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ALTERNATIVE AGRICULTURAL POLICIES IN KOREA

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Highlights

Unlike the previous rounds of the GATT negotiations, the Uruguay round of the GATT negotiations has been dominated by trade issues related to agricultural products. The United States proposed elimination of all agricultural policies which distort trade flows of agricultural products over a ten year period. This proposal also includes the "tariffication" concept whereby all current agricultural nontariff barriers be converted to fixed tariffs and then reduced gradually over the period. In addition, the United States has been promoting free trade of agricultural products through bilateral negotiations with major importing countries such as Japan and Korea. The outcome of the current GATT negotiations is uncertain. It is, however, certain that agricultural products trade will be freer than before. This implies that trade flows of agricultural products will be determined on the basis of the principle of comparative advantage.

Under the given circumstance, Korea may not be able to maintain its traditional protectionist agricultural policies. There would be substantial reductions in agricultural production and farm income in Korea if the Korean government liberalizes its domestic market. Korea needs an agricultural policy which optimizes its agricultural sector.

The primary objective of this paper is to evaluate alternative agricultural policies the Korea government can use under free trade environment and implications on the Korean agricultural sector.

A spatial equilibrium model based on a mathematical programming algorithm is developed to evaluate the policy alternatives. The model includes four crops; rice, wheat, corn, and soybeans. Korea is divided into 36 producing regions and 18 consuming regions. The model also contains 3 import ports and 8 major exporting countries. The objective function of the model is to minimize production costs of the crops in producing regions, domestic transportation costs in shipping the crops from producing regions to consuming regions, and import costs of the crops from exporting countries to Korea. The objective function is optimized subject to the following constraints; 1) arable land in each producing region, 2) domestic demand for the crops in each consuming region, 3) equilibrium condition in each producing region, and 4) inventory clearing condition at each port.

This study reveals that Korea should place more emphasis on optimization of production and import patterns for crops rather than the rice self-sufficiency policy. Optimizing agricultural production based on the principle of comparative advantage will reduce substantially production costs and improve its competitiveness in producing agricultural products.

Since the Korean agricultural sector plays an important role, liberalization of agricultural trade should take place gradually over the extended time period to avoid impairment of the country's overall economic growth. The Korean government should adopt a producer subsidy system similar to the target price program used in the United States to protect the Korean agricultural sector. A combination of the farm subsidy program and import tariffs will provide the same extent of protection to the Korean agricultural sector but the government outlays for the program will be much smaller than *the program without import tariffs. The import tariffs should be reduced gradually at an annual rate similar to the industrial growth rate to maintain the economic growth in Korea.*

Korea will increase substantially its imports of agricultural commodities in the future because 1) the domestic prices of agricultural commodities will be reduced to the world prices under this subsidy program and 2) continuous increases in pasta and meat consumption require increased demand for wheat, soybeans, and corn as personal income increases. Thus, the proposed policy is beneficial to both Korea and agricultural exporting countries.

Liberalization of agricultural trade should take a place in Korea in such a way that liberalization does not disrupt economic growth in that country. This is also true in developing countries whose agriculture is not competitive, but plays an important role.

Alternative Agricultural Policies in Korea

Won W. Koo and Kyu D. Cho[‡]

I. Introduction

Korea has a comparative disadvantage in producing most agricultural products, including livestock, compared to agricultural exporting countries such as the United States, Canada, Argentina, and Australia. The Korean government has used protectionist trade policies for agricultural products to protect its agricultural sector. The rice self-sufficiency policy and restrictions on beef imports are classic examples of protectionism employed by the Korean government. Although Korea is industrialized, the Korean agricultural sector plays an important role, contributing about 7 percent to the Korean GDP in 1987. The farm population was about 18.5 percent of the total population.

Unlike the previous rounds of the GATT negotiations, the Uruguay round has been dominated by trade issues related to agricultural products. The United States proposed eliminating all agricultural policies which distort trade flows of agricultural products over a 10-year period. It also incorporates the "tariffication" concept whereby all current agricultural nontariff barriers would be converted to fixed tariffs and then reduced gradually over the period. The proposal has received general support from the Cairns group but been rejected by the EC member countries. The outcome of the current negotiations of the GATT is uncertain. It is certain, however, that agricultural product trade will be freer in the future. In addition, the United States has been promoting free trade of agricultural products through bilateral negotiations with major importing countries including Japan and Korea. This implies that future trade flows of agricultural products will be determined largely on the basis of the theory of comparative advantage.

Under the given circumstances, Korea may not be able to maintain its traditional protectionist agricultural polices. Agricultural production and farm income in Korea would be reduced substantially if the government abandons its traditional agricultural policies. Such a change in the agricultural sector could be a significant factor impairing overall economic growth in Korea. This is not only Korea's unique problem, but also a common prolem of all developing countries whose agricultural sectors have comparative disadvantage over agricultural exporting countries but play an important role in their economy.

The objective of this paper is to evaluate the impacts of alternative agricultural policy options under free trade on production, domestic consumption, and imports of agricultural products in Korea. Comparative advantage in producing agricultural commodities is evaluated in terms of production and marketing costs in Korea. This study uses a spatial equilibrium model based on a mathematical programming algorithm.

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2. An Overview of Korean Agriculture

Korean agriculture may be described best as semi-subsistence production in the small rice farm economy of the Monsoon area. Korea is geomorphologically characterized by abundant hills and mountains which occupy nearly 70 percent of its total territory.

Table 1 shows the general situation of the Korean agricultural economy. Only 21.6 percent of the total area, approximately 2.1 million hectares, was cultivated intensively. About 1.9 million farm families were engaged in farming with an average arable land of 1.15 hectares (2.84 acres) in 1987. The farm population decreased from 15.8 million (55.1 percent of total population) in 1965 to 7.8 million (18.5 percent) in 1987.

TABLE 1. LAND UTILIZATION, FARM HOUSEHOLDS, AND FARM POPULATION IN KOREA, SELECTED YEARS

Item	1965	1970	1975	1980	1985	1987
Total land (A) (1000 ha)	9,843	9,848	9,881	9,899	9,914	9,992
Arable land (B) (1000 ha)	2,256	2,298	2,240	2,196	2,144	2,143
Percentage (B/A)	22.9	23.3	22.7	22.2	21.6	21.6
Number of farms (1000 households)	2,507	2,483	2,379	2,156	1,926	1,871
Acreage per farm (hectares)	0.90	0.93	0.94	1.02	1.11	1.15
Total population (1000 people) (C)	28,705	32,241	35,281	38,124	40,806	41,575
Farm population (1000 people) (D)	15,812	14,422	13,244	10,827	8,521	7,771
Percentage (D/C)	55.1	44.7	37.5	28.4	20.8	18.5

SOURCE: Handbook of Agricultural Statistics, 1988, Korea.

Most Korean farmers grow a variety of crops such as rice, barley, wheat, corn, soybeans, potatoes, sorghum, millet, buckwheat, and sweet potatoes. Korean farming could be described as a self-supporting agricultural economy. Korea has suffered from food shortage and low farm income. Promoting food self-sufficiency and increasing farm income have been primary objectives of agricultural policy. Great efforts have been directed toward increasing agricultural productivity, especially rice production.

Paddy fields on which rice is grown have annually increased through land reclamation and transformation of the uplands since 1970. In contrast, total arable land and planted acreages for barley, wheat, corn, and soybeans have decreased since 1970. This trend is due mainly to the expanded investment in rice production, increased nonfarm use of land, and low profitability in production of barley, wheat, corn, and soybeans.

As shown in Table 2, the ratio of planted acres of rice to total planted acres increased from 34.6 percent in 1970 to 48.6 percent in 1987. The ratio of planted acres of barley to total planted acres decreased from 21.0 percent in 1970 to 6.2 percent in 1987. Barley, which was once a major staple food, has been substituted continuously for rice as rice production continues to increase. Today, barley has almost disappeared from the Korean diet.

