

Projections and Policy Implications of Supply and Demand of Rice in South Korea

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1 Introduction

Rice is the most important crop for the Korean people, and it has played a vital role in Korea's socioeconomic stabilization after the World War II. The majority of farmers are engaged in rice production, and about 48 percent of farm income is derived from it. Approximately 60 percent of arable land is used for rice production.

Since hunger and malnutrition became national issues in the early 1960s, the primary goal of the Korean government has been to achieve self-sufficiency in rice. The rice sector has been protected by various policy measures including price support, border protection, and investment in land infrastructure. Korea's rice policy was very successful in increasing rice production, succeeding in achieving rice self-sufficiency in the mid-1980s. However, the rice self-sufficiency policy has also caused serious problems, and the Korean agricultural sector now faces the following emerging issues.

- 1) The Korean government has maintained the rice self-sufficiency policy since the beginning of the 1970s, and has not imported rice since 1984. However, the Korean

government accepted the agricultural agreement of the GATT Uruguay Round. South Korea has ratified the Uruguay Round agreement, and accepted the Minimum Access rice import. South Korea began to import rice in 1995. Minimum Access rice import will further increase the anxiety of rice farmers and could have a negative effect on their desire to produce rice.

- 2) There has been a huge deficit in the Food Grain Management Account. This has been primarily caused by the buying and selling operations of rice by the Government. This huge deficit puts a financial burden on the Government and reduces the budget available for the achievement of agricultural policy objectives such as enlarging the scale of farms and increasing productivity in rice production.
- 3) In the process of rapid economic growth, the comparative disadvantage of the agricultural sector have increased, and government protection of the agricultural sector has increased through price support and border protection. The gap between domestic and international price has been widening over time. According to the agreement of the GATT Uruguay Round, agricultural protection measured in Aggregate Measure of Support has to be reduced, and it is urgent that the price gap is reduced through the achievement of structural improvement and technological change.

2 Rice Supply Analysis

production compared with non-agricultural activities as well as non-rice agricultural production activities, such as green house vegetable production and fruits production. Hence, one variable ERI which represents the relative profitability of rice production is added to equation (1). ERI is the expected income from rice production compared with income from other economic activities. Wages of all industries are used as a proxy variable for income from other economic activities. Since rice income and wages of all industries are not known at rice planting time, farmers are assumed to make planting decisions based on the previous year's rice income and wages. ERI is defined as previous year's rice income per 10 ares (0.1 hectare) relative to wages of all industries. The rice acreage response function is then expressed as follows:

$$\ln A_t = b_0 + b_1 \ln P_{rt-1} + \sum_{j=2}^n b_j \ln P_{jt-1} + b_k \ln ERI_{t-1} \quad \dots\dots(2)$$

2) Rice Yield Function

It is assumed that rice yield function can be expressed as follows:

$$q_t = c_0 + c_1 (P_{wt-1}/P_{rt-1})^{1/2} + c_2 T + c_3 HY_t \quad \dots\dots(3)$$

where q is rice yield, P_r is farm gate rice price, P_w is farm wage rate, T is time trend representing technological change, and HY is the proportion of the high yield rice variety planted area. The proportion of high yield rice variety planted areas is added in the rice yield equation since the diffusion of the high yield rice variety i.e. Tongil-type varieties contributed to increase rice yields in the 1970s and 1980s.

Rice yields fluctuate from year to year affected by weather conditions and/or disease. Since appropriate data representing weather conditions are not available, a three year moving average yield is used instead of the actual yearly yield data. Rice yield decreased drastically in 1980 because of low-temperature injury. It's yield was 36 percent lower compared with previous year's yield. Since the purpose of estimating the yield function is to capture the average trend of rice yields, the extremely low yields of 1980 were eliminated from observation, and it is replaced by the average yield of 1979 and 1981.

(2) Data for Rice Supply Analysis

Annual data for the period 1984–1992 are used to estimate the rice acreage response function. Data for rice acreage and rice income per 10 ares are obtained from “Major Agricultural Statistics” of the Korean Ministry of Agriculture, Forestry and Fisheries (hereafter KMAFF for short). Data on farm wage rate and farm gate rice prices are taken from “Agricultural Cooperative Yearbook” of the National Agricultural Cooperative Federation. The wages of all industries are taken from “Korea Statistical Yearbook” of National Statistical Office.

Table 1 Variables for the Model

Variable	Description
A	paddy rice planted area (1,000ha)
P_w	real farm wage rate index (1985=100)
P_r	real farm gate rice price index (1985=100)
q	three year moving average rice yield (kg per 10 ares)
ERI	expected rice income relative to wages of all industries
HY	proportion of Tongil-type variety planted area (%)
T	time trend

The annual data for the period 1976–1992 are used to estimate the rice yield function. Data for rice yields, proportion of high-yield variety planted areas are obtained from “Major Agricultural Statistics” of the KMAFF. Table 1 gives explanations of variables used for the estimation of rice yield function and rice acreage response function.

(3) Estimation Results

1) Estimation results of rice acreage function

The estimation result of the rice acreage function is

$$\ln A_t = 6.495 + 0.165 \ln P_{rt-1} - 0.080 \ln P_{wt-1} + 0.053 \ln ERI_{t-1} \quad \dots\dots(4)$$

(23.637) (2.765) (-2.059) (0.866)

$$R^2 = 0.889, \text{ D.W.} = 1.874$$

The coefficient of determination adjusted for degrees of freedom is 0.889 implying that the fit of the model is considerably good. All estimated parameters except ERI are different from zero at the 5 percent significance level. Estimation result shows that paddy rice planted areas are positively related to rice prices, negatively related to farm wages, and positively related to expected relative rice income. The signs of the estimated parameters are consistent with the economic theory.

The elasticity of rice acreage with respect to rice prices is 0.165. While the elasticity of rice acreage with respect to farm wage rate is -0.080 , and with respect to expected relative rice income is 0.053. This implies that a 10 percent decrease in real rice price would caused a 1.65 percent decrease in rice planted

areas, and similarly, a 10 percent increase in farm wage rate would bring about 0.8 percent reduction in rice planted areas. A 10 percent decrease in expected rice income relative to wages of all industries would bring about 0.53 percent reduction in rice acreage.

