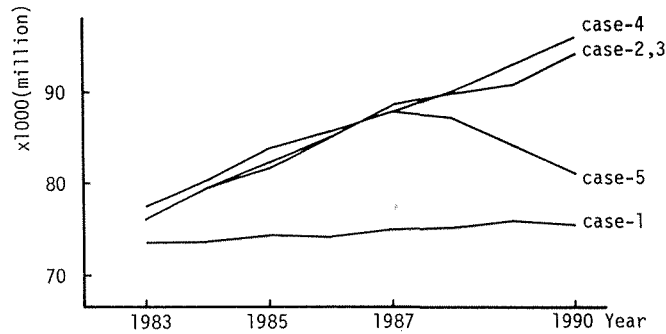


Fig. 8.5. The debtor balance of farm households.



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

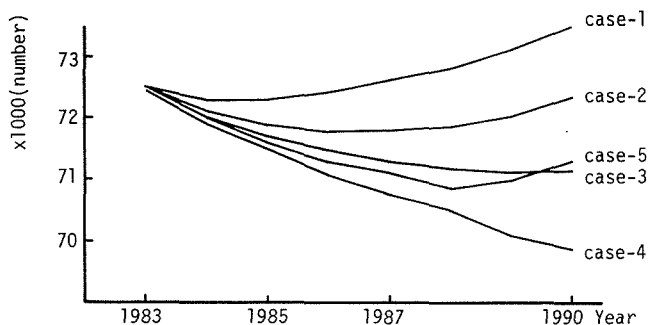


Fig. 8. 7. The population engaged in agriculture.

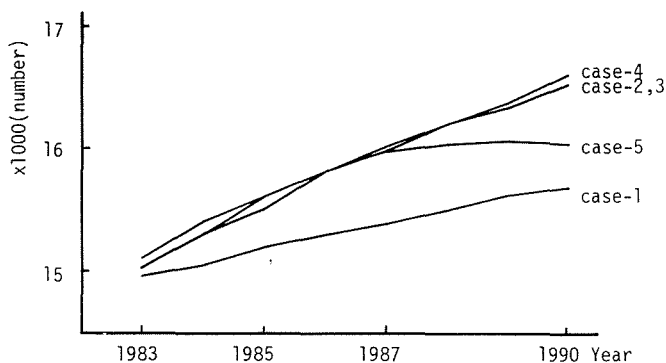


Fig. 8. 8. The number of head of raising dairy cows.

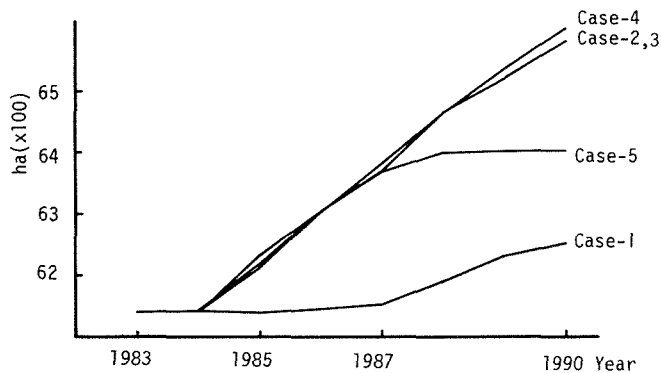


Fig. 8. 9. The area of feed for needs of development.

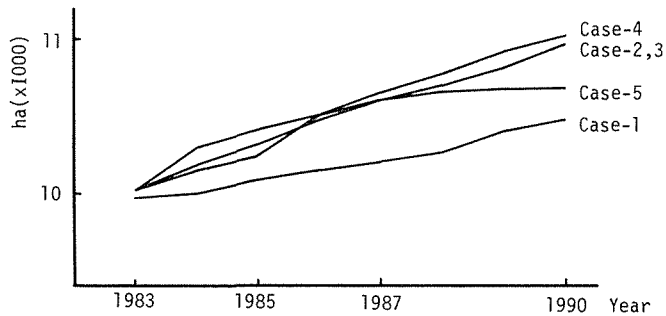


Fig. 8.10. The area of pasturage for needs of development.

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 shown 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 artificial 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) Improvement 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 loan (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                         |
| TANDTN    | : 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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