Study on Impact Mechanism for Beef Cattle Farming and Importance of Evaluating Agricultural Information in Korea Using DEMATEL, PCA and AHP

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Abstract

The dual-fold purpose of this study was to investigate whether there was a correlation between agricultural information and beef cattle farming and to analyze what improving information services had an effect on beef cattle farming. Evaluations of the impact mechanism between beef cattle farming and prevailing conditions were fundamentally the same for the farmers or the civil servants and staff members of PAIs(Public Agricultural Institutions). All information elements had large and minus relation index values. Both responding groups thought that the change in elements involving beef cattle farming easily improved information services, whereas it did not strongly affect beef cattle farming or prevailing conditions. The Decision-Making and Evaluation Laboratory (DEMATEL) method, which separates the interacting elements of a system into cause and effect groups as a structural modeling approach, is a good technique for analyzing the correlation between pairs of elements. Principal Component Analysis (PCA) was applied to the total relation matrix to find out the extent of the cause-effect relationship on the results. The features or correlations within all elements, based on patterns of similarity between the cause or effect groups, were confirmed. The evaluation of the information itself in the AHP(Analytic Hierarchy Process) results was not the same as the magnitude of its impacts in the DEMATEL analysis. However, a serious problem is that improving information services did not affect beef cattle farming or prevailing conditions. It was established that the correlations or potential structures between pairs of elements could be confirmed more easily, in detail, by applying PCA to the total relation matrix.

Keywords

information service, beef cattle farming, DEMATEL, PCA, AHP.

Introduction

Information technology has recently expanded rapidly to various fields of industry throughout Korea. The need for a new way of organizing information is required in the agricultural industry, including the livestock industry, as both its supply and demand has significantly changed since the market was opened. To date, land, labor, and natural phenomena have been the most important factors in agricultural

management, but now, agricultural information and knowledge, which assist competitiveness and business rationalization, have become more important. Speedy acquisition of agricultural information could help to increase agricultural income and efficiency through product inventories or shipping control and improve agricultural competitiveness. Therefore, the Korean Ministry of Agriculture and Forestry (KMAF) has tried to develop an agricultural information program that was based on the "Plan for construction of comprehensive

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agricultural and forestry information network” . Thirteen agricultural institutions have participated since 1993 (KMAF 1998; Kang 2002).

The livestock industry, which accounts for more than 20% of agricultural production, is very important in Korea. Native Korean cattle are the main domestic animal in the Korean livestock industry and constitute a very large proportion of Korean farmers' incomes. For many years, beef consumption in Korea has steadily increased due to the increase in national income and economic growth. However, there have not been sufficient investigations into how much the supply of and improvement in agricultural information services affect beef cattle farming and the circumstances that surround it. The supply of and improvement in agricultural information not only affect various other factors but are also affected by them.

The Decision-Making and Evaluation Laboratory (DEMATEL) method, which separates interacting elements of a system into cause and effect

groups, as a structural modeling approach, is a good technique for analyzing the impact of agricultural information. However, not many studies have applied the DEMATEL method in Korea, and agricultural research including related beef cattle farming one has not shown how it has been applied. Cho (2002) used his comparison of DEMATEL method and KJ theory how design factors were structured. Hwang and Lee (2002) evaluated how many in the aged population went to resorts by applying the DEMATEL method. Oh *et al.* (1998) studied planning in mountainous Korean and Japanese cities with DEMATEL and quantification theory.

The dual-fold purpose of this study was to investigate whether there was a correlation between agricultural information and beef cattle farming or prevailing conditions, and to analyze what the supply of and improvement in information services had an effect on beef cattle farming with the DEMATEL method. Moreover, features or

Fig. 1 Location of Non-san

correlations that were based on similarities in cause element groups or effect element groups were confirmed by applying Principal Component Analysis (PCA) to the total relation matrix.

Investigated area

The field survey for the DEMATEL analysis was conducted in Non-san, a city in Chung-nam province, Korea. Non-san lies to the southwest of the metropolis of Dea-jeon (Fig. 1), which has a population of more than 1,450,000 people. Livestock farming is a very important industry in Non-san, where livestock represents more than 25% of the total agricultural product. Many meat-processing factories are also located there.