2) Estimation Result of Rice yield function

The rice yield function is estimated for Japonica type variety as well as for weighted average of Japonica type variety and Tongil-type variety. The estimation result of rice yield function of Japonica type variety is as follows:

$$q_t = \frac{381.942}{(20.582)} - \frac{4.331(P_{wt-1}/P_{rt-1})^{1/2}}{(-2.155)} + \frac{7.438T}{(9.194)} + \frac{0.895HY_t}{(5.788)} \dots\dots(5)$$

$$R^2=0.910, D.W.=2.282$$

All of the estimated coefficients are different from zero at the 5 percent significance level. Estimation result shows that rice yields are negatively related to relative farm wages and positively related to proportion of the Tongil type variety planted areas and time trend. From these estimation results, it can be pointed out that an increase in the farm wage rate relative to rice price had the effect of decreasing rice yields, while an increase in the proportion of the Tongil type variety planted areas had increased the rice yield level. Technological change which is expressed by time trend had contributed to increase rice yields. These estimation results are consistent with the economic theory.

On the other hand the rice yield function of weighted

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On the other hand the rice yield function of weighted

average of Japonica type and Indica type varieties is also estimated. The estimation result is

$$q_t = 351.429 - 8.616(P_{wt-1}/P_{rt-1})^{1/2} + 7.699T + 1.257HY_t$$

(19.727) (-3.254) (13.759) (14.140)

.....(6)

$$R^2 = 0.983, D.W. = 1.647$$

The coefficient of determination adjusted for degrees of freedom is 0.983 implying that the fit of the model is considerably good. All of the estimated coefficients are different from zero at the 5 percent significance level. Rice yields are negatively related to the ratio of farm wages and rice price, and positively related to the proportion of Tongil type variety planted areas and time trend.

Tongil-type variety was no longer planted in 1992 because of the consumer's preference for high-quality rice, and will not be planted in the future. Because of this reason the estimation result for Japonica type variety i.e. equation (5) is adopted for the purpose of rice yield projection.

3 Rice Demand Analysis

(1) Model Development of Rice Demand Function

In this study, a partial equilibrium model will be used to carry out the medium-and long-term rice demand projection. It is assumed that the representative consumer maximizes utility, given a fixed income. The demand schedule for rice is derived by maximizing consumer's utility. This study assumes that per capita demand for rice is a function of income, rice prices, and

prices of substitutes and complements of rice. It is also assumed that consumers do not adjust rice demand instantaneously to changes in prices and income. To incorporate dynamic adjustment in rice consumption, the partial adjustment model developed by M. Nerlove is employed. Rice demand function to be estimated is specified as follows:

$$\ln C_t = \alpha_0 + \alpha_1(1/y_t) + \alpha_2 \ln y_t + \alpha_3 \ln P_{rt} + \alpha_4 \ln P_{bt} + (1-r) \ln C_{t-1} + \alpha_5 D_t + e_t \quad \dots\dots(7)$$

where C is annual per capita rice consumption, y is per capita income, P_r is farm gate rice price in the case of farm households, and consumer price of rice in the case of non-farm households, P_b is prices of wheat and barley. r is a constant of proportionality which may be called as the elasticity of adjustment. D is a dummy variable, and takes 1 for 1975 and 1976, and 0 for 1977 through 1992. This dummy variable is introduced to capture the effect of the government's anti-consumption campaign. Income and prices are deflated by the consumer price index (1985=100) in the case of non-farm households and purchasing price index of all commodities in the case of farm households. The disturbance term e is assumed independent, identically distributed normal variate.

(2) Data Description

Data for household income is obtained from the "Annual Report on the Family Income and Expenditure Survey" of the Korean Statistical Association, and "Major Agricultural Statistics" of the Korean Ministry of Agriculture, Forestry, and Fisheries (KMAFF). Per capita income is obtained by dividing

household income by the number of persons per household. The consumer price index appearing in the “Annual Report on the Price Survey” of the Korean Economic Planning Board is utilized. The purchasing price index of all commodities for farm households is obtained from “Statistics on Prices in Rural Area” of National Agricultural Cooperative Federation. Data on per capita rice consumption are obtained from “Major Agricultural Statistics” of KMAFF. Data for farm prices such as farm gate rice price index, farm gate price index of wheat and barley are taken from “Agricultural Cooperative Yearbook” of the Korean National Agricultural Cooperative Federation.

Table 2 Variables for the Model

Variable	Description
C	annual per capita rice consumption (kg)
P _r	real rice price index (1985=100)
y	annual per capita income (1985 price)
P _b	price index of wheat and barley (1985=100)

(3) Estimation Results

Since the time trends of per capita rice consumption for farm households and non-farm households are quite different, rice demand function for farm households and non-farm households will be estimated separately.

1) Rice Demand Function of Non-Farm Households

Rice demand function of non-farm households is estimated by OLS using annual data for the period 1975–1992. The estimation result is

$$\ln C_t = 3.842 - 81.252(1/y_t) - 0.118 \ln y_t - 0.117 \ln P_{rt} \\ (4.128) \quad (-1.148) \quad (-2.204) \quad (-1.780) \\ - 0.075D + 0.500 \ln C_{t-1} \quad \dots\dots(8) \\ (-2.595) \quad (3.861)$$

$$R^2 = 0.915 \quad D.W. = 1.780$$

The coefficient of determination adjusted for degrees of freedom is 0.915 meaning that the fit of the model is considerably good. T-statistics in parentheses are large and estimates of all parameters except for rice price and inverse of income are different from zero at the 5 percent significance level. The estimation result shows that the demand for rice is negatively related to income and own price as expected. Estimated coefficient for dummy variable D is negative implying that rice consumption for the period 1975–1976, which is the period under the government's anti-consumption campaign, is lower than later years.

The own price elasticity is -0.117 . The value of income elasticity changes over time as shown in Table 3. It is 0.038 in 1975, and has been declining over time, and became negative in 1977, and is -0.089 in 1992.

The estimated value of the elasticity of adjustment is 0.5. This implies that 50 percent of the change in the ratio of optimum rice consumption in year t and actual rice consumption in year $t-1$ is adjusted in year t , and 50 percent was left for adjustment for later years.

