An Econometric Analysis on the Interrelations among Rural Industries Structure, Agricultural Productivities and Climate Changes

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1. Introduction

The purpose of this paper is to discuss about the Interrelations among Rural Industries Structure, Agricultural Productivities and Climate Changes. For this purpose, following analyses are carried out in each section.

(1). Generation of Agriculture based IO table in 3 time point (1985, 1990, 1996)

(2). Industry Structure Analysis

- (i) Influence & Responsive Degree Coefficient,
- (ii) Inducement Coefficient,
- (iii). Skyline Analysis

(3).Prediction of Input coefficient by RAS method

- 1).Estimation of R (substitution change coefficient) & S (processing degree change coefficient)
- 2) Prediction of Input Coefficient and Impact of Climate Factors on Agricultural Productivities

(4) Implications at this stage

2. Generation of Agriculture based IO table in 3 time point (1985, 1990, 1996)

Original Input-Output tables have been published for the year 1985, 1990 and 1996 by Turkish Government. Those are tables of the competing import type and the commodity based type. The 1985 and 1990 tables contain 64 industry sectors, 7 final demand sectors and 7 value added sectors and 1996 table contains 98 industry sectors, 7 final demand sectors and 7 value added sectors. The unit of all tables are million Turkish Lira.

By aggregating non-rural sectors as much as possible, these tables were reduced to the smaller size of 24 industry sectors, 6 final demand sectors and 4 value added sectors and they were converted to the Agriculture based IO tables. These tables are shown in Table 1, Table2 and Table3. In the following, due to the space limitations, only the rural sectors (i.e. 6 sectors from grain to fisheries) are indicated explicitly and non-rural sectors (i.e. 18 sectors from coal/oil to administration) are indicated implicitly by the notation **** in the corresponding rows and columns.

3. Industry Structure Analysis

1) Influence & Responsive Degree Coefficients

The following orthodox manipulation of the Input-Output Analysis are applied to these Agriculture-based IO tables.

$$AX + F = X \quad \ldots\ldots\ldots\ldots\ldots(1)$$

$$X = (I - A)^{-1} F \quad \ldots\ldots\ldots\ldots\ldots(2)$$

Here, A: input coefficient matrix
F: final demand column vector
X: output column vector
I : unit matrix

And matrix $(I - A)^{-1}$ is known as the Leontief's Inverse matrix B, which shows the production inducement multiplier matrix. From these formula, the following two coefficients are derived,

<Influence Degree coefficient>

$$E_j=\Sigma_i b_{ij}/(\Sigma_j\Sigma_i b_{ij}/n), \quad (i,j=1,2, \ldots,n) \ldots\ldots\ldots(3)$$

<Responsive Degree coefficient>

$$K_i=\Sigma_j b_{ij}/(\Sigma_i\Sigma_j b_{ij}/n), \quad (i,j=1,2, \ldots,n) \ldots\ldots\ldots(4)$$

Each industry can be categorized by the combination of these 2 coefficients as shown in Figure 1.

Table1 Agriculture Based Input Output Table(1985) (unit: billion Turkish Lira, 1985)

		Intermediate Demand Sector								Final Demand Sector							Total Production
		Grain	Vegetable	Fruits	Livestock	Forestry	Fisheries	****	Intermediate Demand Total	Private Consumption	Public Consumption	Private Investment	****	Export	Final Demand Total	(-)Import	
Intermediate Input Sector	Grain	1465	0	0	7122	0	0	****	20556	4834	96	0	****	689	4799	-948	24407
	Vegetable	0	33	0	0	0	0	****	565	6658	25	0	****	76	7126	-24	7667
	Fruits	0	0	379	0	0	0	****	2154	11608	49	0	****	686	12784	-71	14867
	Livestock	12	399	130	0	0	0	****	5993	16055	62	11	****	670	16817	-475	22335
	Forestry	0	0	0	0	0	0	****	2699	601	164	0	****	97	869	-440	3128
	Fisheries	0	0	0	0	0	0	****	112	1560	0	0	****	117	1672	-8	1777
	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****
	Intermediate Input Total	9225	2284	1726	10699	489	286	****	242327	221979	29808	23169	####	59180	368546	-78935	531938
Value Added	Tax	-1800	-104	257	105	28	4	****	14080								
	Depreciation	369	129	317	108	15	16	****	15961								
	Wage	2740	844	592	539	820	179	****	59881								
	Profits	13873	4514	11974	10883	1777	1291	****	199688								
	Value added Total	15181	5383	13140	11636	2639	1491	****	289611								
Total Products		24407	7667	14867	22335	3128	1777	****	531938								

("****" shows the sectors omitted to list)

Table 2 Agriculture Based Input Output Table(1990) (unit: billion Turkish Lira, 1990)