Farmers and public agricultural institutions (PAIs) may differently evaluate what agricultural information has an effect on beef cattle farming and prevailing conditions. Therefore, evaluations of the effects of agricultural information by seven farmers and seven civil servants or staff members of PAIs, which were the Non-san Agriculture Technology Center (NATC) and Agricultural Cooperative Association (ACA), were assessed in this study to determine whether they were different.

The average age of the farmers was 51.86, the average number of cattle being raised per farmer was 61.43, and the average area of cultivated land was 1.09ha. An average of two family members was engaged

in raising cattle. The average age of the civil servants or staff members of PAIs was 41.57, and they were in charge of agricultural management or providing advice on livestock. Their average length of service was 13.86 years.

Application Method and Elements of Beef Cattle Farming Mechanism

DEMATEL is a practical and useful method of examining the structure of complicated causal and contextual relationships between the elements of a system. We first extracted all the elements that belonged to beef cattle farming. Figure 2 shows part of a survey sheet. Some sub-elements considered to have no relationships were removed to reduce the frequency of answers. The pair-wise comparison scale was assigned six levels, where the scores 0, 1, 2, 3, 4, and 5 meant "No influence", "Very low influence", "Low influence", "Medium influence", "High influence", and "Very high influence". We next focused on the strength of relationships between elements and tried to find this for all pairs of elements (Hoshino 1992). The results were calculated with the arithmetical mean of five relationship strengths after removing the maximum and minimum values. The initial direct-relation matrix Z was an $n \times n$ matrix obtained by pair-wise comparisons in terms of influences and directions of elements, in which z_{ij} was the degree to which element C_i affected element C_j (Lin and Wu 2004). As a result, all principal diagonal

Survey of Impact Mechanism on Beef cattle farming

Please check whether these elements have direct effects on the next subelements. If they have direct effects, to what degree.

Elements	N	L		M		H
1. Fall in beef price						
2. Fall in price of calves	0	1	2	3	4	5
8. Increase in national demand for beef	0	1	2	3	4	5
11. Stagnation of local economy	0	1	2	3	4	5
12. Improving information service for domestic and imported beef	0	1	2	3	4	5
13. Improving information service for beef prices	0	1	2	3	4	5
14. Improving information service for price of calves	0	1	2	3	4	5

Fig. 2 Example questions on effect of elements

elements z_{ij} of matrix Z were set to zero.

$$Z = \begin{matrix} & \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} 0 & z_{12} & \cdots & z_{1n} \\ z_{21} & 0 & \cdots & z_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \cdots & 0 \end{bmatrix} \end{matrix} \quad (1)$$

The normalized directed-relation matrix X can be

obtained by

$$X = \frac{Z}{s} \quad (2)$$

$$\text{where } s = \max_{1 \leq i \leq n} \left(\sum_{j=1}^n z_{ij} \right), \quad (3)$$

Total relation matrix T can be obtained by

$$T = \lim_{k \rightarrow \infty} (X + X^2 + \cdots + X^k) = X(I - X)^{-1} \quad (4)$$

Table 1 Elements of beef cattle farming, prevailing conditions, and agricultural information

1) Market conditions	
x_1 FBP	Fall in beef prices
x_2 FCP	Fall in calf prices
x_3 ILC	Increase in labor costs
x_4 RIFGP	Rise in imported feed or grain prices
x_5 TL	Trade liberalization
x_6 OBSE	Outbreak of BSE
x_7 RGNP	Rise in GNP
x_8 INDB	Increase in national demand for beef
x_9 UBI	Urbanization near beef industry
x_{10} IBS	Increase in beef supply
x_{11} SLE	Stagnation of local economy
2) Agricultural information	
x_{12} IDIBIS	Improving domestic and imported beef information services
x_{13} IBPIS	Improving beef price information services
x_{14} ICPIS	Improving calf price information services
x_{15} IPIS	Improving policy information services
x_{16} IITMIS	Improving industrial technology and material information services
x_{17} IDIS	Improving disease information services
3) Agricultural policy	
x_{18} RTL	Relaxing terms for loans
x_{19} IALL	Increasing activities at local level
x_{20} IPSP	Implementating or improving price stabilization or support policy
x_{21} DPD	Deregulating production or distribution
4) Livestock technology	
x_{22} TAF	Technological advances in fattening
x_{23} TAB	Technological advances in breeding
x_{24} TACF	Technological advances in cultivating feed
5) Beef management condition	
x_{25} ABF	Aging beef farmers
x_{26} RNBF	Reduced number of beef farmers
x_{27} ISBF	Increased scale of beef cattle farming
x_{28} ICBF	Improved capabilities of beef farmers
x_{29} RPC	Reduced of production costs
x_{30} IIBF	Increased income of beef farmers
x_{31} IMQ	Improved meat quality
x_{32} ILP	Increased livestock pollution
x_{33} INFSJ	Increased number of farmers with second job
x_{34} DCF	Decreased cultivation of feed