2) Rice Demand Function of Farm Households

The estimation result of the rice demand function of farm

Table 3 Income Elasticity for Rice Demand

Year	Farm Households	Non-Households
1975	0.261	0.038
1976	0.222	0.014
1977	0.184	-0.006
1978	0.167	-0.026
1979	0.139	-0.039
1980	0.151	-0.036
1981	0.119	-0.035
1982	0.088	-0.042
1983	0.061	-0.051
1984	0.015	-0.057
1985	-0.008	-0.062
1986	-0.027	-0.067
1987	-0.049	-0.073
1988	-0.084	-0.077
1989	-0.100	-0.083
1990	-0.113	-0.086
1991	-0.128	-0.090
1992	-0.135	-0.089

households using the time series data for the period 1976-1992 is as follows:

$$\begin{aligned} \ln C_t = & 3.375 - 317.305(1/y_t) - 0.253 \ln y_t - 0.209 \ln P_{rt} \\ & (2.528) \quad (-2.742) \quad (-3.882) \quad (-2.168) \\ & + 0.218 \ln P_{bt} + 0.735 \ln C_{t-1} \quad \dots (9) \\ & (2.721) \quad (4.361) \end{aligned}$$

$$R^2 = 0.972, \quad D.W. = 2.355$$

The coefficient of determination adjusted for degrees of freedom is large, 0.972. All of the absolute values of the t-statistics are large, indicating that all of the estimated parameters are different from zero at the 5 percent significance level. The demand for rice is negatively related to income and own-price as expected. Coefficient for prices of wheat and barley has a positive sign, indicating that wheat and barley is

a substitute for rice. The own price elasticity is -0.209 and cross price elasticity with respect to wheat and barley is 0.218 . The value of income elasticity is 0.261 in 1975, and has been declining over time, and turned to negative in 1985, and is -0.135 in 1992. This implies that rice became an inferior good in the middle of the 1980s for farm household members.

The estimated value of the elasticity of adjustment is 0.265 , and is smaller than that of the non-farm households. This implies that 26.5 percent of the change in the ratio of optimum rice consumption in year t and actual rice consumption in year $t-1$ was adjusted in year t , and 73.5 percent was left for adjustment for later years. These estimation results show that it takes more time for farm household members to adjust rice consumption level to the changing economic conditions than non-farm household members.

4 Projections of Rice Supply

(1) Projection of rice production

In order to project total rice production, rice yields per 10 ares and rice acreage are projected first, then total rice production is calculated by multiplying these projected values. Rice acreage and rice yields for the period 1993–2010 are projected based on several assumptions with respect to economic variables such as real farm gate rice prices, ratio of rice income and wages of all industries, and real farm wages. These assumptions are shown in Table 4. Figures in Table 4 show annual rate of changes of these variables. Projections are

carried out for three cases.

Table 4 Assumptions on Annual Rate of Change of Variables

variables	case 1	case 2	case 3
Real farm gate rice price	-3.0	-1.7	-3.0
Real farm wage	7.0	9.5	5.0
Ratio of rice income and wages of all industries	-6.3	-6.3	-6.3

Case 2 represents the assumption that these economic variables will essentially follow the past trends in the future. More specifically, rice acreage and rice yields are projected based on the assumptions that real farm gate rice price will decrease at 1.7 percent per annum, real farm wage rate will increase at 9.5 percent, and ratio of rice income per 10 ares and wages of all industries will decrease at 6.3 percent in the future. Case 1 assumes that real farm gate rice prices will decrease at 3.0 percent per annum, real farm wages will increase at 7.0 percent, and the ratio of rice income and wages of all industries will decrease at 6.3 percent. Case 3 assumes that real farm gate rice prices will decrease at 3.0 percent per annum, real farm wage rate will increase at 5.0 percent, and the ratio of rice income and wages of all industries will decrease at 6.3 percent.

Table 5 and Figure 1 show predicted rice yields for three cases. In case 1, rice yields of Japonica type variety are 454 kg per 10 ares in 1993 and increase by 2.7 kg per annum on average over the period 1992–2010. In case 2, rice yields increase by 2.0 kg per annum, and reach 488 kg in 2010. In

case 3, rice yields increase by 3.9 kg per annum on average, and are predicted to be 520 kg in 2010. Projected rice yields in these three cases are relatively higher in the 1990s, and gradually slows down after that. These projected annual increase in rice yields of Japonica type variety is smaller than that of the period 1982–1992 during which rice yields increased by 4.8 kg per annum.

Table 5 Rice Yield Projection

year	case 1	case 2	case 3
1993	454	454	454
1994	458	460	458
1995	462	464	463
1996	466	468	467
1997	470	471	471
1998	474	474	475
1999	477	477	479
2000	481	480	483
2001	484	482	487
2002	486	484	491
2003	489	486	495
2004	491	488	499
2005	493	489	503
2006	495	489	507
2007	497	490	510
2008	498	490	514
2009	499	489	517
2010	500	488	520

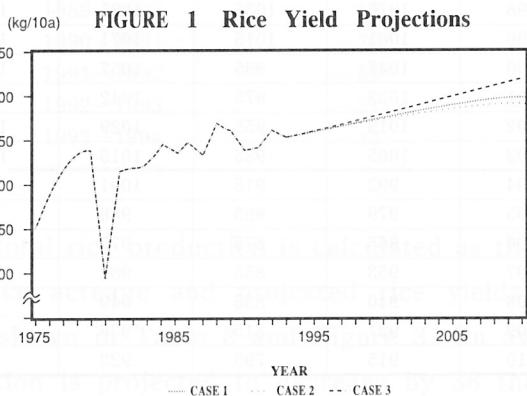


Table 6 and Figure 2 show projected rice areas. In case 1 rice acreage is predicted to decrease by 14 thousand ha per annum from 1,150 thousand ha in 1993 to 915 thousand ha in 2010. In case 2, rice acreage decreases by 13 thousand ha per annum, from 1,150 thousand ha in 1993 to 923 thousand ha in 2010. In case 3, it decreases by 13 thousand ha on average. These projected annual decrease are smaller than the average decrease of 21 thousand ha of the past period 1987–1993. Since rapid decrease in rice acreage has been observed in the first half of the 1990s as shown in Table 7, one more case is added in rice acreage projection. Rice acreage is assumed to decrease by 20 thousand ha per annum, and this projection is called case 1' and considered to be the baseline projection.