		Intermediate Demand Sector								Final Demand Sector							Total Production
		Grain	Vegetable	Fruits	Livestock	Forestry	Fisheries	****	Intermediate Demand Total	Private Consumption	Public Consumption	Private Investment	****	Export	Final Demand Total	(-)Import	
Intermediate Input Sector	Grain	32416	0	0	83915	1	0	****	239872	62561	1477	0	****	9735	111476	-19272	332076
	Vegetable	0	724	0	0	0	98	****	13293	86161	383	0	****	1079	86830	-486	99636
	Fruits	0	0	8376	0	0	32	****	37356	150230	749	0	****	9692	164819	-1448	200727
	Livestock	189	6266	2036	14739	2	0	****	77381	204032	696	871	****	3433	199250	-4664	271967
	Forestry	0	409	0	0	45	0	****	30310	9996	1835	0	****	263	8220	-4779	33751
	Fisheries	0	0	0	0	0	16	****	2395	23194	2	0	****	928	23993	-139	26249
	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****	**** ****
	Intermediate Input Total	111095	26237	24516	138060	4930	5315	****	2912476	2622059	430835	616643	****	520616	4599592	-824312	6687757
Value Added	Tax	-7820	-451	1114	114	626	144	****	205143								
	Depreciation	82	29	70	1880	155	197	****	262409								
	Wage	34620	10658	7485	12916	6102	2289	****	1071025								
	Profits	194099	63163	167542	118996	21938	18304	****	2236703								
	Value added Total	220981	73399	176211	133906	28821	20934	****	3775280								
Total Products		332076	99636	200727	271967	33751	26249	****	6687757								

("****" shows the sectors omitted to list)

Table 3 Agriculture Based Input Output Table(1996) (unit: billion Turkish Lira, 1996)

		Intermediate Demand Sector								Final Demand Sector							Total Production
		Grain	Vegetable	Fruits	Livestock	Forestry	Fisheries	****	Intermediate Demand Total	Private Consumption	Public Consumption	Private Investment	****	Export	Final Demand Total	(-)Import	
Intermediate Input Sector	Grain	97251	0	0	289980	472	0	****	886723	231000	25410	0	****	73441	418655	-128576	1176803
	Vegetable	0	2171	0	0	0	143	****	34256	318000	6590	0	****	8141	334304	-3245	365314
	Fruits	0	0	25127	0	0	46	****	93278	554000	12883	0	****	73118	673231	-9661	756848
	Livestock	470	15609	5071	41118	22	0	****	235783	478000	504	5569	****	8455	640598	-17866	858515
	Forestry	0	1300	0	0	1481	22	****	85686	18845	1306	0	****	350	20503	-11819	94370
	Fisheries	0	265	0	0	0	672	****	9418	89888	22	0	****	1972	92494	-135	101777
	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
	Intermediate Input Total	444000	102000	93655	448245	12956	23924	****	11752352	9840000	1711286	3130000	****	3650000	19966954	-4133894	27585412
Value Added	Tax	-97000	-5615	13866	8583	2477	900	****	586262								
	Depreciation	25767	9034	22136	13764	401	690	****	837440								
	Wage	104000	32059	22514	41927	24943	8018	****	3234567								
	Profits	701000	228000	604674	345994	53590	68242	****	11174788								
	Value added Total	733000	263000	663192	410269	81413	77852	****	15833059								
Total Products		1176803	365314	756848	858515	94370	101777	****	27585412								

("****" shows the sectors omitted to list)

In this Figure 1, Quadrant 1 shows combination of both coefficients of bigger than one. Quadrant 2 shows combination of the responsive coefficient bigger than one and influence degree coefficients less than one. Quadrant 3 shows combination of both coefficients less than one. Quadrant 4 shows combination of responsive coefficients less than one and influence degree coefficient bigger than one. Most of rural industries except grain and livestock sectors are located in the Quadrant 3, which indicates that those rural industries are isolated minor industries separated from the other industrial activities. However, only grain sector is located in Quadrant 2 indicating that grain sector is more responsive to the whole economic activities than the average and less influencial to the whole economy. Only livestock industry is located in Quadrant 4 indicating that the livestock industry is in the situation closer to the other industrial sector among the rural sectors. In addition to these, figure 1 shows the shifts of each sectors from 1985 to 1996. Most of rural industries except fishery have shifted to the different direction between the first half period and latter half period. But all of rural industries remained within the same Quadrant.