There are many elements in beef cattle farming. In this study, these were classified into five categories and subdivided into 34 elements. Those 34 elements were determined by a Korean Rural Economic Institute researcher who was in charge of the Livestock Division, and these are the same as those listed in Table 1.

DEMATEL Results

The row-sum, column-sum, relation index, and influence index for the DEMATEL results for livestock farmers and civil servants or staff members of PAIs are listed in Table 2.

D_p , the sum of rows, means the total influence element is having on the others, both directly and indirectly, and R_p , the sum of the columns, means the total influence the others are having on element. The relation index, which was obtained by adding R_i to D_i , shows how important element i is, whereas the influence index, which was obtained by subtracting R_i from D_i , can divide elements into cause and effect groups. All information elements had large relation index values ($D_i + R_i$) which were more than the average and were important. However, all their influence index values ($D_i - R_i$) were negative and they therefore belonged to the effect group (Monma 1992). Farmers thought that changed elements in the prevailing conditions for beef cattle farming easily affected information services, whereas information did not affect beef cattle farming or prevailing conditions. The D_i for x_{12} IDIBIS, x_{13} IBPIS, x_{14} ICPIS, x_{15} IPIS, and x_{17} IDIS were less than the average value for row-sum (1.545). Only the row-sum for x_{16} IITMIS (1.717) was more than the average value for row-sum, which had a relatively strong influence ($t_{ij} > 0.100$) on x_{19} IALL, x_{27} ISBF, x_{28} ICBF, and x_{30} IIBF. Prevailing market elements, which were x_4 RIFGP and x_5 TL, and domestic economic development elements, which were x_3 ILC, x_7 RGNP, x_8 INDB, and x_9 UBI, belonged to the cause group. x_{30} IIBF and x_{19} IALL belonged to the effect group.

All information elements had a large relation index for civil servants or staff members of PAIs, like

the results for farmers, which were more than average (3.334) and which indicated importance. However, all their influence index values were negative and they therefore belonged to the effect group. The civil servants or staff members of PAIs also considered that changed conditions in beef cattle farming affected information services, whereas information did not affect beef cattle farming or prevailing conditions. Farmers and civil servants or staff members of PAIs basically evaluated the impact mechanisms for beef cattle farming and prevailing conditions the same. However, whereas the row-sum for x_{16} IITMIS for the former group was more than average, all information elements for the latter was less than the average for row-sums (1.667) and they were not more than 0.100 of the total relation elements. Prevailing market elements such as x_4 RIFGP, x_5 TL, and x_6 OBSE, and the domestic economic development elements, which were x_3 ILC, x_7 RGNP, x_8 INDB, and x_9 UBI, belonged to the cause group as in the results for farmers. x_{30} IIBF and x_{19} IALL belonged to the effect group.

PCA Results

Results based on the relation index and influence index could be considered with the original DEMATEL method (Tamura *et al.* 2003). The general positioning of all elements in the total system could be confirmed by applying this, whereas it was difficult to evaluate features that were based on the cause-effect relationships of all elements. PCA was applied here to the total relation matrix to find out what effect the cause-effect relationship had on the results. The features or correlations within all elements, based on their similarities with cause or effect groups, were then confirmed. This was an application of the method of functional area division that applied PCA to the Origin-Destination (OD) matrix discussed in the geographical researches (William and Duane 1963; Paul 1975). The total relation matrix can be regarded as an OD matrix because it consists of data on the strength of the cause-effect relationship. There are frequent occasions when the inverse of the