Table 6 Rice Acreage Projections

(1,000ha)

year	case 1	case 1'	case 2	case 3
1993	1150	1135	1150	1161
1994	1134	1115	1146	1136
1995	1119	1095	1130	1122
1996	1104	1075	1115	1107
1997	1090	1055	1100	1093
1998	1075	1035	1085	1080
1999	1061	1015	1071	1066
2000	1047	995	1057	1053
2001	1033	975	1042	1040
2002	1019	955	1029	1028
2003	1005	935	1015	1016
2004	992	915	1001	1005
2005	979	895	988	993
2006	965	875	975	982
2007	953	855	962	971
2008	940	835	949	960
2009	927	815	936	949
2010	915	795	923	938

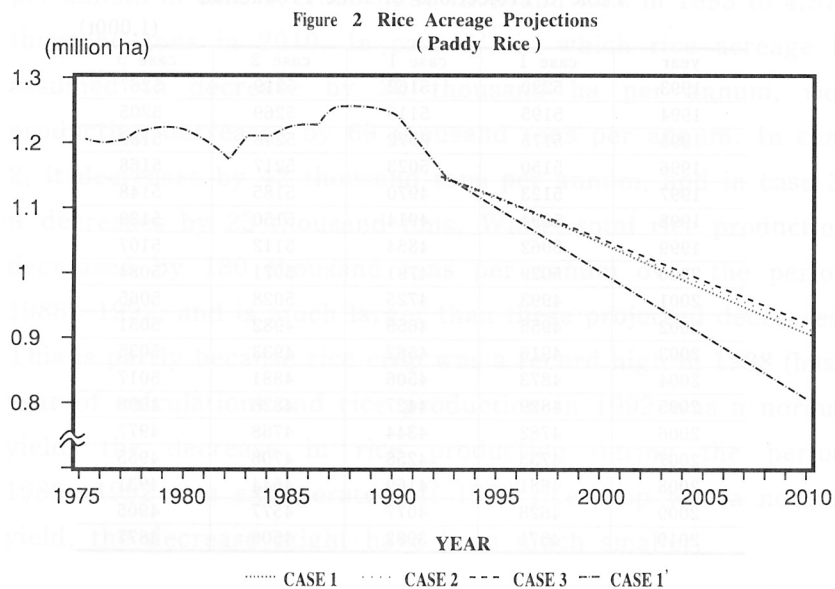


Table 7 Annual Change in Rice Area
(1,000 ha)

Year	Change in Rice Acreage
1987-1988	-2
1988-1989	-3
1989-1990	-13
1990-1991	-36
1991-1992	-51
1992-1993	-21
1993-1994	-33

Future total rice production is calculated as the product of projected rice acreage and projected rice yields. Projection results are shown in Table 8 and Figure 3. On average, total rice production is projected to decrease by 38 thousand tons

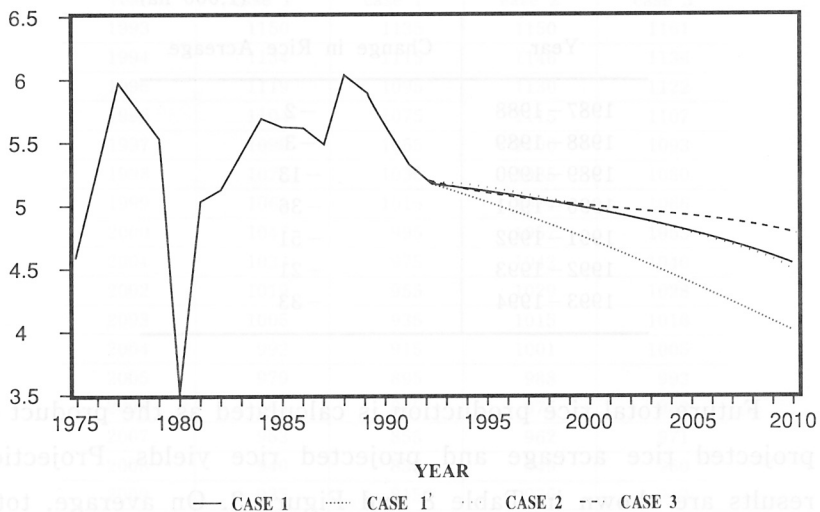
Table 8 Projections of Rice Production

(1,000t)

year	case 1	case 1'	case 2	case 3
1993	5220	5162	5219	5267
1994	5195	5116	5269	5205
1995	5175	5072	5248	5189
1996	5150	5023	5217	5168
1997	5123	4970	5185	5148
1998	5094	4914	5150	5129
1999	5062	4854	5112	5107
2000	5029	4791	5071	5084
2001	4993	4725	5028	5065
2002	4956	4655	4982	5051
2003	4916	4582	4933	5035
2004	4873	4506	4881	5017
2005	4829	4427	4826	4998
2006	4782	4344	4768	4977
2007	4733	4258	4708	4955
2008	4681	4169	4644	4931
2009	4628	4077	4577	4905
2010	4571	3982	4506	4877

Figure 3 Projections of Paddy Rice Production

(thousand tons)



per annum in case 1, from 5,220 thousand tons in 1993 to 4,571 thousand tons in 2010. In case 1', in which rice acreage is assumed to decrease by 20 thousand ha per annum, rice production decreases by 69 thousand tons per annum. In case 2, it decreases by 42 thousand tons per annum, and in case 3, it decreases by 23 thousand tons. While, total rice production decreased by 180 thousand tons per annum over the period 1988–1992, and is much larger than these projected decreases. This is partly because rice crop was a record high in 1988 (base year of calculation) and rice production in 1992 was a normal yield, the decrease in rice production during the period 1988–1992 was exaggerated. If 1988 rice crop was a normal yield, the decrease might have been much smaller.

(2) Future Rice Import

According to the agreement of the Uruguay Round of the GATT negotiations the Korean government accepted the Minimum Access rice import; starting at 1 percent of total rice consumption (51 thousand tons) of the base period (1988–1990) in 1995 and increasing to 4 percent (205 thousand tons) through 2004. It is not decided yet whether South Korea will accept tariffication measure or continue the Minimum Access scheme after 2005. In this study it is assumed that the Minimum Access rice import will be continued for the period 2005–2010, and rice import will increase at the same rate as the period 1995–2004. Future total rice supply is calculated by adding these Minimum Access rice import to the Projected domestic rice production.