2) Inducement coefficients

The production inducement coefficients are derived as follows from equation (2),

$$\Delta X \;=\; (I - A)^{-1}\Delta F \qquad (5)$$

Similarly, the import inducement coefficients are derived from (5),

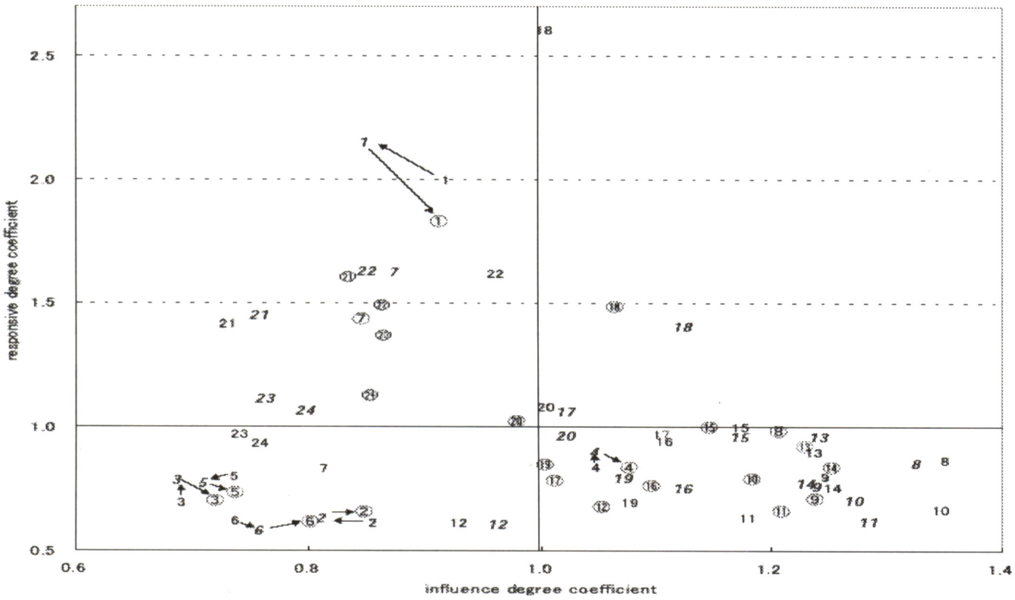
$$\Delta M \;=\; m\Delta X \;=\; m(I - A)^{-1}\Delta F \qquad (6)$$

the value added inducement coefficients are derived from (5) ,

$$\Delta V \;=\; v\Delta X \;=\; v(I - A)^{-1}\Delta F \qquad (7)$$

Here, m is the import coefficients (import / production ratio) and v is the value added coefficients (value added / production ratio).

Figure1: Influence & Responsive Degree Coefficients (1985⇒1990⇒1996)



1.grain	2.vegetable	3.fruits	4.livestock
5.forestry	6.fishery	7.coal/oil/minings	8.food processing/dairy
9.fat	10.flour/bread/cake	11.sugar	12.tabaco/alcohl/beverage
13.textile	14.leather/shoes	15.wood product/paper	16.fertilizer
17.medicine	18.nonmetal materials/metal materials	19.machine/cars/furniture	20.utilities/construction
21.retail	22.transport	23.finance	24.administration

Those inducement coefficients in 1985, 1990 and 1986 are shown in the following Figures 2. From these figures, at least two points are pointed out. One is that the industrial structure have not changed substantially during these period from 1985 to 1996. Another point is that Inducement coefficients are much smaller in rural sectors than the other sectors and those in service sectors are much bigger.

3) Skyline Analysis

In the equation (2), $\{X = (I - A)^{-1} F\}$, the final demand vector (F) consists of domestic demand vector (D), export vector (E) and the import vector (M). Here, D is sum of consumption (C), investment (I) & government (G). So, this formula can be rearranged as follows.

$$X = (I-A)^{-1} \{ (C+I+G)+E-M \}$$
$$= (I-A)^{-1} \{ D+E-M \}$$
$$= Xd + Xe + Xm \ldots\ldots\ldots\ldots\ldots (8)$$

From this formula, the 4 indicators of production ratio (Xi / X), self-sufficiency rate (Xid / X), export ratio (Xie / X) and import ratio (Xim /X) are derived as shown in Figure 3. From these figures, following points are pointed out.

(i).Industrial structure has not changed substantially during sample period 1985-1996.

(ii).Rural industries are less important and tertiary sectors are more increasingly important in terms of production ratio.