Table 2 DEMATEL Results

Elements	Row sum (D)		Column sum (R)		Relation index (D+R)		Influence index (D-R)	
	Farmers	PAIs	Farmers	PAIs	Farmers	PAIs	Farmers	PAIs
x ₁ FBP	1.875	2.001	1.121	1.461	2.996	3.462	0.754	0.541
x ₂ FCP	1.659	1.949	1.137	1.539	2.795	3.488	0.522	0.411
x ₃ ILC	1.656	2.020	0.523	0.570	2.179	2.590	1.134	1.450
x ₄ RIFGP	1.533	1.860	0.367	0.335	1.900	2.195	1.167	1.525
x ₅ TL	2.507	2.459	1.310	1.393	3.817	3.852	1.197	1.066
x ₆ OBSE	1.467	1.825	0.636	0.720	2.103	2.545	0.831	1.106
x ₇ RGNP	1.997	2.232	0.412	0.293	2.409	2.525	1.584	1.940
x ₈ INDB	2.176	2.289	0.974	0.989	3.151	3.277	1.202	1.300
x ₉ UBI	1.387	1.770	0.202	0.358	1.589	2.128	1.186	1.412
x ₁₀ IBS	1.915	2.237	1.986	2.224	3.901	4.460	-0.071	0.013
x ₁₁ SLE	0.809	0.852	0.734	0.764	1.543	1.616	0.076	0.089
x ₁₂ IDIBIS	1.450	1.525	2.726	3.012	4.176	4.537	-1.276	-1.487
x ₁₃ IBPIS	1.170	1.237	2.451	2.749	3.620	3.987	-1.281	-1.512
x ₁₄ ICPIS	0.989	1.177	2.467	2.602	3.455	3.779	-1.478	-1.424
x ₁₅ IPIS	1.208	1.288	2.510	2.853	3.718	4.141	-1.303	-1.564
x ₁₆ IITMIS	1.717	1.596	2.924	3.241	4.641	4.837	-1.207	-1.645
x ₁₇ IDIS	1.201	1.363	2.164	2.363	3.365	3.726	-0.963	-1.000
x ₁₈ RTL	1.356	1.351	1.700	1.652	3.056	3.003	-0.345	-0.301
x ₁₉ IALL	1.048	1.059	2.442	2.375	3.490	3.434	-1.395	-1.317
x ₂₀ IPSP	1.115	1.015	0.908	1.108	2.023	2.123	0.207	-0.092
x ₂₁ DPD	1.632	1.689	1.659	2.052	3.291	3.741	-0.027	-0.362
x ₂₂ TAF	1.948	1.968	2.017	2.027	3.964	3.995	-0.069	-0.059
x ₂₃ TAB	1.752	1.928	2.101	2.153	3.853	4.081	-0.349	-0.225
x ₂₄ TACF	1.604	1.698	1.376	1.413	2.980	3.111	0.228	0.285
x ₂₅ ABF	1.211	1.302	0.473	0.790	1.684	2.092	0.739	0.512
x ₂₆ RNBF	1.843	1.826	0.915	1.074	2.758	2.900	0.929	0.753
x ₂₇ ISBF	2.474	2.696	2.568	2.608	5.042	5.304	-0.094	0.089
x ₂₈ ICBF	1.963	2.089	2.696	2.918	4.660	5.007	-0.733	-0.829
x ₂₉ RPC	1.708	2.157	1.974	2.126	3.681	4.283	-0.266	0.031
x ₃₀ IIBF	1.254	1.353	2.696	2.626	3.950	3.979	-0.1442	-1.273
x ₃₁ IMQ	1.582	1.520	2.289	2.014	3.871	3.533	-0.707	-0.494
x ₃₂ ILP	1.533	1.580	0.789	0.813	2.322	2.394	0.744	0.767
x ₃₃ INFSJ	1.139	1.064	0.707	0.756	1.846	1.820	0.432	0.307
x ₃₄ DCF	0.665	0.699	0.589	0.710	1.254	1.409	0.075	-0.010
Average value	1.545	1.667	1.545	1.667	3.091	3.334	-0.000	-0.000

correlation matrix is used to calculate the loadings for factor analysis. It is impossible to calculate the factor loading when there are the same number of samples and variables. Therefore, PCA was applied here. In all PCAs of farmers and civil servants or staff members of PAIs, seven principal components (PCs) with eigenvalues greater than 1.0, explain 77.1% and 79.8% of the total variance, respectively, as listed in Table 3. The Varimax rotation method with Kaiser Normalization was used.

The top three results for farmers were as follows. In the PCA results, the similarities among factor loadings and those among sample scores respectively express those among cause or effect elements. Both factor loadings and sample scores are necessary to understand both similarities. Therefore, two kinds of values were evaluated.