5 Projections of Rice Demand

Future total rice demand for direct food use is projected as follows. First, per capita rice demand of farm households and non-farm households are forecasted based on the estimated parameters of rice demand functions. Then, total rice demand for direct food use is predicted by multiplying these quantity to future population projection. Finally, total rice demand is calculated as the sum of projected total rice demand for direct food use, projected rice demand for processed food, seed, and loss.

(1) Projection of Per Capita Rice Demand

1) Assumptions of Projection

Per capita rice demand for the period 1993–2010 is projected based on several assumptions with respect to rate of changes in economic variables such as per capita income, rice prices, and wheat and barley prices. The Korean government has been intervening in the market of rice, wheat, and barley, and seems to continue the similar types of price policies in the future. If the government keeps intervening in the markets of these agricultural commodities, price levels will depend on not only supply and demand of these commodities but also the government price control programs. Since one of the major objectives of the government rice control program is to keep the rice price level stable, future rice prices will not fluctuate very much like vegetable prices. Similarly, prices of wheat and barley may be affected by the government policies. Hence rice prices, wheat and barley prices are treated as exogenous

variables in this study.

Future per capita rice demand is projected for three cases. Assumptions on economic variables are shown in Table 9. Case A assumes that rice prices and wheat and barley prices will follow the past trends in the future; farm gate real rice prices are assumed to decrease at 1.7 percent, and real retail rice prices are assumed to decrease at 0.2 percent per annum. It is also assumed that farm gate real wheat and barley prices will decrease at 2.5 percent per annum. We consider that projection result based on case A assumption as our base line projection.

Table 9 Assumptions on Annual Rate of Changes of Variables

Variables	(%)		
	case A	case B	case C
per capita income of non-farm households	5.8	6.8	4.8
retail rice prices	-0.2	-0.2	-0.2
per capita income of farm households	5.8	6.8	4.8
farm gate rice prices	-1.7	-1.7	-1.7
farm gate wheat and barley prices	-2.5	-2.5	-2.5

Per capita real income of farm households and non-farm households are predicted based on the projected GNP growth rate²⁾. In case A per capita income is assumed to increase at 5.8 percent. In case B it is assumed to be 1 percent higher than case A. while, in case C it is assumed to be 1 percent lower than case A. For case B and C, the rate of change of rice price and wheat and barley prices are assumed to be the same as case A.

2) Projection of Per Capita Rice Demand

Projections of per capita rice demand of farm households are shown in Table 10. In case A, per capita rice demand of farm households decreases by 3.0 kg per annum on average, from 152 kg in 1993 to 100 kg in 2010. In case B, which corresponds to higher economic growth, it decreases by 3.8 kg per annum on average, from 152 kg in 1993 to 87 kg in 2010. While in case C, which corresponds to lower economic growth, it decreases by 2.1 kg per annum, from 152 kg to 116 kg in 2010.

Table 10 Projections of Per Capita Rice Demand of Farm Households

year	case 1	case 2	case 3
1993	152	152	152
1994	151	150	151
1995	148	147	149
1996	145	144	146
1997	142	140	144
1998	138	135	141
1999	134	131	138
2000	130	126	135
2001	127	121	133
2002	123	117	130
2003	120	113	128
2004	117	108	126
2005	114	105	124
2006	111	101	123
2007	108	97	121
2008	106	93	120
2009	103	90	118
2010	100	87	116

On the other hand, Table 11 shows projections of per capita rice demand of non-farm households. In case A per capita rice demand of non-farm households decreases from 104 kg in 1993 to 83 kg in 2010. On average, per capita rice

demand decreases by 1.2 kg each year which is about 33 percent less than the annual decrease in rice demand for the period 1980-1992. In case B, per capita rice consumption decreases by 1.5 kg per annum. While in case C, it decreases by 0.9 kg each year. These projection results show that per capita rice demand decreases faster when growth rate of income is higher.

Table 11 Projections of Per Capita Rice Demand of Non-Farm Households

year	case 1	case 2	case 3
1993	104	104	104
1994	103	103	103
1995	102	102	102
1996	100	100	101
1997	99	98	100
1998	97	96	99
1999	96	94	97
2000	94	93	96
2001	93	91	95
2002	92	90	94
2003	91	88	93
2004	90	87	92
2005	89	86	92
2006	87	84	91
2007	86	83	90
2008	85	82	89
2009	84	80	88
2010	83	79	88

(2) Projection of Population

Projection of the population in 1995, 2000, 2005, 2010 are derived from "Korea Statistical Yearbook" of National Statistical Office, Republic of Korea. Future farm population and future non-farm populations for the period 1994-1996 are derived from "The Seventh Five Year Economic and Social Development Plan 1992-1996".

It is assumed that future farm household populations will decrease following the past trend. Following functions were estimated by OLS using the time series data of the period 1975–1991.

$$\text{Ln}P_t = 16.462 - 0.047_t \quad \dots\dots(10)$$

$$(1609.590)(-47.298)$$

$$R^2=0.992, \text{ D.W.}=1.380$$

where P_t , t , Ln , R^2 , D.W. stand for farm populations, time trend, natural logarithm, coefficient of determination adjusted for degrees of freedom, and Durbin Watson statistics, respectively. Based on this estimation result farm populations are assumed to decrease at 4.7 percent per annum over the period 1997–2010. Future non-farm populations are calculated by subtracting the projected farm populations from the projected total populations. Non-farm populations are predicted to increase at 1.2 percent per annum in the projection period. While, total populations are predicted to increase at 0.7 percent per annum. The calculation results are shown in Table 12.