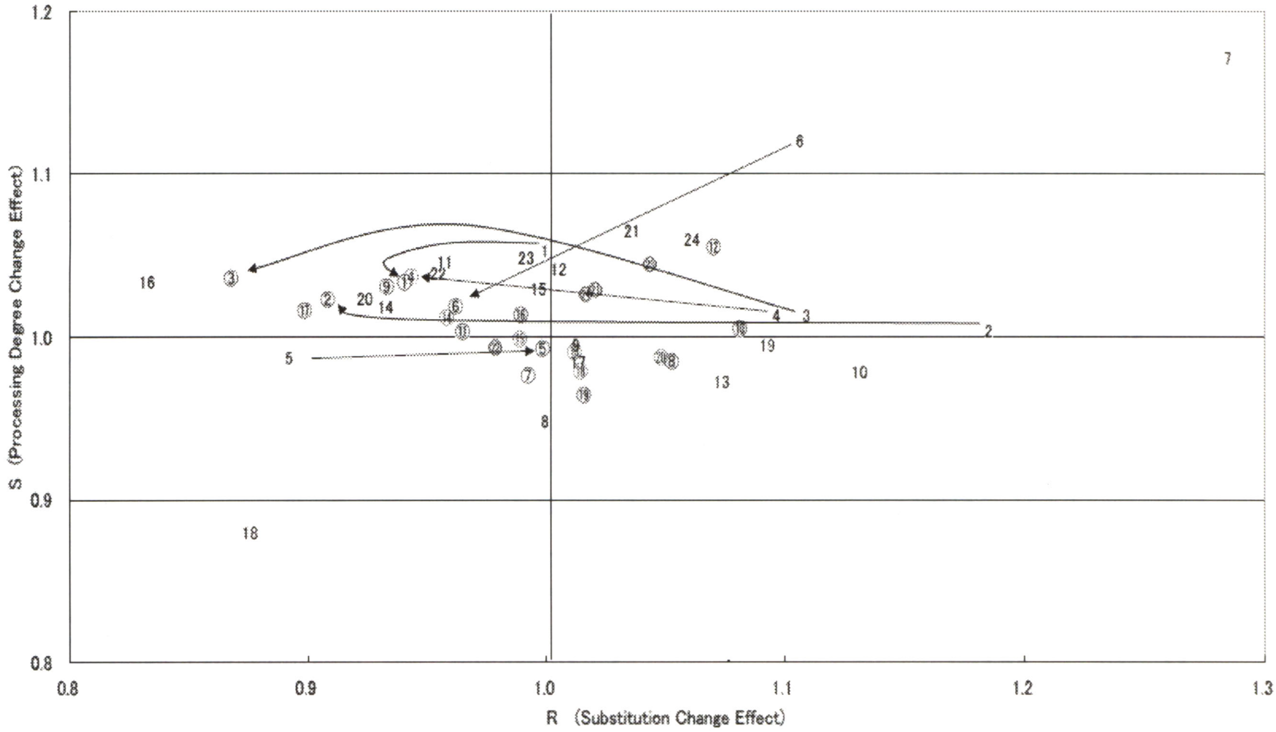
(iii). Among rural industries, grain and livestock sector decreased self sufficiency rate while forestry sector increased.

4. Prediction of Input Coefficient by RAS method

1). Estimation of R (substitution change coefficient) & S (processing degree change coefficient),

In order to predict the Input Coefficient matrix, the following relation are utilized. Here, matrix A is the original input coefficient matrix at base year T and matrix A' is the coefficient matrix at predicted year T+m.

Figure 4 Shift of Substitution Change Effect and Processing Degree Change Effect from 1985-90 to 1990-96



1.grain	2.vegetable	3.fruits	4.livestock
5.forestory	6.fishery	7.coal/oil/minings	8.food
9.fat	10.flour/bread/cake	11.sugar	12.tabaco/alcohl/beverage
13.texitile	14.leather/shoes	15.wood product/paper	16.fertilizer
17.medicine	18.nonmetal materials/metal materials	19.madecine/cars/furniture	20.utilities/construction
21.retail	22.transport	23.finance	24.administration

$$\begin{bmatrix} r_1 & 0 & 0 & 0 \\ 0 & r_2 & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & r_n \end{bmatrix}^m \bullet \begin{bmatrix} a_{11} & \cdots & \cdots & a_{1n} \\ \vdots & a_{22} & & \vdots \\ \vdots & & \ddots & \vdots \\ a_{n1} & \cdots & \cdots & a_{nn} \end{bmatrix}_{t=T} \bullet \begin{bmatrix} s_1 & 0 & 0 & 0 \\ 0 & s_2 & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & s_n \end{bmatrix}^m = \begin{bmatrix} d_{11} & \cdots & \cdots & d_{1n} \\ \vdots & d_{22} & & \vdots \\ \vdots & & \ddots & \vdots \\ d_{n1} & \cdots & \cdots & d_{nn} \end{bmatrix}_{t=T+m}$$

By solving the above relation of the RAS method, matrix R and S are derived. Here, matrix R is row wise correction matrix of the original input coefficient matrix A and it indicates the substitution change effect matrix. Similarly, matrix S is column wise correction matrix of A and it indicates the processing degree change effects matrix. In other word, the elements r_i of matrix R show the increase rate of intermediate demand for sector i by every sector. The elements s_i of matrix S show the increase rate of intermediate input in sector i from every sector. Therefore, the sectors with combination of r_i bigger than one and s_i smaller than one can be considered as the growing sectors while the sectors with combination of r_i less than one and s_i bigger than one can be considered as the declining sectors. In this way, each sectors can be categorized as shown in Figure 4. In addition, Figure 4 shows the shift of each sector from beginning half period to the latter half period. From this observation, the dynamic phase change of each sector can be analyzed.