TABLE 2. UTILIZATION OF TOTAL ARABLE LAND IN KOREA, SELECTED YEARS

Item	1965	1970	1975	1980	1985	1987
	---1,000 Ha---					
Rice (A)	1,228	1,203	1,218	1,233	1,238	1,262
Other Crops:						
Barley	827	730	708	297	165	160
Wheat	93	97	44	28	3.1	1.2
Corn	49	47	32	35	26	26
Other grains[a]	178	83	50	53	88	56
Edible beans[b]	362	358	324	244	196	212
Vegetables	151	255	246	368	356	308
Fruits	43	60	74	99	109	114
Others[c]	629	645	448	408	411	459
Planted acres (B)	3,560	3,478	3,144	2,765	2,592	2,598
Ratio of rice acres to total acres (A/B) (%)	34.5	34.6	38.7	44.6	47.8	48.6

[a]Other grains represents sorghum, buckwheat, millet, hop, rye, and oats.
[b]Edible beans contain soybean, red bean, mung bean, kidney bean, and other beans.
[c]Others include potatoes, peanuts, sesame, medicinal plants, sericulture, forage, etc.

SOURCE: (1) Handbook of Agricultural Statistics, Each Year, Korea.
(2) Agricultural Statistics Yearbook, 1988, Korea.

Planted acres of wheat, corn, and soybeans have decreased mainly because the production of these crops is not profitable even though demand for those crops has increased with changes in consumption patterns in Korea.

The Korean government has adopted a policy of increasing the production of rice to a self-sufficiency level since the 1950s. The strategies for self-sufficiency in rice production include the following policy instruments:

1. Developing and distributing new high yielding varieties (the "Green Revolution"),

2. Increasing use of improved agricultural inputs,

3. Improving irrigation and drainage facilities and consolidating arable land,

4. Expanding financial support and loans for farm inputs such as machinery, fertilizer, chemicals, and pesticides, and,

5. Protecting the agricultural sector from foreign competitors.

To narrow the income gap between rural and urban areas, the Korean government has carried out a policy of high price support for rice since the end of the 1960s. The policy is characterized by the Double Rice Price System--a high purchase price from farmers and low release price to consumers.

Rice is the most important food crop grown by a majority of small farmers. In 1987, Korea used 71.1 percent of its total planted food-crop land for rice production (Table 3). This rice production represented 82.1 percent of total production of food crops and generated 87.9 percent of farm revenue obtained from food crops in 1987. However, rice accounted for only 34.3 percent of the total crop consumption in 1987 while wheat accounted for 27.7 percent, corn 22.9 percent, soybeans 7.5 percent, and other food crops (including barley) 7.7 percent.

The increased wheat, corn, and soybean consumption is due mainly to changes in the food consumption pattern, which is characterized mainly by increased pasta consumption and increased consumption of livestock products as a result of increases in disposable income. The increased consumption of livestock products increased demand for feed grains. In the early 1960s when livestock was raised as a sideline, most animal feed came from farm by-products. As livestock production became a more prominent activity, farmers increasingly used grain-based feeds. Only 320 thousand tons of wheat, corn, and soybeans were used for feed in 1970; however, the amount rose to 6,671 thousand tons in 1987 (Livestock Handbook and Feed Bulletin).

Since domestic production of wheat, corn, and soybeans was insufficient for food use, a rapid increase in imports of wheat, corn, and soybeans was the only way to meet increased demand for the grains. As the demand for livestock products is expected to expand in the future, increasing imports of these commodities should be expected.

The increasing gap between the domestic supply of and demand for wheat, corn, and soybeans has made it inevitable for Korea to rely on a large quantity of grain supplied from imports. In 1987, Korea produced 9.2 million metric tons of grains, including carryover stock from the previous year, and imported 10.15 million metric tons. Domestic supply of the crops was 47.4 percent of total demand.

TABLE 3. CONTRIBUTION OF RICE TO AGRICULTURAL ECONOMY IN KOREA, 1987

Item	Used Land 1000 Ha	%	Production 1000 mt	%	Consumption[a] 1000 mt	%	Farm Revenue[b] 1000 wons	%
Rice	1,262	71.1	5,493	82.1	5,618	34.3	2,920	87.9
Barley	160	9.0	388	5.8	325	2.0	99	3.0
Wheat	1	0.1	4	0.1	4,545	27.7	-	-
Corn	26	1.5	127	1.9	3,749	22.9	49	1.5
Soybeans	154	8.7	203	3.0	1,225	7.5	117	3.5
Others[c]	172	9.7	473	7.1	939	5.7	136	4.1
Total	1,775	100.0	6,688	100.0	16,401	100.0	3,321	100.0

[a]Consumption includes food and feed grains on the basis of a crop year (November -October).
[b]Farm revenue represents the revenue per farm household generated from only food crops.
[c]Others contains potatoes, rye, red beans, sorghum, hop, buckwheat, sweet potatoes, and other grains.

SOURCE: Handbook of Agricultural Statistics, 1988, Korea.

The imports of wheat, corn, and soybeans are presumed to continue to increase. On the other hand, total rice consumption will not increase because per capita annual consumption of rice is decreasing (136.4 kilograms in 1970 to 126.2 kilograms in 1987) (Handbook of Agricultural Statistics).

3. Methodology and Model Development

A spatial equilibrium model based on a mathematical programming algorithm is developed to optimize domestic production and import patterns of agricultural products and to evaluate alternative agricultural policies on optimal production and import patterns. The model includes four crops; rice, wheat, corn, and soybeans. Korea is divided into 36 producing regions (Figure 1), and 18 consuming regions (Figure 2). The model also includes three import ports located in Korea and eight major exporting countries. The objective function of the model is to minimize production costs of the crops in the producing regions, domestic transportation costs in shipping the crops from producing regions to consuming regions, and import costs of the crops from eight exporting countries to Korea. Constraints imposed on the models are: 1) arable land in each producing region, 2) domestic demand for each crop in each consuming region, 3) a demand and supply equilibrium condition in each producing region, and 4) inventory clearing condition at each import port. The model forces the utilization of cropland at the 1987 level.