(3) Projections of Total Rice Demand

1) Projection of total rice demand for direct food use

Total rice demand for direct food use in the future is calculated as the product of projected per capita rice demand and projected population. This calculation is carried out for farm households and non-farm households, separately. Total rice demand for direct food use is predicted by adding these calculation results. Since per capita rice demand is projected for three cases, total rice demand for direct food use is

Table 12 Projections of Population

(1,000 , %)

year	total population	farm household population	non-farm household population	proportion of farm population
1975	35281	13244	22037	37.5
1976	35849	12785	23064	35.7
1977	36412	12309	24103	33.8
1978	36969	11527	25442	31.2
1979	37534	10883	26651	29.0
1980	38124	10827	27297	28.4
1981	38723	9999	28724	25.8
1982	39326	9688	29638	24.6
1983	39910	9475	30454	23.7
1984	40406	9015	31498	22.3
1985	40806	8521	32285	20.9
1986	41214	8180	33004	19.8
1987	41622	7771	33804	18.7
1988	42031	7272	34703	17.3
1989	42449	6786	35594	16.0
1990	42869	6661	36208	15.5
1991	43268	6068	37200	14.0
1992	43663	5707	37956	13.1
1993	44056	5407	38649	12.3
1994	44453	5269	39184	11.9
1995	44851	5030	39821	11.2
1996	45248	4788	40460	10.6
1997	45633	4550	41083	10.0
1998	46019	4323	41696	9.4
1999	46404	4108	42296	8.9
2000	46789	3903	42886	8.3
2001	47118	3709	43409	7.9
2002	47447	3524	43923	7.4
2003	47776	3349	44427	7.0
2004	48105	3182	44923	6.6
2005	48434	3023	45411	6.2
2006	48684	2873	45811	5.9
2007	48934	2730	46204	5.6
2008	49183	2594	46589	5.3
2009	49433	2465	46968	5.0
2010	49683	2342	47341	4.7

Table 13 Projections of Total Rice Demand for Direct Food Use
(1,000 t)

year	case A	case B	case C
1993	4840	4840	4840
1994	4837	4832	4846
1995	4806	4787	4826
1996	4756	4726	4791
1997	4707	4661	4754
1998	4658	4596	4717
1999	4604	4529	4683
2000	4553	4462	4645
2001	4507	4399	4616
2002	4467	4347	4592
2003	4432	4295	4574
2004	4397	4249	4553
2005	4364	4199	4536
2006	4323	4147	4512
2007	4288	4095	4489
2008	4248	4044	4466
2009	4209	3993	4438
2010	4169	3943	4415

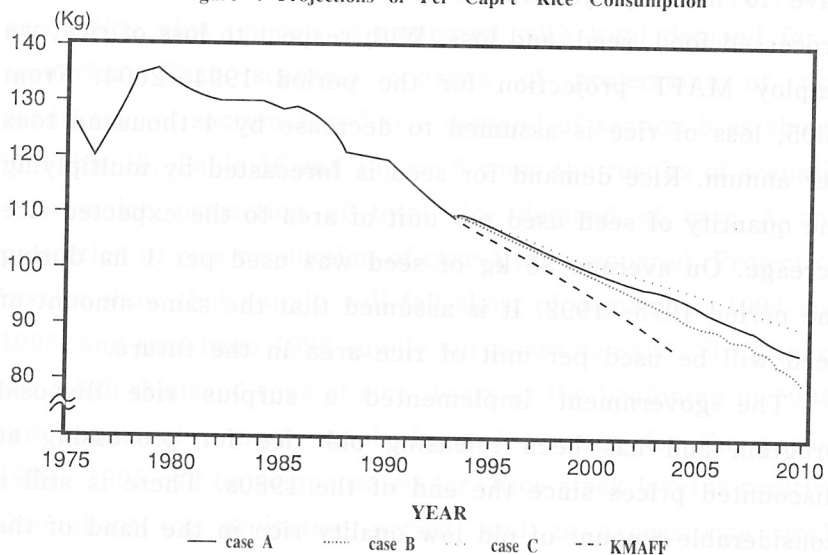
calculated for these three cases, and calculation results are shown in Table 13. In case A total rice demand for direct food use is predicted to decrease from 4,840 thousand tons in 1993 to 4,169 thousand tons in 2010. It is a 671 thousand tons decrease over the 17 years. On average, it decreases by 39 thousand tons per annum. Total rice demand for direct food use in case B and case C are calculated in the similar way. In case B, total rice demand for direct food use decreases by 53 thousand tons per annum, while in case C it decreases by 25 thousand tons. On the other hand, rice demand for direct food use decreased by 33 thousand tons per annum in the last 17 years of the period 1975–1992, and this rate of decline is rather similar to that of case A.

2) National average per capita rice demand

Table 14 Projections of Per Capita Rice Demand

year	case A	case B	case C	KMAFF
1993	110	110	110	
1994	109	108	109	108
1995	107	107	107	105
1996	105	104	106	103
1997	103	102	104	100
1998	101	100	102	98
1999	99	97	101	95
2000	97	95	99	93
2001	95	93	98	91
2002	94	91	97	89
2003	93	90	96	87
2004	91	88	95	85
2005	90	87	94	
2006	89	85	93	
2007	88	84	92	
2008	86	82	91	
2009	85	81	90	
2010	84	79	89	

Figure 4 Projections of Per Capita Rice Consumption



National average per capita rice demand for direct food use in the future is calculated dividing the projected total demand for direct food use by projected population. Table 14 and Figure 4 show the calculation results. In case A (base line projection) per capita rice demand decreases on average by 1.5 kg per annum, from 111 kg in 1993 to 84 kg in 2010. The rate of decrease is slightly less than the past trend annual decrease of 1.8 kg. In case B, which corresponds to higher growth rate of income, the rate of decrease is 1.8 kg, and is exactly the same decrease as the past trend. In case C, which corresponds to slower growth rate of income, the rate of decrease in per capita rice demand is much slower, 1.2 kg per annum.

3) Projection of total rice demand

In order to make projection of total rice demand we also have to make projections with respect to rice demand for processed food, seed, and loss. With respect to loss of rice, we employ MAFF projection for the period 1994–2004. From 2005, loss of rice is assumed to decrease by 4 thousand tons per annum. Rice demand for seed is forecasted by multiplying the quantity of seed used per unit of area to the expected rice acreage. On average 36 kg of seed was used per 1 ha during the period 1975–1992. It is assumed that the same amount of seed will be used per unit of rice area in the future.

The government implemented a surplus rice disposal program and has been releasing old rice for processing at discounted prices since the end of the 1980s. There is still a considerable amount of old low quality rice in the hand of the government, and this rice will be mainly used for processing.