Table 4 Estimation of Input Coefficient Function

Grain

Variables	Coeff	t-value	p-value
const.	-5320.633	-5.90	0.010
RainK	0.268	1.70	0.189
TempK	6.527	2.34	0.101
RainA	-0.038	-0.30	0.786
TempA	-9.018	-2.24	0.111
DMdt	-25.913	-5.90	0.010
DM93	2.499	0.59	0.598
DM94	-2.186	-0.31	0.775
DM99	2.190	0.54	0.624
DM01	-7.015	-1.31	0.282
year	2.741	6.06	0.009

R^2(adj)= 0.791 DW= 1.807

Vegetable

Variables	Coeff	t-value	p-value
const.	-1266.381	-16.16	0.001
RainK	0.014	1.04	0.374
TempK	0.076	0.31	0.774
RainA	-0.019	-1.71	0.185
TempA	0.091	0.26	0.811
DMdt	-2.284	-5.99	0.009
DM93	-0.939	-2.54	0.085
DM94	0.267	0.44	0.690
DM99	-0.395	-1.13	0.340
DM01	0.149	0.32	0.770
year	0.649	16.52	0.000

R^2(adj)= 0.983 DW= 1.997

Fruit

Variables	Coeff	t-value	p-value
const.	-1059.882	-6.87	0.006
RainK	0.042	1.57	0.215
TempK	1.194	2.51	0.087
RainA	-0.006	-0.27	0.806
TempA	-1.636	-2.38	0.098
DMdt	-5.778	-7.69	0.005
DM93	0.584	0.80	0.481
DM94	-0.356	-0.30	0.786
DM99	0.150	0.22	0.841
DM01	-1.427	-1.56	0.217
year	0.548	7.08	0.006

R^2(adj)= 0.863 DW= 1.863

Livestock Product

Variables	Coeff	t-value	p-value
const.	-1408.864	-5.87	0.010
RainK	0.059	1.41	0.253
TempK	2.000	2.70	0.074
RainA	-0.001	-0.03	0.976
TempA	-2.805	-2.62	0.079
DMdt	-7.673	-6.57	0.007
DM93	1.458	1.29	0.288
DM94	-0.729	-0.39	0.722
DM99	0.190	0.18	0.871
DM01	-2.636	-1.85	0.162
year	0.749	6.23	0.008

R^2(adj)= 0.829 DW= 2.008

Forestry

Variables	Coeff	t-value	p-value
const.	-89.595	-0.78	0.494
RainK	0.033	1.65	0.197
TempK	0.869	2.44	0.093
RainA	-0.003	-0.19	0.862
TempA	-1.223	-2.38	0.098
DMdt	-3.103	-5.52	0.012
DM93	0.473	0.87	0.449
DM94	-0.276	-0.31	0.778
DM99	0.296	0.57	0.606
DM01	-0.973	-1.42	0.251
year	0.059	1.02	0.381

R^2(adj)= 0.892 DW= 1.878

Fisheries

Variables	Coeff	t-value	p-value
const.	-9328.142	-3.54	0.038
RainK	0.770	1.67	0.193
TempK	19.237	2.37	0.099
RainA	-0.064	-0.17	0.874
TempA	-27.104	-2.31	0.104
DMdt	-66.717	-5.21	0.014
DM93	9.687	0.78	0.492
DM94	-7.405	-0.36	0.741
DM99	7.884	0.67	0.550
DM01	-21.098	-1.35	0.270
year	4.850	3.68	0.035

R^2(adj)= 0.734 DW= 1.863

From this Figure 4, the following points are indicated.

(i)Rural industries show characteristics of declining sector in that most of them has substitution change coefficient R<1 and processing degree coefficient S>1 for latter half period 1990-96.

(ii) Forestry sector shows both coefficient R and S less than one and moved to the average one.

(iii) All other rural sectors shifted from region I (R>1 and S>1) to the region II (R<1 and S>1)

2). Prediction of Input Coefficient and Impact of Climate Factors on Agricultural Productivities.,

By multiplying R and S to the Input Coefficient Matrix in the base year, time series of the input Coefficient Matrix are obtained. The reverse of input coefficient indicates productivity or efficiency of input in each sector. Then, the following regression equation are estimated to investigate impacts of climate factors on agricultural productivity.. Table 4 shows the results of this regression analysis. According to the major statistical criteria such as adjusted determination coefficient, Durbin Watson ratio and t-value, considerably good results are shown for all of rural industries. Among error terms, serial correlations were not observed and most of coefficient estimates are statistically significant.

$$a_j = a_{(\Sigma i)j} = f(Prec, Temp, DM,...)$$

Here, a_j ; Input Coefficient in Sector j

Prec ; Precipitationin Konnya, Adana

Temp; Temperature in Konnya, Adana

DM; dummy variable corresponding to difference in data source, abnormal weather, etc

Figure 5 shows comparison of the predicted and actual input coefficients in the above regression results for all 6 rural industries. It shows that most of prediction series follow the actual series very well although there are rather big discontinuities of the data series in the middle of the prediction period (i.e. before and after 1996) reflecting the difference of data source. Such discontinuity is bigger in the case of grain, livestock and fishery than the case of fruit and forestry. And it is very small in the case of vegetable. As a whole, as shown by the statistical validation test, it is confirmed that most of the estimation results are reliable.

Also, Figure 6 indicates the relation between climate factors such as precipitation and temperature in Konnya and Adana regions on input coefficients in grain sector. Due to space limitation, the figures for other rural industries such as vegetable, fruit, livestock, forestry and fisheries are omitted from this report although all of these were actually calculated. However, they have shown almost similar pattern to the situation of grain sector.