【First PC】 The first PC was characterized by information elements and some other elements. Four information elements, which were x_{14} ICPIS, x_{13} IBPIS, x_{12} IDIBIS, and x_{17} IDIS, had similarities in their cause and effect elements. According to the results for the total relation matrix, the cause elements were x_5 TL, x_8 INDB, and x_{27} ISBF, and those for prevailing conditions or the increased scale of beef cattle farming were related to the improvement in information services. The x_{28} ICBF, x_{22} TAF, x_{23} TAB, and x_{19} IALL elements were similar to the previous four information elements in the cause groups. While the previous four information elements exerted a small influence on the other elements, they had a relatively strong influence on x_{10} IBS, x_{19} IALL, x_{27} ISBF, x_{30} IIBF, and x_{31} IMQ. Although the degree of influence was low, the improvement in information services including x_{16} IITMIS had a direct or indirect influence on improved beef cattle farming or local activities. Information elements also had a relatively strong influence on one another. However, x_{16} IITMIS, in which the cause elements were x_1 FBP, x_5 TL, x_8 INDB, x_{10} IBS, x_{22} TAF, x_{23} TAB, x_{27} ISBF, and x_{28} ICBF, had many cause elements compared with the other five information elements.

In other words, although it had a pattern similar to that of the effect elements, it had been affected by more elements than the other five information elements.

【Second PC】 The second PC was characterized by several elements. Of these, x_{26} RNBF, x_{34} DCF, x_{11} SLE, and x_{33} INFSJ had similar cause and effect elements. However, x_{30} IIBF had different cause and effect elements because these reflected the differences between the two types of elements, which were positive and negative attitudes to beef cattle farming.

【Third PC】 The third PC, which was characterized by x_{29} RPC, x_{10} IBS, x_{27} ISBF, x_{31} IMQ, and some other elements, had similar cause and effect elements.

The results for civil servants or staff members of PAIs are as follows.

【First PC】 The elements x_{27} ISBF, x_{10} IBS, and x_{29} RPC had similar cause and effect elements. However, the effect elements from those three were very different from those from x_{17} IDIS.

【Second PC】 The six information elements had similar cause elements for the second PC. Specifically based on the results for the total relation matrix, these six information elements were strongly affected by x_5 TL, x_6 OBSE, x_8 INDB, x_{27} ISBF, x_{28} ICBF, and x_{29} RPC. There were many cause elements compared with the farmers. The four information elements x_{12} IDIBIS, x_{13} IBPIS, x_{14} ICPIS, and x_{17} IDIS had similar effect elements, which were x_{10} IBS, x_{19} IALL, x_{27} ISBF, x_{28} ICBF, and x_{30} IIBF. The other two information elements x_{15} IPIS and x_{16} IITMIS also had a relatively strong influence on the above effect elements. Although the degree of influence was not strong, six kinds of information elements also had an influence on improved beef cattle farming or local activities and a relatively strong influence on one another.

【Third PC】 The third PC, which was characterized by x_{11} SLE, x_{26} RNBF, x_{20} IPSP, x_{34} DCF, x_{33} INFSJ, and x_6 OBSE, had similar cause elements. Of these, elements x_{20} IPSP, x_{26} RNBF, and x_{11} SLE also had