The quantity of rice used for processing in the future will for the most part be determined or controlled by the government. Hence, we employ the government projection of rice to be used for processing for the period 1994–2004. It is also assumed that 285 thousand tons of rice will be used for processed food during the period 2005–2010. Finally, the total rice demand for the period 1993–2010 is calculated by adding the projected rice demand for direct food use, processed food, seed, and loss. In baseline projection total rice demand is 5.3 mmt in 1994 and becomes 4.6 mmt in 2010. It is a 13 percent decrease over the 17 years.

6 Projections of Supply and Demand Balance of Rice

In order to ascertain whether there is a sufficient supply of rice to fulfill rice demand for each year, total rice supply (i.e. production plus import) is compared with total demand for 5 scenarios. Each scenario consists of projections of rice production of section 4 and rice demand of section 5 as shown in Table 15. Table 16 and Figure 5 show the results of scenario 1 in which projection of total rice demand of case A and projection of rice production of case 1 are compared. Projection results show that supply will fall short of demand in 1994 and 1995, and that from 1996 supply surpasses demand. Since there are 1,820 thousand tons of rice stocks at the beginning of 1994, the deficit of annual supply/demand balance for the period 1994–1995 can be compensated for. Rice stock level is positive throughout the projection period, and an excess rice stock problem will emerge around 2005.

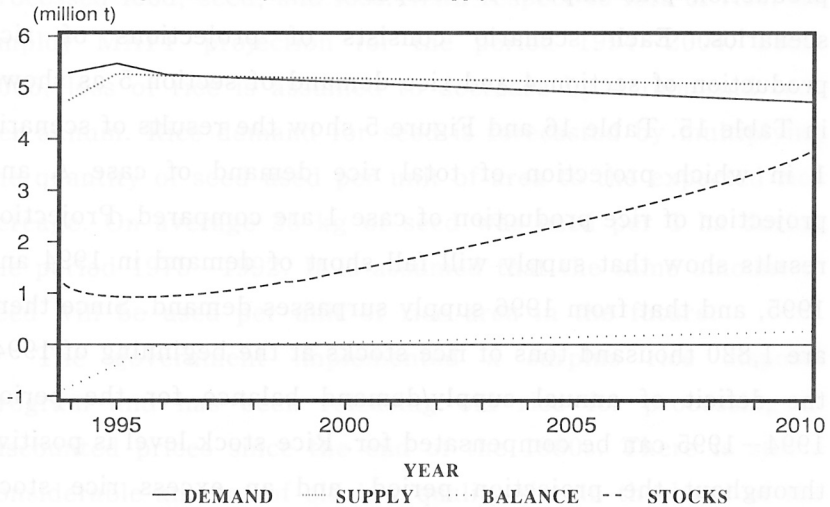
Table 15 Scenarios for Rice Supply and Demand Projection

scenario no.	production	demand
1	case 1	case A
2	case 1'	case A
3	case 2	case B
4	case 2'	case B
5	case 3	case C

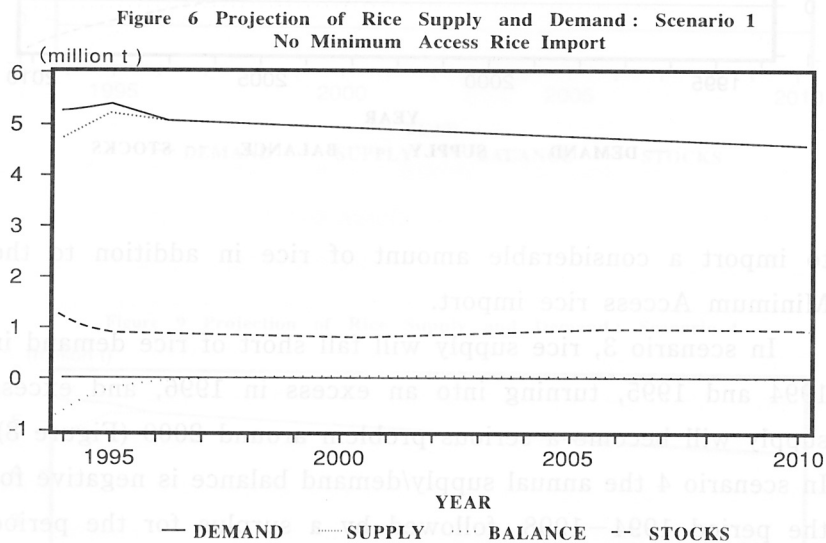
Table 16 Results of Rice Supply And Demand Bdalance Projection

scenario	supply and demand bdalance		year end stocks	
	positive	negative	positive	negative
scenario 1	1994-1995	1996-2010	1994-2010	
scenario 2	1994-2010		1994-2005	2006-2010
scenario 3	1994-1995	1996-2010	1994-2010	
scenario 4	1994-1998 2006-2010	1996-2005	1994-2010	
scenario 5	1994-1996	1997-2010	1994-2010	

Figure 5 Projection of Rice Supply and Demand : Scenario 1

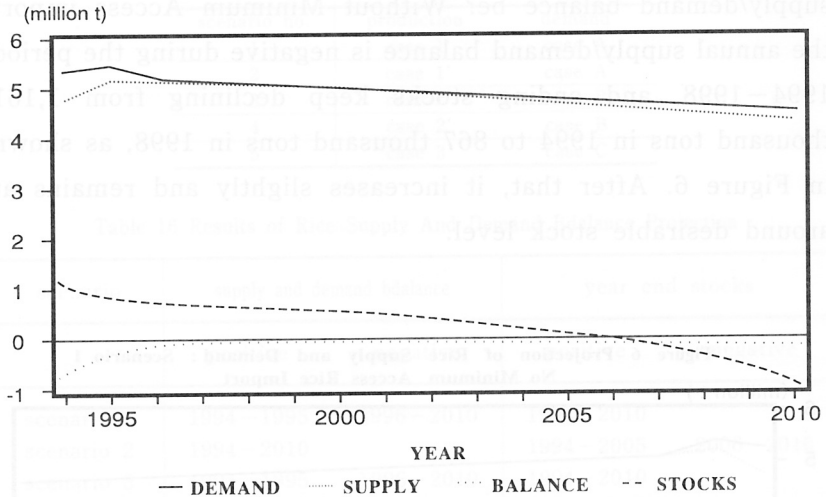


If there is no Minimum Access rice import what will the supply/demand balance be? Without Minimum Access import the annual supply/demand balance is negative during the period 1994–1998, and ending stocks keep declining from 1,161 thousand tons in 1994 to 867 thousand tons in 1998, as shown in Figure 6. After that, it increases slightly and remains at around desirable stock level.