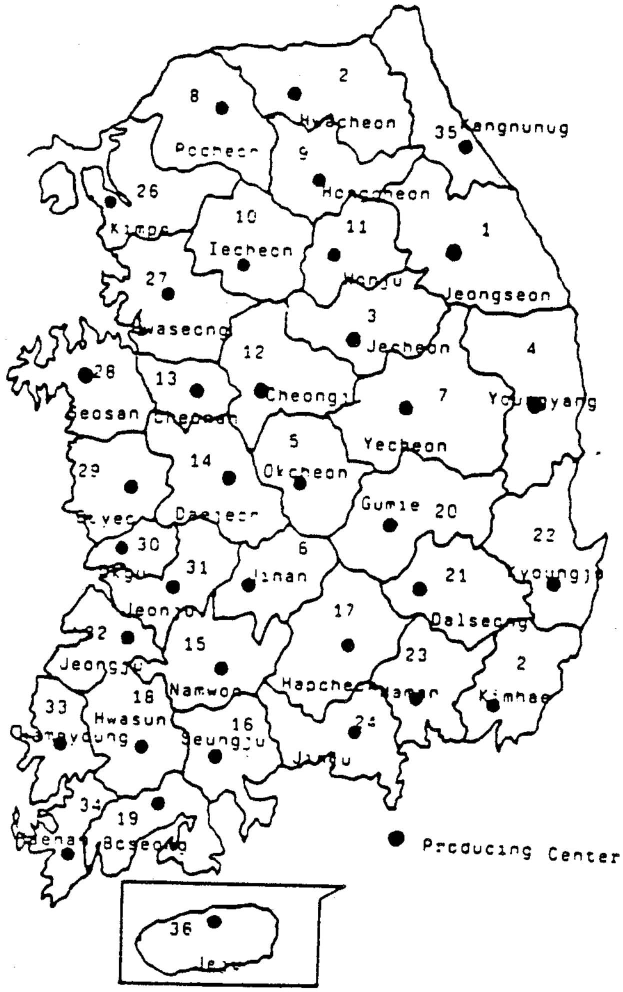

Figure 1. Crop Producing Regions in Korea

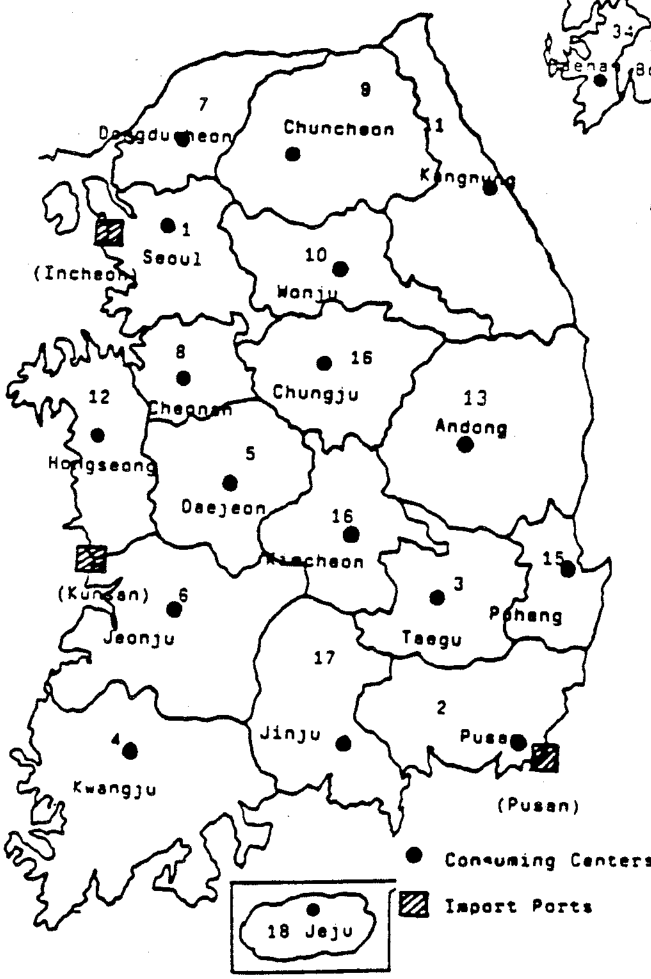

Figure 2. Consuming Regions and Import Ports in Korea

The Mathematical Model

The objective of the model is to minimize the total supply costs of rice, wheat, corn, and soybeans. The objective function is written as follows:

$$\text{Min } Z = \sum_{c=1}^{4}\sum_{i=1}^{36} L_{ci}.PC_{ci} + \sum_{c=1}^{4}\sum_{i=1}^{36}\sum_{j=1}^{18} TRC_{cij}.X_{cij} +$$

$$\sum_{c=1}^{4}\sum_{h=1}^{3}\sum_{j=1}^{18} TRM_{chj}.X_{chj} + \sum_{c=1}^{4}\sum_{e=1}^{8}\sum_{h=1}^{3} IP_{ceh}.X_{ceh} \qquad [1]$$

where c = index of crops. c = 1, 2, 3, 4

i = index of producing regions. i = 1, 2, ... 36

j = index of consuming regions. j = 1, 2, ... 18

h = index of import ports. h = 1, 2, 3

L_{ci} = number of hectares used in producing crop c in producing region i.

PC_{ci} = production cost of one hectare of crop c in producing region i.

TRC_{cij} = the transport cost per ton of crop c from producing region i to consuming region j.

X_{cij} = quantity in ton of crop c from producing region i to consuming region j.

TRM_{chj} = the transport cost per ton of crop c from import port h to consuming region j.

X_{chj} = quantity in ton of crop c from import port h to consuming region j.

IP_{ceh} = import cost per ton of crop c in import port h from exporting country e.

X_{ceh} = quantity in ton of crop c in import port h from exporting country e.

The objective function in Equation 1 is the summation of four separate activities. The first summation of Equation 1 represents production cost of each crop in producing regions measured in won per hectare. The second and third summations represent transportation costs of crops measured in won from each producing region and import port to consuming regions, respectively. The fourth summation represents the total import costs of each crop measured in won.

Optimal production, marketing, and importing activities will be determined by minimizing the objective function value subject to a set of linear constraints. Four linear constraints are placed on the above model as follows:

1) $$TL_i = \sum_{c=1}^{4} L_{ci} \qquad [2]$$

2) $$DD_{cj} = \sum_{i=1}^{36} X_{cij} + \sum_{h=3}^{3} X_{chj} \qquad [3]$$

3) $$\sum_{e=1}^{8} X_{ceh} = \sum_{j=1}^{18} X_{chj} \qquad [4]$$

4) $$L_{ci}.Y_{ci} = \sum_{j=1}^{18} X_{cij} \qquad [5]$$

where TL_i = total land available in producing region i.

DD_{cj} = demand for crop c in consuming region j.

X_{ceh} = quantity of crop c imported at import port h from exporting country e.

Y_{ci} = yield in ton of crop c in producing region i.

$L_{ci}.Y_{ci}$ = total production in ton of crop c in producing region i.

Constraint One represents the total land available in each producing region and is equal to the land used in producing the crops. The second constraint refers to the demand and supply equilibrium condition. That is, the total demand for crops in each consuming region is equal to total crops shipped from producing regions and from import ports to each consuming region.

Constraint Three is an inventory clearing condition which forces all crops imported to be shipped to consuming regions. Equation 5 is an internal storage condition, which implies that the total quantity of crops produced in each producing region should be consumed in consuming regions. In addition, upper bounds are imposed to restrict imports of the crops from exporting countries due mainly to production and export capacities in each exporting country.

The Base and Alternative Models

The base and three alternative models developed in this study are as follows:

1. Base model (Model 1) - Production, marketing, and trade activities of rice, wheat, corn, and soybeans are assumed to be the same as those in 1987. Arable land and demand constraints are assumed to be the same as those in 1987. All data used in this model are based on 1987 prices.

2. Model 2 - All activities and data used are the same as those in the base model with implementation of the rice self-sufficiency policy.

3. Model 3 - All activities and data are the same as those in the base model with implementation of a producer subsidy program similar to one in the United States (target price system). In this system, the domestic prices of crops are the same as the world prices and the government sets the support price of crops to protect the minimum farm income. Whenever the market prices fall below the support prices, the government pays the farmers the differences in the prices as a deficiency payment. This is similar to the target price system in the United States.

4. Model 4 - All activities and data are the same as those in the base model except domestic consumption of these crops. This model uses the projected demand in 2001.

4. Data Collection and Development

Total available land for the production of rice, wheat, corn, and soybeans was determined on the basis of the total planted acres in 1986. Lower bounds for rice production are calculated on the basis of the actual planted land for rice in 1986. Table 4 shows the total land available and the lower bounds for producing rice in each producing region.

The production cost used in this study is a variable cost, which does not include land cost. Data on production costs were obtained from Agricultural Statistics Yearbook and Farm Household Standard Income Estimate published by the Ministry of Agriculture, Forestry and Fishery (MAFF) and the Rural Development Agency (RDA).

The rice production costs are reported annually on a national basis and by farm sizes. The MAFF does not report the production costs of wheat, corn, and soybeans. Accordingly, this study used the RDA report of agricultural management costs of corn and soybeans in nine producing regions (Farm Household Standard Income Estimate). Wheat production costs were obtained from unpublished data of MAFF.

To get the rice production cost in each producing region, rice production costs in each province are calculated on the basis of production costs at the national level by size of farm. The production costs in counties, which are located in a province, are assumed to be equal to the production cost in the province. The rice production cost in a producing region is a weighted average level of the production costs in counties in the producing region. The weights used are a ratio of paddy fields in the counties to total paddy fields in the producing regions.