Table 3 PCA Results

Farmer	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Eigenvalue	7.873	4.972	4.834	2.910	2.362	1.783	1.467
Proportion (%)	23.155	14.624	14.217	8.557	6.948	5.244	4.314
Accumulated P. (%)	23.155	37.780	51.997	60.554	67.502	72.746	77.060
Factor Loadings	x ₁₄ 0.883	x ₂₆ 0.934	x ₂₉ 0.783	x ₅ 0.722	x ₂ 0.709	x ₃ 0.623	x ₃₂ 0.712
	x ₁₃ 0.866	x ₃₄ 0.855	x ₁₀ 0.706	x ₂₄ 0.617	x ₁ 0.654	x ₈ 0.445	
	x ₁₂ 0.835	x ₁₁ 0.804	x ₂₇ 0.683	x ₄ 0.504	x ₉ -0.607	x ₂₁ -0.311	
	x ₁₇ 0.736	x ₃₃ 0.738	x ₃₁ 0.661		x ₇ -0.448	x ₁₁ -0.339	
	x ₂₈ 0.734	x ₂₅ 0.628	x ₃₀ 0.606			x ₂₀ -0.532	
	x ₂₂ 0.689	x ₂₀ 0.555	x ₁₈ 0.603				
	x ₂₃ 0.680	x ₆ 0.513	x ₁₆ 0.593				
	x ₁₉ 0.642	x ₃₀ -0.211					
	x ₁₅ 0.627						
	x ₂₁ 0.606						
Sample Scores	x ₁₄ 0.303	x ₂₆ 0.251	x ₂₉ 0.315	x ₅ 0.378	x ₂ 0.375	x ₃₁ 0.313	x ₃₂ 0.336
	x ₁₃ 0.274	x ₁₁ 0.163	x ₂₇ 0.285	x ₂₄ 0.257	x ₁ 0.306	x ₃ 0.277	x ₂₃ -0.318
	x ₁₇ 0.235	x ₃₃ 0.149	x ₃₁ 0.251		x ₉ -0.056	x ₈ 0.246	x ₂₂ -0.336
	x ₁₂ 0.214	x ₃₄ 0.129	x ₁₀ 0.247		x ₇ -0.127	x ₂₁ -0.243	
		x ₃₀ -0.211	x ₁₈ 0.214		x ₂₇ -0.411	x ₂₀ -0.250	
						x ₂₇ -0.408	
PAIs	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Eigenvalue	7.123	4.516	4.345	3.188	2.930	2.872	2.144
Proportion (%)	20.949	13.282	12.780	9.378	8.617	8.448	6.307
Accumulated P. (%)	20.949	34.231	47.011	56.389	65.006	73.454	79.761
Factor Loadings	x ₂₇ 0.897	x ₁₃ 0.732	x ₁₁ 0.846	x ₅ 0.761	x ₂ 0.809	x ₇ 0.719	x ₃₂ 0.764
	x ₁₀ 0.864	x ₁₇ 0.723	x ₂₆ 0.803	x ₂₄ 0.690	x ₁ 0.766	x ₂₅ 0.671	x ₃ 0.731
	x ₂₉ 0.802	x ₁₄ 0.702	x ₂₀ 0.780	x ₄ 0.571		x ₈ 0.607	
	x ₃₀ 0.793	x ₁₂ 0.691	x ₃₄ 0.732	x ₁₈ 0.545		x ₉ 0.512	
	x ₃₁ 0.724	x ₁₅ 0.571	x ₃₃ 0.584				
Sample Scores		x ₁₆ 0.538	x ₆ 0.487				
	x ₂₇ 0.353	x ₁₇ 0.431	x ₂₀ 0.291	x ₅ 0.430	x ₂ 0.433	x ₂₅ 0.290	x ₃₂ 0.367
	x ₁₀ 0.306	x ₁₃ 0.317	x ₂₆ 0.201	x ₂₄ 0.318	x ₁ 0.356	x ₈ 0.252	x ₃ 0.289
	x ₂₉ 0.233	x ₁₂ 0.275	x ₁₁ 0.183	x ₁₂ -0.228		x ₁₅ -0.310	
	x ₁₇ -0.254	x ₁₄ 0.263	x ₁₇ -0.236				
		x ₁₅ 0.141					
		x ₁₆ 0.061					
		x ₂₉ -0.224					
		x ₂₇ -0.247					

Note 1. Only element scores characterizing each factor are shown.
 2. SPSS 10.0 was used for calculation.

similar effect elements, while they had different effect elements from x_{17} IDIS.

Patterns of similarity between cause and effect elements were identified by interpreting the results for the extracted PCs. This could easily be done by applying PCA to the total relation matrix. No similarities in cause and effect patterns in any element can be found by merely observing the total relation matrix, the relation index, or the influence index with the DEMATEL method. Therefore, applying PCA with the DEMATEL method would be more useful.

Impact of Information Transfer

Farmers and civil servants or staff members of PAIs basically evaluated the impact mechanisms for beef cattle farming and prevailing conditions the same. However, farmers evaluated x_{16} IITMIS as an important element in beef cattle farming. x_{16} IITMIS had a relatively strong impact compared with the other information elements because it was fundamental to the input sector of beef cattle farming and had an influence on product and management results.

Links, which were “the improvement in information services on beef or calf prices result in increased managerial salaries” and “the improvement in information services on domestic or imported beef lead

to reduced the production costs” , were very weak. Efficient use of information in beef cattle farming will be a subject for future study.