5. Some Implications at This Stage

From the above estimation and prediction results, as for the relation among the agricultural productivities and climate factors, the following points are observed.

(i) For grain, fruit, livestock product, forestry and fisheries, temperature in Konnya (+) and Adana (-) affect significantly but differently.

(ii) For vegetable, climate change in both area does not affect significantly.

(iii) Temperature affects most significantly on livestock products, secondly on fruit. Next, forestry, fisheries and grain follow in this order.

(iv) Precipitation in both areas does not affects for any rural industries significantly.

(v) For all cases, Temperature in Konnya affects more significantly than those in Adana.

(vi) For all cases, significant trend effects are observed.

6.Reference

[1] Masaru KAGATSUME, "Input Output Analysis on the Environmental Resources Conservation in Rice Growing Areas in Australia",Journal of Oceania Economy Studies], No.7, October, 1993, Association of Oceanian Economic Studies

[2] Masaru KAGATSUME, "Global warming and methane emission from the rice growing", The Farm Accounting Studies, No.24, December 1991

[3] Lashof, D & Tirpak, D., "Policy options for stabilizing global climate" (draft), US. EPA, Washington, DC., 1989

[4] Yuzuru MATSUOKA, "Effects estimation model of global warming alleviation measures", Environmental Research, No.77, 1990

[5] State Institute of Statistics Prime Ministry Republic Of Turkey, The Input-Output Structure of The Turkish Economy, 1996