The production costs of wheat, corn, and soybeans in each producing region were calculated on the basis of the production costs in provinces. The production costs of wheat, corn, and soybeans in counties, which are located in a province, were assumed to be equal to those in the province. The production costs of these crops in a producing region are weighted average levels of the production costs in counties in the producing region. The weights used are ratios of harvest land of crops in the counties to total

TABLE 4. TOTAL LAND AVAILABLE AND LOWER BOUNDS FOR PRODUCTION OF RICE IN EACH PRODUCING REGION

Region	Available Land	Lower Bound
	------------hectares----------	
1	18,487	12,222
2	22,027	14,563
3	21,298	17,955
4	23,448	20,695
5	21,374	18,019
6	17,240	16,245
7	79,155	69,860
8	23,522	21,822
9	17,634	11,658
10	40,462	37,537
11	18,060	11,940
12	48,568	40,944
13	29,207	26,712
14	52,568	48,076
15	30,754	28,979
16	39,510	32,698
17	36,938	32,936
18	63,412	52,479
19	59,470	49,217
20	46,123	40,706
21	31,526	27,824
22	43,225	38,149
23	52,025	46,388
24	51,193	45,646
25	39,847	35,530
26	61,743	57,283
27	76,993	71,428
28	71,755	65,624
29	47,723	43,645
30	39,767	37,472
31	42,401	39,953
32	52,923	49,869
33	51,430	42,563
34	44,409	36,753
35	17,139	11,331
36	10,264	1,199
Total	1,443,621	1,255,918

SOURCE: Agricultural Statistics Yearbook, 1988, Korea.

harvest land of crops in producing regions. The formula used to calculate the production costs per hectare is as follows:

$$PC_{ci} = \Sigma \ W_{cji} PC_{cji} \qquad [6]$$

where PC_{ci} = production cost of crop c in producing region i.

W_{cji} = ratio of acres for crop c in county j which is a subset of producing region i.

PC_{cji} = production cost of crop c in county j which is a subset of producing region i.

Table 5 shows the production cost of each crop in each producing region. Table 6 shows the yields of the four crops by producing regions. Data on yields are obtained from Agricultural Statistics Yearbook, which reports national and provincial yields of crops calculated from three years' data, 1984-1986. The yields of crops in a province were assumed to be equal to those in counties, which are located in the province. Yields of crops in each producing region are average yields in counties which are located in a province.

Marketing Activities

Marketing activities include shipments of grain from producing regions and import ports to domestic consuming regions and foreign exporting countries to importing ports. Optimal marketing patterns are determined by relative transportation costs of railroad and truck.

Railroad transportation is implemented currently by the National Railroad Administration (NRA). The NRA imposes transportation costs on the freight with the following equation:

$$TRC = FR \cdot D/50$$

where TRC = transportation cost per metric ton by railroads.

FR = freight rate of a metric ton per 50 kilometer.

D = transportation distance from each producing center and import port to consuming centers.

The freight rate per 50 kilometers is classified into three categories: first, second, and third grades. The freight rate per 50 kilometers used in this study is based on the second grade rate (867 wons/ton).

The total railroad transportation costs finally were calculated by adding handling charges (100 wons/a 80 Kg. of sack) to the rail transportation costs calculated in Equation 7.

TABLE 5. PRODUCTION COSTS OF CROPS BY PRODUCING REGIONS IN KOREA

Region	Rice	Wheat	Corn	Soybeans
	---1000 wons/ha---			
1	2,205	942	1,062	853
2	1,955	961	1,187	909
3	1,958	942	1,125	885
4	2,085	929	1,077	869
5	2,033	968	1,142	886
6	2,085	999	1,143	898
7	1,924	975	1,062	853
8	2,049	961	1,188	909
9	1,907	934	1,188	909
10	1,940	961	1,136	880
11	1,862	934	1,136	880
12	1,882	1,001	1,183	900
13	1,880	1,019	1,212	901
14	1,981	995	1,158	882
15	2,027	990	1,149	940
16	2,050	991	1,149	940
17	2,085	1,005	1,131	921
18	1,962	977	1,152	938
19	1,921	980	1,150	954
20	1,905	991	1,106	896
21	1,933	998	1,119	921
22	1,909	998	1,119	921
23	1,900	1,007	1,119	921
24	1,909	1,006	1,147	949
25	1,977	1,007	1,119	921
26	1,894	1,045	1,316	979
27	1,875	1,019	1,212	907
28	1,890	1,042	1,289	903
29	1,927	1,008	1,221	912
30	1,863	996	1,221	912
31	1,937	973	1,221	912
32	1,892	976	1,152	938
33	1,862	977	1,152	938
34	1,871	980	1,150	954
35	1,946	878	1,060	840
36	1,952	996	1,254	880

SOURCE: (1) Agricultural Statistics Yearbook, 1988, MAFF.
(2) Farm Household Standard Income Estimate, 1988, RDA.

TABLE 6. YIELDS OF CROPS BY PRODUCING REGIONS IN KOREA

Region	Rice	Wheat	Corn	Soybeans
	---------------------------MT/ha---------------------------			
1	4.0983	3.1567	5.81	1.4717
2	4.0983	3.1567	5.81	1.4717
3	4.6560	3.1993	4.87	1.5429
4	4.4280	3.0733	3.9667	1.5659
5	4.6560	3.1933	4.87	1.5429
6	5.0025	2.6833	1.3333	1.3725
7	4.4280	3.0733	3.9667	1.5659
8	4.2709	3.1367	2.57	1.4337
9	4.0983	3.1567	5.81	1.4717
10	4.2709	3.1367	2.57	1.4337
11	4.0983	3.1567	5.81	1.4717
12	4.6560	3.1933	4.87	1.5429
13	4.7886	3.4633	1.2367	1.4359
14	4.7886	3.4633	1.2367	1.4359
15	5.0025	2.6833	1.3333	1.3725
16	4.3989	3.0333	1.5433	1.3667
17	4.0284	3.1	1.2067	1.5143
18	4.4148	3.0333	1.5417	1.4044
19	4.3989	3.0333	1.5433	1.3667
20	4.4280	3.0733	1.5433	1.3667
21	4.3666	3.2053	3.386	1.5851
22	4.4280	3.0733	3.9667	1.5659
23	4.0284	3.1	1.2067	1.5143
24	4.0284	3.1	1.2067	1.5143
25	3.9703	3.115	1.2078	1.4878
26	4.2563	2.9108	2.4901	1.4177
27	4.2709	3.1367	2.57	1.4357
28	4.7886	3.4633	1.2367	1.4359
29	4.7886	3.4633	1.2367	1.4359
30	5.0025	2.6833	1.3333	1.3725
31	5.0025	2.6833	1.3333	1.3725
32	5.0025	2.6833	1.3333	1.3725
33	4.3989	3.0333	1.5433	1.3667
34	4.3989	3.0333	1.5433	1.3667
35	4.0983	3.156	5.81	1.5429
36	2.6288	3.13	0.8033	1.0468

SOURCE: Agricultural Statistics Yearbook, 1988, MAFF.

Truck transportation costs are determined by estimating trucking costs. A medium sized truck is used commercially to haul grain from producing centers and import ports to consuming centers.

The cost for this truck is estimated on the basis of the following assumptions: 1) each year has 260 working days, 2) each working day has 10 working hours, and 3) the average trucking speed is 80KM per hour.

Total trucking costs per kilometer are estimated using the method presented by Koo and Thompson in their previous study (1982). The estimated trucking cost function is

$$TRC\ (won/MT) = 19.475612 + 19.475612\ D + H \qquad [8]$$

where D = transportation distance in Km.

H = highway toll.

Consumption Activities

Consumption activities refer to the actual consumption of the four crops in each consuming region. The demand for rice, wheat, corn, and soybeans in each consuming region is a function of the population and the capacity of processing facilities of foodgrains and assorted feed.

Rice is consumed only for food. Hence, demand for rice in each consuming region can be calculated by multiplying the total rice consumption by the ratio of the population in each consuming region to the 1985 total population (Korea Statistics Yearbook 1988, EPB). Total rice consumption at the national level was obtained from Handbook of Agricultural Statistics (MAFF). However, per capita annual rice consumption is different between rural and urban areas. Rice is consumed more in rural areas than in urban areas. The total demand for rice is divided into urban and rural consumption on the basis of urban and rural population. The demand for rice in each consuming region is calculated on the basis of urban and rural population in each consuming region (Table 7).

Wheat, corn, and soybeans are used as an input for food and assorted feed. The demand for these crops as food in each consuming region is calculated on the basis of population and the processing capacity in each consuming region.