The Analytic Hierarchy Process (AHP) was used to support complex evaluations and the decision process by doing pair-wise comparisons of elements and by ranking them on the basis of numerical scores (Kinoshita 2000; Shin *et al.* 2002). AHP was used to evaluate the priority of information as listed in Table 4. The weights for the criteria and the scores for the alternatives have been considered as decision elements in the second step of the decision process. To find the relative importance of information elements, the pair-wise comparison scale was divided into three levels, where scores of 1, 3, and 5 respectively mean “Both elements are equally important to beef cattle farming” , “Element i is slightly more important to beef cattle farming than element j ” , and “Element i is significantly more important to beef cattle farming than element j ”. If element j is more important than element i , reciprocal numbers are used. Each set of comparisons for a level with n elements requires ${}_nC_2$ judgments. Positive reciprocal matrix A of pair-wise comparisons is constructed (Eq. 5) in this way. The columns of matrix A are summed, and each a_{ij} is converted to a percentage of

Table 4 AHP Analysis Result

	Farmers	PAIs		
		Total	Civil servants of NATC	Staff members of ACA
x_{12} IDIBIS	0.402	0.219	0.180	0.239
x_{13} IBPIS	0.169	0.129	0.129	0.119
x_{14} ICPIS	0.137	0.136	0.141	0.112
x_{15} IPIS	0.135	0.173	0.189	0.144
x_{16} IITMIS	0.069	0.139	0.185	0.107
x_{17} IDIS	0.087	0.204	0.176	0.279
CI (CR)	0.046 (0.037)	0.051 (0.041)	0.070 (0.056)	0.074 (0.060)

- Note
1. Pair-wise comparisons scale was divided into three levels, where scores of 1, 3, and 5.
 2. CI : Consistency index, CR : Consistency ratio.
 3. CR = CI/Random Consistency (R).
 4. Excel program was used for calculation.

its column total. The rows are averaged and the averages of these rows determine the priority for ordering corresponding elements. The higher the average, the more important that element is. AHP enables the analyst to evaluate the goodness of judgments with the consistency index (CI). A CI of 0.10 or less implies a more consistent judgment, which is acceptable.

$$A = [a_{ij}] = \begin{matrix} & \begin{matrix} A_1 & A_2 & \cdots & A_n \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{matrix} & \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix} \end{matrix} \quad (5)$$

where

$$a_{ij} = w_i/w_j, \quad a_{ji} = 1/a_{ij}, \quad W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \quad (6)$$

First, checking the priority values, the farmers' case indicates that 40.2% of the information weight is on x_{12} IDIBIS, 16.9% on x_{13} IBPIS, 13.7% on x_{14} ICPIS, 13.5% on x_{15} IPIS, 8.7% on x_{17} IDIS, and 6.9% on x_{16} IITMIS. In the PAIs' case, 21.9% of the information weight is on x_{12} IDIBIS, 20.4% on x_{17} IDIS, 17.3% on x_{15} IPIS, 13.9% on x_{16} IITMIS, 13.6% on x_{14} ICPIS, and 12.9% on x_{13} IBPIS. The NATC civil servants and the ACA staff members evaluated the priority of information differently. While the civil servants regarded x_{15} IPIS as being the most important, the ACA staff members thought x_{17} IDIS was the most important. The farmers and civil servants or staff members of PAIs regarded x_{12} IDIBIS to be the most important. x_{12} IDIBIS was thought to represent the most fundamental information with respect to beef products.

The PAIs' civil servants or staff members regarded x_{17} IDIS as being more important than the farmers did because they were anxious about the strong impact a disease outbreak would have on the district from the standpoint of the public. They took little notice of x_{16} IITMIS in the AHP analysis. However, x_{16} IITMIS had been evaluated as having a relatively strong impact

on the six kinds of information in the DEMATEL analysis. Neither the farmers nor civil servants and staff members of PAIs considered the importance of information in considering its impact.

Generally speaking, the civil servants and staff members of PAIs evaluated all the information equally, while the farmers attached greater importance to x_{12} IDIBIS and paid little attention to x_{16} IITMIS. One explanation is that their different positions with regard to beef cattle farming led to differences in their evaluations.

The importance of the information itself in the AHP results was not the same as the magnitude of its impacts in the DEMATEL ones. In the DEMATEL analysis, x_{16} IITMIS was the largest and x_{14} ICPIS was the smallest influence element (D_i), which meant the magnitude. However, in the AHP result, x_{12} IDIBIS was the most and x_{16} IITMIS (farmers) and x_{13} IBPIS (PAIs) were the least important element in beef cattle farming.