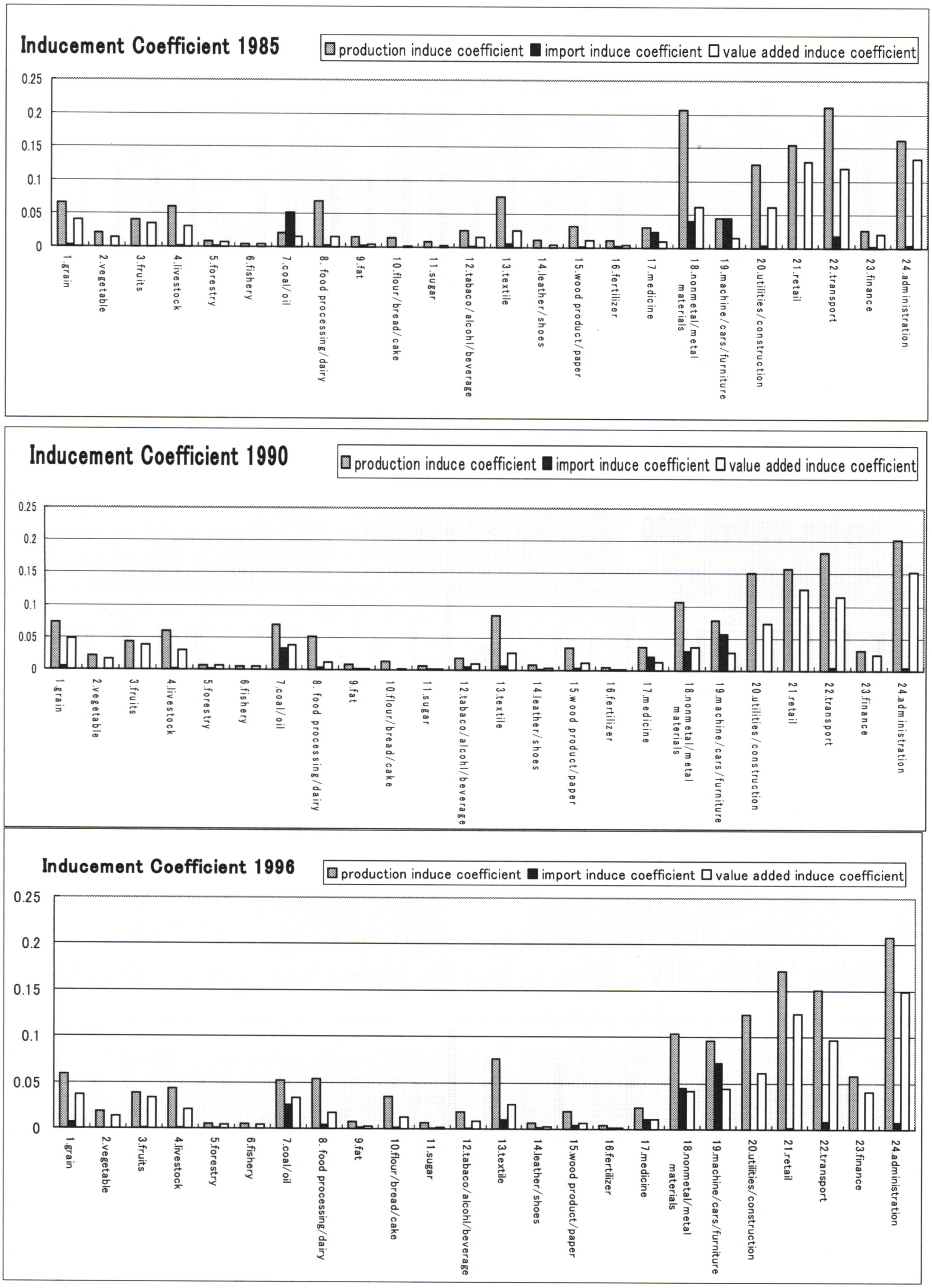


Figure 2 Inducement Coefficients in 1985, 1990 and 1996

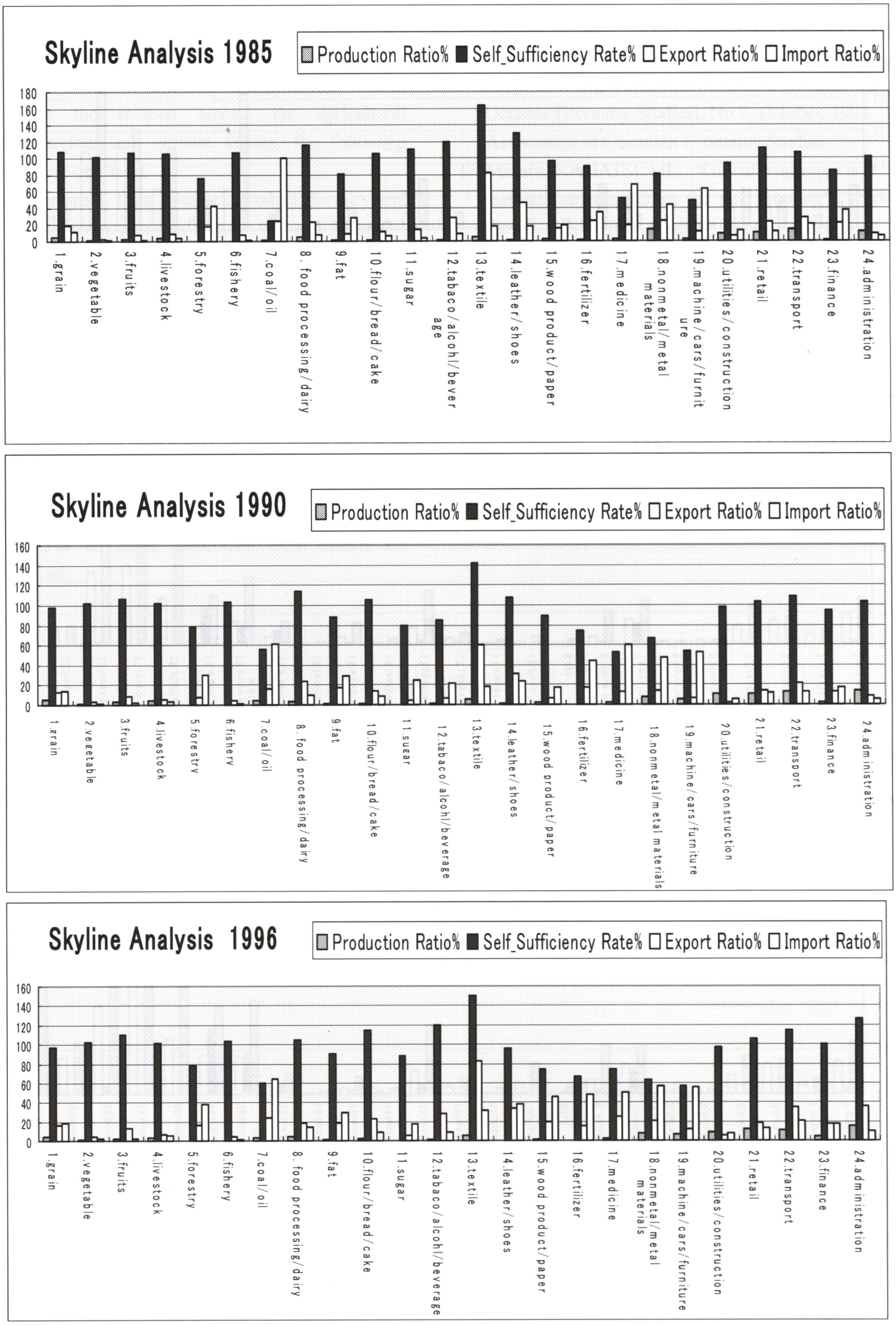


Figure 3 Industrial Structures in 1985, 1990 and 1996