Importing Activities

Importing activities refer to shipments of rice, wheat, corn, and soybeans from the exporting countries to import ports to supplement a shortage of domestic supply of the crops. The optimal import pattern is determined by the comparative advantage between Korea and exporting countries and by competitive advantage among the exporting countries. The comparative and competitive advantages are determined by the relative exporting price, which includes production cost, domestic transportation cost in exporting countries, ocean freights, and handling charges.

TABLE 7. DEMANDS FOR RICE, WHEAT, CORN, AND SOYBEANS BY CONSUMING REGIONS IN KOREA

Region	Rice	Wheat Food	Wheat Feed	Corn	Soybeans
	1000 MT				
1	1,851.2	1,073	734	2,192.1	1,214.8
2	768.8	1,020	286	600.1	26.2
3	349.5	0	96	155.8	11.7
4	570.0	180	118	192.9	16.7
5	301.2	0	133	213.1	9.5
6	333.1	0	180	303.2	9.8
7	110.0	0	107	168.5	3.1
8	127.7	0	177	278.4	3.8
9	72.9	0	0	1.0	2.1
10	83.5	0	83	181.7	2.4
11	132.7	0	47	75.6	4.0
12	185.5	0	70	111.8	4.9
13	156.1	0	42	67.1	4.3
14	118.0	0	28	45.8	3.3
15	100.5	0	42	66.6	3.1
16	105.8	0	42	66.6	3.1
17	181.7	0	75	164.5	5.2
18	70.1	0	13	20.7	2.2
Total	5,618.0	2,273	2,272	4,905.0	1,330.0

SOURCE: (1) Handbook of Agricultural Statistics, 1988, MAFF.
(2) Livestock Handbook and Feed Bulletin, 1988, MAFF.
(3) Korea Statistic Yearbook, 1988, EPB.

In this study, FOB prices of the four crops at major ports in exporting countries are obtained from Rice Situation and Outlook Report (USDA), Agricultural Outlook (ERS, USDA), and World Grain Situation and Outlook (FAS, USDA). CIF prices are obtained from Handbook of Agricultural Statistics (MAFF, Korea).

No source listed all the different ocean freight rates needed for the base L.P. model; therefore, the ocean freight equation which Koo and Drennan (1989) developed was used to calculate all ocean freight rates. They developed the ocean freight function using rates from 57 shipping routes reported in World Wheat Statistics (IWC 1985) and regressed these freight costs against one-way mileage over a three-year period, 1982-1984, to produce the following function:

$$OFC = 14.668312 + .0015590\ M \quad [9]$$
$$(5.890)$$

R^2 = .5329 d.f. = 26 ( ) = t value

where OFC is ocean freight rates for a route and M is one-way ocean mileage in the route. Distances between exporting ports and import ports were based on the publication of Distance Between Ports (Defense Mapping Agency 1985).

Handling charges at import ports are assumed to be 5 percent of the sum of FOB prices and ocean freight costs. In the United States, handling charges at export ports are assumed to be 5 percent of price at major milling centers. The import cost from each exporting country is calculated by summing up the FOB price, ocean freight costs, and handling charges.

Major rice exporting countries are Thailand and the United States. In 1987, total export volume of the two countries was 6,799 million MT, which was 53.4 percent of the world total export of rice.

In the United States, rice is produced mainly in California, the Gulf Coast, and the Delta. The Gulf port was chosen as an export port of rice in the United States. Average FOB prices at major milling centers such as Arkansas and Houston are obtained from Rice Situation and Outlook Report (USDA).

Domestic transportation costs from the milling centers to the Gulf port are calculated with the following equation, which is developed by Koo and Drennan (1989):

$$RC\ (75\text{-car}) = 8.0849 + .04141\ M. \qquad [10]$$

where RC is rail rates for a route and M is rail mileage in the route.

Major exporting countries of wheat are the United States, Canada, Australia, EC, and Argentina. The countries' total export volume in 1986/1987 was 84.7 million MT, 93.4 percent of world total exports.

Korea has imported wheat as a food grain from the United States, Australia, Canada, and Argentina. The U.S. export price is based on the FOB prices at Gulf ports (Agricultural Outlook, USDA).

In Canada, the FOB price of #1 CWRS Vancouver is used (Statistical Handbook 1988, Canada Grains Council). The FOB price at Buenos Aires is used as Argentina's export price (World Grain Situation and Outlook 1988, USDA). The export price of Australian wheat was based on the CIF price.

China, Australia, Canada, and EC are major import sources of wheat as a feed grain. The 1987 actual import costs on the basis of CIF plus handling charge at each import port were used as the import costs from these countries. The import costs were obtained from Handbook of Agricultural Statistics (MAFF, Korea).

The major exporting countries of corn used in this study are the United States, China, and Thailand. Argentina is excluded in this study because Argentina's corn has not been competitive in Korea.

The import cost from the United States is based on FOB at Gulf ports (FATUS). Actual import costs on the basis of CIF plus handling charges were used as import costs from Thailand and China because the data were not available.

Major exporting countries of soybeans are the United States, Brazil, and Argentina. The export volume in 1986/1987 of the three countries was 23.2 million MT. The exporting countries included in this study are the United States and Brazil.

The FOB price at the Gulf ports (FATUS) is used in this study. The import cost from Brazil is based on the 1987 actual import cost (CIF) plus handling charges at each import port.

5. Results

The major emphasis of analysis is placed on the change in optimal production and import patterns for the four crops under alternative scenarios described in Section 3. The optimal solution in the base model is presented in this section and the current and alternative agricultural policies related to the four crops are evaluated and analyzed in the following section.

Base Model Solution

The base model is based on 1987 costs. The base model assumes that total available land is used totally to produce the four crops. Upper bounds are placed on the imports of the four crops from exporting countries.

Supply of Agricultural Products

Table 8 shows the optimal and actual land utilization in 1987. About 1.3 million hectares, 87 percent of total available land, were actually used to produce rice while only 0.2 million hectares were used to produce other crops. However, the optimal solution shows significant changes in acres, particularly for rice and wheat. Hectares for rice decrease from 1.26 million hectares in 1987 to 0.82 million hectares in the base model while those for wheat increase from 0.001 million hectares in 1987 to 0.47 million hectares in the base model. Hectares for corn are doubled compared to the 1987 hectares for corn production, and those for soybeans decrease from 0.15 million hectares in 1987 to 0.1 million hectares.

The optimal production and import patterns for the four crops are significantly different from the 1987 production and imports. Table 9 illustrates changes in the production and import patterns. Rice still represents the greatest percentage of total production at 66 percent; however, rice production decreases from 5.5 million tons in 1987 to 3.8 million tons in the base model. On the other hand, wheat production significantly increases from 3,000 metric tons in 1987 to 1.5 million tons in the base model and makes up 25 percent of the total production. Corn production almost triples from 0.13 million tons in 1987 to 0.34 million tons in the base model. But soybean production falls from 0.21 million tons in 1987 to 0.16 million tons in the base model. Total production of the four crops in the base model is 5.7 million tons, which is smaller than 1987 production, since rice production is substituted for production of wheat and corn, which have lower yields than rice.

TABLE 8. LAND UTILIZATION FOR RICE, WHEAT, CORN, AND SOYBEANS IN BASE MODEL

Item	Rice	Wheat	Corn	Soybeans	Total
	1000 ha				
Land (A)	816.3 (56.5)	466.7 (32.3)	57.8 (4.0)	102.8 (7.1)	1,443.6 (100)
Actual (B)	1,262.3 (87.4)	1.2 (0.1)	26.3 (1.8)	153.8 (10.7)	1,443.6 (100)
Ratio (A/B)	0.65	388.9	2.2	0.67	1

Note: Figures in ( ) are percentage to total planted land.

TABLE 9. PRODUCTION, IMPORT, AND SELF-SUFFICIENCY RATIO IN BASE MODEL

Item	Demand (A)	Production (B)	Import	Ratio (B/A)
	1000 MT			percent
Rice	5,618	3,776	1,842	67.2
Wheat	4,545	1,452	3,093	31.9
Food	2,273	1,452	821	63.9
Feed	2,272	0	2,272	0
Corn	4,905	336	4,569	6.9
Soybeans	1,330	160	1,170	12.0
Total	16,398	5,724	10,674	34.9

The total production cost in the base model is 2,168 billion won, which is about 18 percent lower than the 1987 production cost (2,613 billion won). This implies that optimizing agricultural production on the basis of the principle of comparative advantage lowers production costs in Korea. This optimal production may make Korea's agricultural products more competitive in the world market.