Conclusion

The DEMATEL method is a good technique for analyzing the correlation between pairs of elements. The dual-fold purpose of this study was to investigate whether there was a correlation between agricultural information and beef cattle farming and to analyze what improving information services had an effect on beef cattle farming. Moreover, features or correlations that were based on the similarity of cause or effect element groups were confirmed by applying PCA to the total relation matrix. The results we obtained are summarized in Fig.3.

Evaluations of the impact mechanism between beef cattle farming and prevailing conditions were fundamentally the same for the farmers or the civil servants and staff members of PAIs. All information elements had large relation index values, which were greater than average and which indicated importance. However, all their influence index values were negative and therefore belonged to the effect group. Both responding groups thought that the change in elements involving beef cattle farming easily improved information services, whereas it did not affect beef cattle

farming or prevailing conditions.

The general positioning of all elements in the total system could be confirmed by applying the original DEMATEL method, whereas it was difficult to investigate features that were based on the cause-effect relationship of all elements. PCA was applied to the total relation matrix to find out the extent of the cause-

effect relationship on the results. The features or correlations within all elements, based on patterns of similarity between the cause or effect groups, were then confirmed (See Fig.3). It was clear that the application of not only the DEMATEL method but also PCA would be more useful.

The evaluation of the information itself in the

Fig. 3 A general flow chart of the analysis

AHP results was not the same as the magnitude of its impacts in the DEMATEL analysis. There is the possibility that the importance of all elements was not evaluated from the viewpoint of impact.

Although agricultural information spread by computers and the information superhighway has been improved and many kinds of information services have been offered by public agencies, its application leaves much to be desired. The spread of computers within the farming community is still lower than the national average and only a few farmers are limitedly utilizing them. Not only the construction and preparation of an information network but also the education of farmers is necessary to solve such problems. The agricultural public agencies should be in charge of the development of agricultural databases and software, training of computer and its software for practical uses and a quick and useful information services.

We found that information has an influence on one another and that improving industrial technology and material information services (x_{16} ITMIS) has a relatively strong impact on various elements. To improve the impacts of agricultural information, it is necessary that information with strong impact on beef cattle farming be improved.

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Economical and social information.

DEMATEL 法と主成分分析法及び AHP 法による韓国における肉用牛経営の波及効果メカニズムと農業情報の重要度評価に関する考察

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摘要

本論文では韓国肉用牛経営を対象として、情報が肉用牛経営およびそれを巻く環境条件との間でどのような相互関係を備えているか、そして情報機能の充実・強化が肉用牛経営に対して持つ効果を DEMATEL 法、主成分分析法及び AHP 法を適用して明らかにした。

DEMATEL 法による計算結果をみると農民や農業関連機関の担当者との間で肉用牛経営と肉用牛経営を取り巻く環境の間の波及効果の評価は基本的に違いがない。全ての情報要因は平均値以上の大きな関連度をもっている。しかし、情報要因の影響度はマイナスで、影響先要因として位置づけられる。農民や農業関連機関の担当者は、肉用牛経営を取り巻く環境は肉用牛に関する情報の充実・強化には影響を与えるが、作成・公表された情報は、肉用牛経営やそれを取り巻く環境にあまり大きな効果をもたらさないと考えている。ただし、情報はその提供・機能充実がある程度は波及効果を与えていていることも明らかになった。このように波及効果を分析するうえで、DEMATEL 法は有効であることが確認できた。

また、DEMATEL 法で計算される総合影響行列を主成分分析にかける方法を提示して、影響を受ける相手側要因の類似性や、影響を与える相手側要因の類似性に基づいて、要因相互間の関係や特徴をより詳細に把握することができた。さらに、AHP 法による重要性把握では、被調査者は波及効果まで考慮して評価していないことが明らかになった。

パソコンやインターネットの普及で農業情報の基盤は向上し、様々な情報が農業関連機関などから提供されているが、その利用はまだ不十分である。農村のパソコン普及率は韓国内の平均値以下で、それを利用する農民も少ない。その問題を解決するためには情報のネットワーク整備だけではなく、農民の教育も必要である。

キーワード

情報サービス, 肉用牛経営, DEMATEL 法, 主成分分析, AHP 法,

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