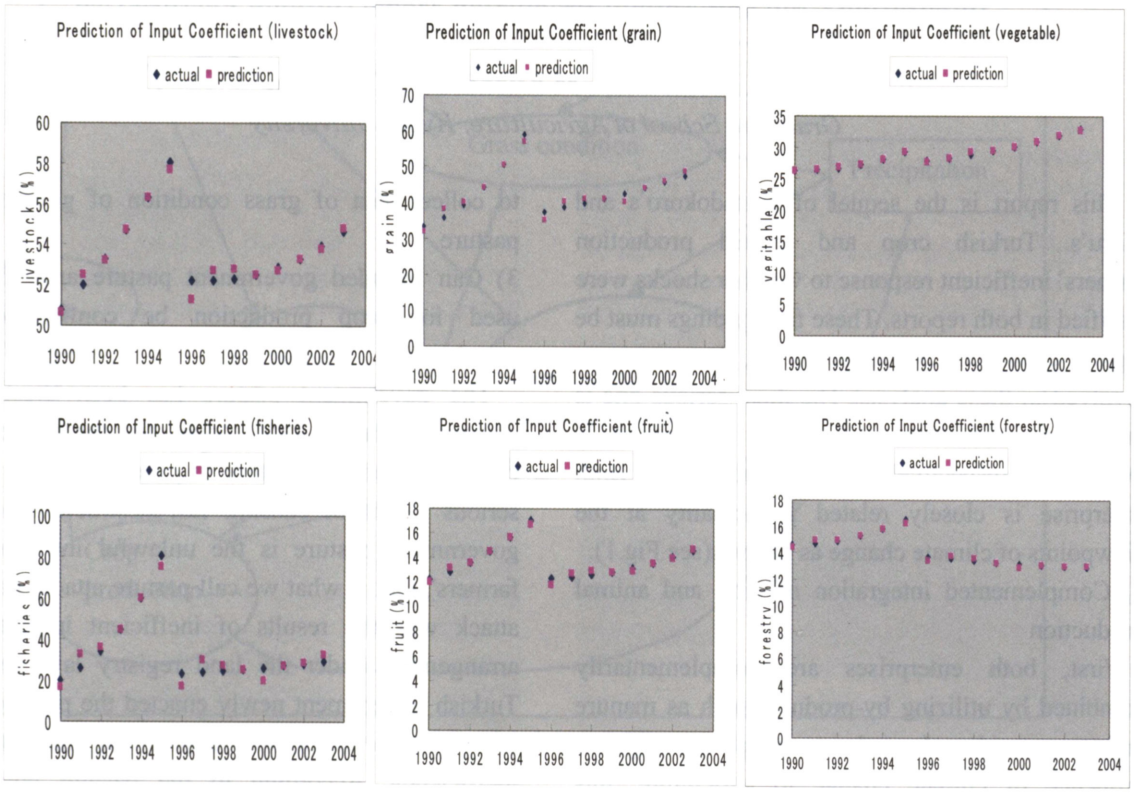


Figure 5 Prediction of Input Coefficient in Rural Industries

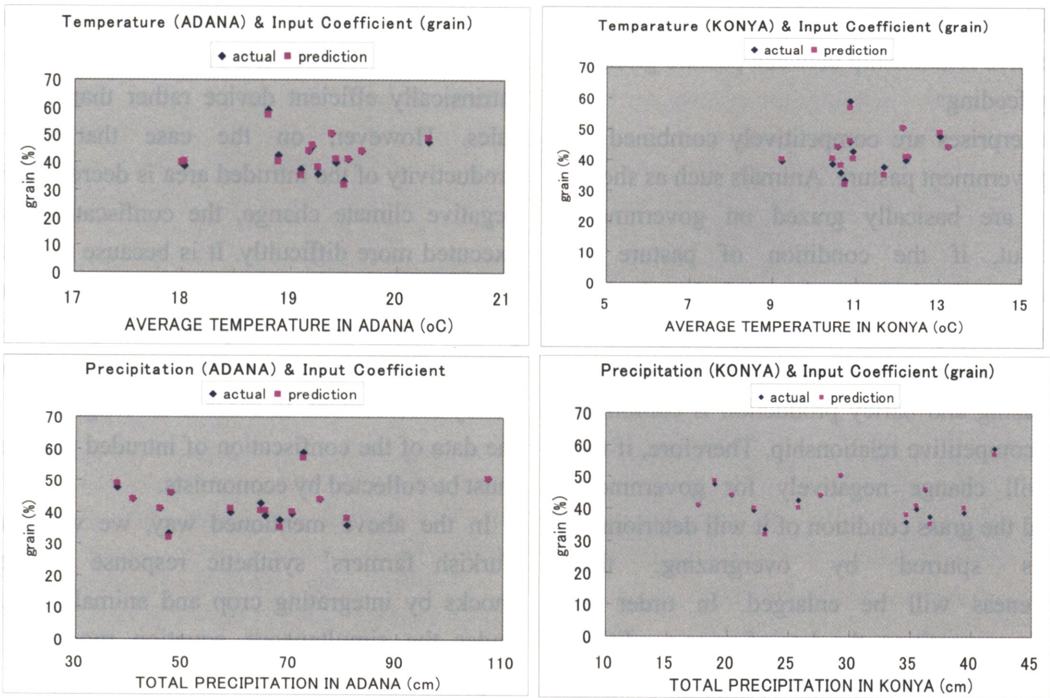


Figure 6 Climate Change Effect on Input Coefficient in Grain