Korea imports 1.8 million tons of rice in the base model. Accordingly, the self-sufficiency ratio in rice falls from 97.8 percent in 1987 to 67.2 percent in the base model. The wheat import is reduced from 4.2 million tons in 1987 to 3.1 million tons in the base model, and the self-sufficiency ratio increases from almost zero to 31.9 percent.

Corn imports are decreased by 0.23 million tons in the base model compared to the 1987 imports, and the self-sufficiency ratio goes up from 2.4 percent to 6.9 percent. There are few changes in soybean production and the self-sufficiency ratio. As a result, total imports of the four crops increase from 10.1 million tons in 1987 to 10.7 million tons in the base model. Accordingly, the self-sufficiency ratio decreases from 35.5 percent in 1987 to 34.9 percent in the base model.

The Optimal Production Patterns

The base model solution implies that Korea should reduce rice production and increase wheat and corn production to minimize the supply cost of the crops even though the total production and self-sufficiency ratio of the crops decrease slightly.

Cropping patterns by producing regions change significantly. Korea has used at least 70 percent of total available land in all areas for rice production. But the optimal production locations and acres for rice are significantly different from those in 1987.

Rice is produced mainly along the West Coast and in Central western areas - Gyung-Gi, Chung-Nam, Jeon-Buk, and Jeon-Nam provinces - in the base model. The regions have a comparative advantage in rice production in terms of soil type and weather conditions. These areas have low production costs and higher yields compared to other areas because of facilities in farm mechanization and irrigation and low labor costs.

Wheat is produced along the South coast and in Central northern areas--mainly, Kyeong-Nam, Jeon-Nam, and Gyung-gi provinces. These areas have a comparative advantage over the other regions in wheat production. Corn is produced mainly in East northern areas (Gang-Won Province)·almost the same as in the actual pattern. Soybeans are produced mainly in Central regions.

Volume and Sources of Imports

The optimal import patterns show how much and from which country Korea should import the four crops to minimize total supply costs. Upper limits are placed on the imports on the basis of historical imports of the four crops from 1985 to 1988. Table 10 shows the optimal quantities of crops Korea should import in the base model. The United States has the largest quantity among exporting countries. The United States takes 66.1 percent of market share, Canada and EC each 9.4 percent, Thailand and China each 5.6 percent, and other countries 4 percent.

Korea imports 1.6 million tons of rice from the United States and 0.2 million tons from Thailand in the base model. Major import sources of wheat as a food grain are the United States and Australia. Imports of wheat from the United States, however, are reduced significantly because of increased domestic production. Wheat as a feed grain is imported from Canada, EC, and Australia. The United States is a major exporting country for corn and soybeans.

TABLE 10. QUANTITIES OF CROPS IMPORTED IN BASE MODEL

Region	Rice	Wheat Food	Wheat Feed	Wheat Total	Corn	Soybeans	Total
	1000 MT						
USA	1,642	571	0	571	3,669	1,171	7,052
Thailand	200				400		600
China			100	100	500		600
Australia		200	172	372			372
Canada			1,000	1,000			1,000
E.C.			1,000	1,000			1,000
Argentina		50		50			50
Total	1,842	821	2,272	3,093	4,569	1,171	10,674

Table 11 shows the optimal import volume at each import port. Imports through Inchon make up the greatest portion mainly because the port is located near Seoul where demands for the four crops are concentrated. Pusan, the second largest city, makes up 25 percent, and Kunsan is 13 percent.

TABLE 11. IMPORTS BY IMPORT PORTS IN BASE MODEL

Item	Rice	Wheat	Corn	Soybeans	Total
	1000 MT				
Inchon	1,067 (57.9)	1,800 (58.2)	2,626 (57.5)	1,130 (96.5)	6,623 (62.0)
Pusan	775 (42.1)	792 (25.6)	1,043 (22.8)	26 (2.2)	2,635 (24.7)
Kunsan	0	502 (16.2)	900 (19.7)	15 (1.3)	1,417 (13.3)
Total	1,842 (100)	3,093 (100)	4,569 (100)	1,171 (100)	10,675 (100)

Note: Figures in ( ) represent the ratio of imports at each import port to total imports.

Alternative Government Policy Analysis

Rice Self-Sufficiency Policy

Model 2 determines production and imports of the crops under the rice self-sufficiency policy. In the model, Korea is assumed to produce rice needed for domestic demand and not to import rice from foreign countries. The model does not include any restrictions on acres of rice in each producing region.

Table 12 presents land utilization and the quantities of crops produced in Model 2. The rice self-sufficiency policy forces most of the available land to be used for rice production. Land used to produce rice is 1.24 million hectares in Model 2 or 86 percent of total available land. The total land used for wheat production is 142 thousand hectares in Model 2. Corn acres do not significantly change among the models. However, crop land used for soybean production significantly decreases in Model 2 compared to the base model.

TABLE 12. OPTIMAL DEMAND, LAND UTILIZATION, PRODUCTION, AND SELF-SUFFICIENCY RATIO IN MODEL 2

Item	Land	Demand (A)	Production (B)	Imports	Ratio(A/B)
Rice	1,244	5,618	5,618	0	100.0
Wheat	142	4,545	433	4,112	0.1
Food		2,273	433	1,841	63.0
Feed		2,272	0	2,272	0.0
Corn	58	4,905	385	4,520	0.1
Soybeans	0	1,330	0	1,330	0.0
Total	1,484	16,398	6,436	9,962	39.0

The optimal rice production in Model 2 is larger than that in the base model. The total crop production in Model 2 is also larger than that in the base model because rice has a higher yield than other crops in Korea.

The total production cost in Model 2 is 2,591 billion won, which is about 19 percent higher than that in the base model. Average production cost (378.6 thousand won/MT) in the base model, however, is lower than that in Model 2 (405 thousand won/MT). This implies that the rice self-sufficiency policy increases total production costs by 208 billion won. In other words, the Korean agricultural sector can reduce production costs by 208 billion won through optimizing agricultural production without the rice self-sufficiency policy.

Target Price Scenario

Model 3 simulates production, marketing, and trade activities of crops under the assumption that the domestic prices of crops are equal to world prices with implementation of the target price system. In this system, the government sets the support prices for the selected crops. Target price system for the crops protects producers by paying the difference between target and market prices whenever the market price falls below the target price for a specified time period. The difference between the target and market prices is referred to as a deficiency payment. Thus, this program protects farm income at the level the government desires.

The optimal land utilization, total demand, production, and import patterns for the crops in Model 3 are shown in Table 13. The optimal land utilization and production patterns are similar to those in the base model.

TABLE 13. OPTIMAL LAND UTILIZATION, DEMAND, PRODUCTION, AND IMPORT OF CROPS IN MODEL 3

Item	Land	Demand (A)	Production (B)	Import	Ratio (B/A)
	-ha-	-----------------1000 MT	-----------------		--percent--
Rice	810.8	5,921.6	3,752.0	2,169.6	63.4
Wheat	483.0	6,118.4	1,501.5	4,616.9	24.5
Food		3,059.3	1,501.5	1,557.8	49.1
Feed		3,059.1	0	3,059.1	0
Corn	70.6	6,447.6	410.3	6,037.3	6.4
Soybeans	79.2	1,547.4	124.0	1,423.4	8.0
Total	1,443.6	20,035.0	5,787.8	14,247.1	28.9

But land used in rice and soybean production is shifted to the production of wheat and corn due mainly to increases in demands for wheat and corn when the domestic prices of the crops equal world prices. In Model 3, demands for wheat and corn increase by 34.6 and 31.4 percent, respectively, compared to the base model. But demands for rice and soybeans increase by 5.4 and 16.3 percent, respectively, compared to the base model. Total crop production increases by 0.1 million tons compared to the base model, from 5.7 million tons to 5.8 million tons. On the other hand, total crop imports increase by 33.5 percent from 10.6 million tons in the base model to 14.2 million tons.

This is due mainly to the limitations of available land to produce crops and to increase demand for crops under the world price. Accordingly, the self-sufficiency ratio decreases from 34.9 in the base model to 28.9 percent in Model 3. The total production cost is the same as in the base model. If Korea adopts a free trade policy for rice, wheat, corn, and soybeans with implementation of the target price system, the total import cost of the crops significantly increases while the total domestic production remains almost unchanged.

Table 14 shows the cost necessary to introduce a target price program for rice, wheat, corn, and soybeans on the basis of the optimal solution in Model 3. Deficiency payments per metric ton are defined as the difference between the 1986 government purchase prices and the 1987 average import prices. The total deficiency payments are 2,422.9 billion won ($2.95 billion) in Model 3. The total deficiency payments for rice farmers are greatest among all farmers.

TABLE 14. COST ESTIMATION FOR TARGET PRICE PROGRAM IN MODELS 2 AND 3

Item	Model 2	Model 3
	--------billion won------------	
Rice	2,810.7	1,877.1
Wheat	115.6	392.8
Corn	59.3	72.6
Soybeans	0	80.4
Total	2,985.6	2,422.0

The formula used to calculate the government costs is: c = (support price - import price) x total production.

The costs necessary to introduce the target price program in Model 2 are 2,985.6 billion won ($3.63 billion), 23.2 percent larger than that in Model 3. This is due mainly to the increased production of rice in Model 2. Deficiency payments per ton of rice are higher than for wheat and corn on the basis of current world and support prices for the crops.

The government outlay in Model 3 for implementing the target price system for all crops was 14.6 percent of the national budget in 1987. The Korean government can use the target price system for a few selected crops, such as rice, to reduce the government outlay. The government can use the target price system and import tariffs at the same time to share the burden with producers in exporting countries.

Under the current government policy, consumers of agricultural products subsidize farmers by paying much higher prices for the same kinds of agricultural products compared to the world prices, while the government subsidizes farmers in the target price system. The government may finance its outlays for the system by imposing higher taxes on consumers. The burden on consumers is almost the same under the current and target price system. The only difference between these two systems is that the current system is not acceptable under the current GATT rule while the target price system is acceptable.

Production and Imports with the Estimated Demand in 2001

Demand for rice, wheat, corn, and soybeans is estimated and used as an input in the spatial equilibrium model.

Estimation of Demand Models

The domestic demand functions for rice, wheat, corn, and soybeans are estimated with annual time series data for 1970 to 1987. The estimated models are used to calculate the domestic consumption of the crops under an assumption that the domestic price of crops is equal to the world price. The models also are used to forecast domestic consumption of the crops in 2001.

Data used to estimate the demand functions were obtained from Handbook of Agricultural Statistics, National Income Account (1988 BOK), and Livestock Handbook and Feed Bulletin. The data were adjusted to represent 1980 prices using the Consumer Price Index (CPI) and per capita GNP was converted using the GNP deflator.

A dynamic model based on the partial adjustment model was used to estimate the rice demand function in a log form. The two-step efficient estimator (Hatanaka) was used because of autocorrelation between a lagged dependent variable and regression disturbances.

The estimated demand function of rice is as follows:

$$LCR_t = 2.2118504 - .0251959\ LRPR_t + .1892431\ LRY_t - .076049\ D_t + .3299053\ LCR_{t-1} - .0160195\ TR \quad [11]$$

$R^2 = .857$ ( ) = t value

Where LCR_t = natural log of per capita consumption of rice in time period t.

$LRPR_t$ = natural log of real price of rice in t.

LRY_t = natural log of per capital real GNP in t.

D_t = dummy variable (if t = 1973-1977, then D_t = 1, otherwise, D_t = 0)

LCR_{t-1} = a lagged dependent variable.

TR = trend variable.

The per capita consumption of rice is inelastic with respect to the real price because rice is a major staple food in Korea. Korean people tend to consume a certain amount of rice regardless of its real price level.

The per capita consumption of rice has a decreasing trend based on changes in food consumption patterns. The consumption of rice is replaced with increases in meat, milk, eggs, instant foods and noodles, and vegetables.

The Korean government intended to control the increasing rice consumption by encouraging mixed-cereal and flour-based meals with administrative guidance in times of shortages. Accordingly, a dummy variable which represents the government's policy is significant in the rice consumption model.

Total wheat consumption is a function of real price and per capita real GNP. Wheat was processed mainly to flour before 1984; however, the consumption of wheat as a raw material of assorted feed has increased since 1984.

The total wheat consumption function was specified as a function of the real price of wheat, per capita real GNP, and a dummy variable. The model was estimated by the two-step efficient estimator as follows:

$$LCW_t = 2.6796661 - \underset{(0.53)}{.1442604}\ LRPW_t + \underset{(0.58)}{.1040046}\ LRY_t$$

$$+ \underset{(2.75)}{.5202688}\ LCW_{t-1} + \underset{(4.85)}{.3877648}\ D_t \qquad [12]$$

R^2 = .9   Durbin h = .6535   ( ) = t value

where LCW_t = natural log of total consumption of wheat in t.

$LRPW_t$ = natural log of real price of wheat in t.

LRY_t = natural log of per capita real GNP in t.

LCW_{t-1} = lagged dependent variable.

D_t = a dummy variable (if t = 1984-1987, then D_t = 1, otherwise, D_t = 0).

The demand functions for corn and soybeans are estimated separately in a log form or linear form, respectively, using static or the partial adjustment algorithm. The estimated demand functions are as follows:

$$CFOC_t = -377.3186 - \underset{(1.32)}{1012.4843}\ RPC_t + \underset{(7.54)}{1.0848172}\ RY_t \qquad [13]$$

R^2 = .978   DW = 1.9747   ( ) = t value

$$LCFEC_t = -\ 4.7681032 - \underset{(1.28)}{.7234964}\ LRPC_t + \underset{(1.42)}{.789092}\ LRY_t \qquad [14]$$

$$+ \underset{(5.24)}{.7118182}\ LRMP_t$$

R^2 = .965   DW = 1.9747   ( ) = t value

$$LCFOS_t = 4.3040911 - .3317587\ LRPS_t + .1989781\ LRY_t \qquad [15]$$
$$\qquad\qquad\qquad (1.89) \qquad\qquad (5.92)$$
$$R^2 = .877 \qquad DW = 1.9708 \qquad (\ ) = t \text{ value}$$

$$LCFES_t = -3.1631394 - .0665536\ LRPS_t + 1.2911327\ LRY_t \qquad [16]$$
$$\qquad\qquad\qquad (0.25) \qquad\qquad (6.25)$$
$$R^2 = .986 \qquad DW = 2.0275 \qquad (\ ) = t \text{ value}$$

where $CFOC_t$ = demand for corn as a raw material for food in t.

RPC_t = real price of corn in t.

RY_t = per capita real GNP in t.

$LCFEC_t$ = natural log of demand for corn as a raw material for assorted feed in t.

$LRPC_t$ = natural log of real price of corn in t.

$LCFOS_t$ = natural log of demand for soybeans as a material for edible oil in t.

LPS_t = natural log of real price of soybean in t.

$LCFES_t$ = natural log of demand for soybeans as a material for assorted feed in t.

$LRMP_t$ = natural log of real average price of beef, pork, and chicken in t.

To estimate the demands in 2001, the estimated parameters of the demand Equations 10 through 16 were assumed to remain stable up to 2001. Total demand for rice was calculated by multiplying the predicted per capita consumption by the population in 2001. Total demands for corn and soybeans were calculated by summing the estimated demands for food and feed. Total population and per capita real GNP in 2001 were obtained from <u>Long-run Estimate of National Economy Index</u> published by EPB.

Table 15 shows the projected demand for each crop in 2001. The demand for each crop in each consuming region was calculated by the same method as that in the base model. Demands for rice, wheat, corn, and soybeans are to change significantly as the food consumption pattern changes. Trends in per capita consumption of wheat, corn, and soybeans increase continuously while per capita consumption of rice decreases. The demand for rice is projected to increase from 5.618 million tons in 1987 to 5.643 million tons in 2001, even though the total population will increase by 20.1 percent during that time period. On the other hand, demands for wheat, corn, and soybeans are projected to increase substantially. Demand for corn is projected to increase by 55 percent from 4.91 to 7.59 million tons in 2001.

TABLE 15. PROJECTED DEMANDS FOR RICE, WHEAT, CORN, AND SOYBEANS IN 2001

Item	1987 Actual (A)	2001 Projection (B)	Ratio (B/A)
	----------------1000 MT	-----------------	---percent---
Rice	5,618.0	5,642.6	100.4
Wheat	4,545.0	5,627.9	123.8
Corn	4,905.3	7,591.7	154.8
Food	1,348.5	3,051.1	226.3
Feed	3,556.8	4,540.6	127.7
Soybeans	1,330.0	2,034.4	153.0
Food	383.5	463.9	121.0
Feed	946.5	1,570.5	165.9
Total	16,398.0	20,896.7	127.4

Optimal Production and Imports

Model 4 shows the changes in the optimal solution in the base model due to an increased demand for the crops in 2001. Table 16 shows the optimal land use, production, import patterns, and changes in the self-sufficiency ratio.

TABLE 16. LAND UTILIZATION, PRODUCTION, AND IMPORT IN MODEL 8

Item	Rice	Wheat	Corn	Soybeans	Total
Demand [A]	5,643	5,628	7,592	2,035	20,897
(1000 MT)	(5,618)	(4,545)	(4,905)	(1,330)	(16,398)
Land	816.3	472.5	75.7	79.2	1,443.6
(1000 ha)	(816.3)	(466.7)	(57.8)	(102.8)	(1,443.6)
Production [B]	3,776	1,469	440	124	5,809
(1000 MT)	(3,776)	(1,452)	(336)	(160)	(5,724)
Import	1,867	4,159	7,152	1,911	15,089
(1000 MT)	(1,842)	(3,093)	(4,569)	(1,170)	(10,674)
Ratio [B/A]	66.9	26.1	5.8	6.1	27.8
(percent)	(67.2)	(31.9)	(6.9)	(12.0)	(34.9)

Note: Figures in ( ) represent the optimal solution in the base model.

The optimal land use and production patterns in Model 4 do not differ significantly from those in the base model. Korea increases wheat and corn production and decreases soybean production compared to the base model. However, total imports increased from 10.7 million tons in the base model to 15.1 million tons due to an increased demand for wheat, corn, and soybeans. Corn importation increases by 56.5 percent, from 4.6 million tons in the base model to about 7.2 million tons. The increase in total imports is due mainly to land constraints and the assumption of no technological change. This implies that unless Korea increases productivity through technological innovation, increased demands will increase crop imports. In this case, the self-sufficiency ratio of the crops decreases from 34.9 in the base model to 27.8 percent.

Summary and Conclusions

Korea adopted a policy in the 1950s to maintain rice production at a self-sufficiency level. The policy is characterized by production support and the direct government purchase programs. Korea has almost attained self-sufficiency in rice production since the 1980s.

The government policy has forced most of the available land into rice production in all producing regions regardless of the comparative advantage in crop production. The rice self-sufficiency policy has increased the rice production cost due mainly to use of marginal land for rice production and to intensive applications of chemicals and fertilizers. Delayed farm mechanization and rising farm labor wages have accelerated the increase in production costs.

The main objective of this study is to evaluate the optimal production and import patterns for rice, wheat, corn, and soybeans under alternative policy options in Korea. A spatial equilibrium model was developed to optimize the production and import patterns for rice, wheat, corn, and soybeans. The base model incorporates 36 producing regions, 18 consuming regions, 3 import ports, and 8 exporting countries. The objective in the base model is to minimize production, import, and distribution costs of the crops. Constraints imposed on the base model are 1) a land constraint, 2) a demand and supply equilibrium condition, and 3) inventory clearing conditions at the import port and in the producing region.

Alternative models are developed to examine the impacts of government farm policies on domestic production and imports of crops. Several models are developed on the basis of the following scenarios: 1) production, marketing, and trade activities for rice, wheat, corn, and soybeans are the same as those in 1987, 2) a base model with the rice self-sufficiency policy, 3) a base model with the target price system, and 4) a base model with the demand in 2001.

The results of this study are summarized as follows:

a) Hectares and production of crops in the base model differ significantly from the 1987 levels, particularly for rice and wheat. Rice production in the base model decreases from 5.5 million tons in 1987 to 3.8 million tons, while wheat production increases by 1.45 million tons compared to that in 1987. Soybean production decreases a little while corn production increases. The total production of crops decreases from 5.8 million tons in 1987 to 5.7 million tons in the base model. The self-sufficiency ratio in the four crops decreases from 35.5 percent to 34.9 percent. The total production costs in the base model are substantially lower than actual production costs, implying that Korea can reduce production costs by optimizing agricultural production.

b) The production of crops in Model 2 differs significantly from those in the base model. Rice production in Model 2 is higher than in the base model while production of other crops is smaller than that in the base model. The total production costs in Model 2 are about 10 percent higher than those in the base model, indicating that the rice self-sufficiency price results in an additional cost of about 200 billion won annually in Korea.

c) The production of crops in Model 3 is similar to those in the base model, indicating that the target price system does not alter production structure while retaining farm income at the current or desired level. The outlays of the program can be financed by increasing consumption tax rate. The target price system is acceptable by the GATT rules while the current system is not.

d) In the year 2001, Korea will increase its imports of the crops. Corn imports will be the largest in Korea as demand for livestock increases if Korea maintains livestock production.

Policy Implications

The rice self-sufficiency policy has contributed to the attainment of self-sufficiency in rice production. However, this study found that the policy has resulted in an inefficient production structure for rice, wheat, corn, and soybeans. The optimal solution in the base model suggests that rice production should be concentrated in the regions which have a comparative advantage to make rice production more competitive in the world market. Other regions should be diverted for other uses or to produce other crops, including wheat and corn. The rice self-sufficiency policy costs the Korean agricultural sector an additional cost of about 200 billion won annually.

Free trade negotiations for agricultural products, including rice, are in progress under the Uruguay Round of the GATT negotiations. Also, bilateral trade negotiations between trading partners are in operation. Major exporting countries are pushing Korea to open its domestic markets for almost all industrial and agricultural products. Under this situation, Korea might have difficulty in protecting the domestic agricultural economy. This study found that a producer subsidy system similar to the target price program could be a feasible alternative government policy to protect domestic production of the crops and farm income. This policy can be implemented with import tariffs to reduce the government expenses associated with this program. This policy is acceptable under the current GATT rules and will protect the Korean agricultural sector.

The most important aspect of liberalizing the Korean agricultural sector is the economy's capability of absorbing the idled resources in the agricultural sector as a result of the liberalization policy. In the context of a dual economy, agricultural and industrial sectors interact with each other in the process of economic development. In Korea, labor force in the agricultural sector has declined as the industrial sector has increased employment with the rapid industrialization in the last two decades.

Agriculture is still one of the most important sectors of the economy and contributes about 7.5 percent of the nation's GNP. The Korean industrial sector is not large enough to absorb the labor force idled from the agricultural sector under liberalization of agricultural trade. Thus, liberalizing agricultural trade might result in a major economic stagnation in Korea.

Liberalization of agricultural trade in Korea should take place gradually by maintaining a balance with industrial growth. This implies that the Korean government should adopt the target price system for the selected crops combined with import tariffs and reduce import tariffs and domestic subsidies (deficiency payments) gradually over the extended time period at the annual rate similar to industrial growth rate.

As long as Korea maintains its economic growth at the current level, the country's imports of agricultural products are projected to increase under the proposed policy options. Thus, the proposed policy option is beneficial to both Korea and agricultural exporting countries.

These policy options could be also adoptable to most developing countries whose agriculture has a comparative disadvantage over agricultural exporting countries but plays an important role under the context of dual economy.

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