In scenario 2, in which rice acreage is assumed to decrease by 20 thousand ha each year, and other assumptions are the same as scenario 1, the annual supply/demand balance is negative for the entire period (Figure 7). Ending rice stocks are positive for the period 1993–2006, becoming negative in 2007. In the case of this happening the Korean government will have

Figure 7 Projection of Rice Supply and Demand: Scenario 2



to import a considerable amount of rice in addition to the Minimum Access rice import.

In scenario 3, rice supply will fall short of rice demand in 1994 and 1995, turning into an excess in 1996, and excess supply will become a serious problem around 2000 (Figure 8). In scenario 4 the annual supply/demand balance is negative for the period 1994–1998, followed by a surplus for the period 1999–2005 (Figure 9), it then becomes negative again for the period 2006–2010. Ending stocks are close to the optimum level.

Scenario 5 is likely to be realized next to Scenario 2. In scenario 5, the annual supply/demand balance of rice is predicted to be negative for the period 1994–1996, becoming positive in 1997, and continuing to be positive until 2010 (Figure 10).

Figure 8 Projection of Rice Supply and Demand: Scenario 3

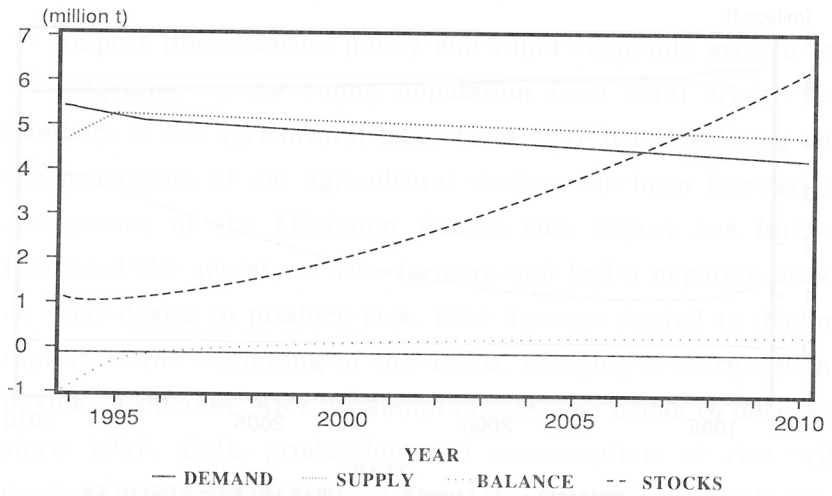


Figure 9 Projection of Rice Supply and Demand: Scenario 4

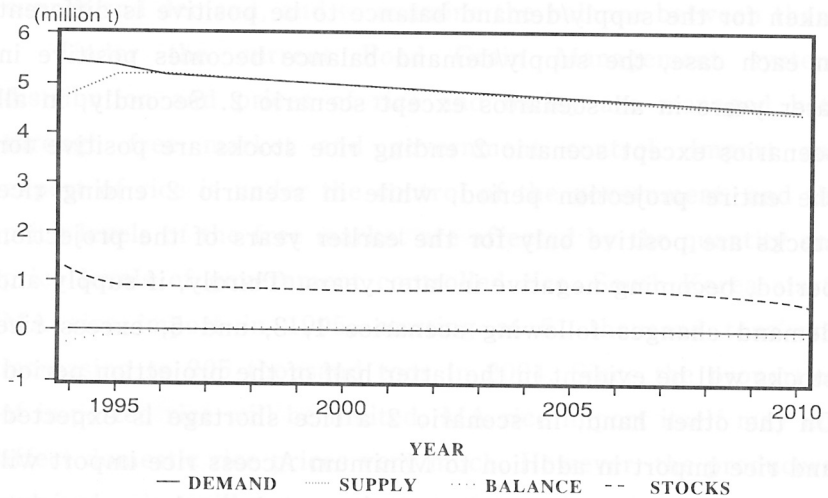
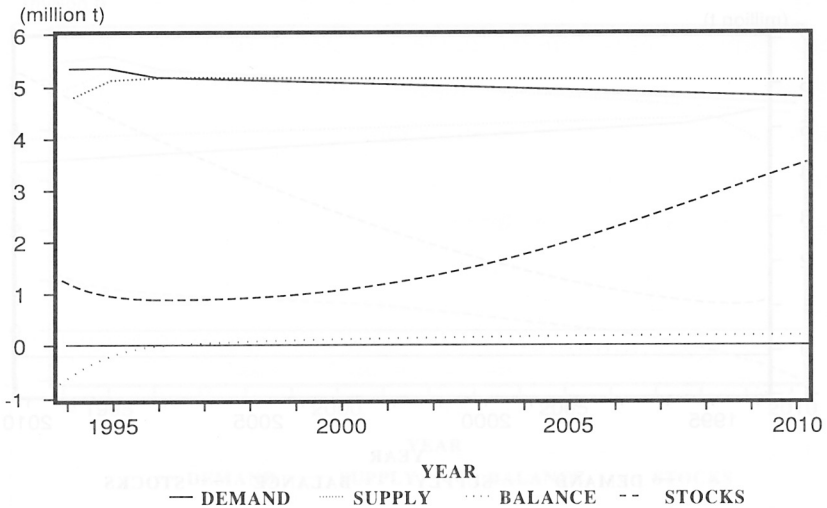


Figure 10 Projection of Rice Supply and Demand: Scenario 5



As a result of the above analysis the following conclusions can be drawn. First, the annual supply/demand balance of rice is negative in 1994 and 1995 in all scenarios. Although the time taken for the supply/demand balance to be positive is different in each case, the supply/demand balance becomes positive in later years in all scenarios except scenario 2. Secondly, in all scenarios except scenario 2 ending rice stocks are positive for the entire projection period, while in scenario 2 ending rice stocks are positive only for the earlier years of the projection period, becoming negative in later years. Thirdly, if supply and demand changes following scenarios 1, 3, and 5, excess rice stocks will be evident in the latter half of the projection period. On the other hand, in scenario 2 a rice shortage is expected, and rice import in addition to Minimum Access rice import will be required. In scenario 4 rice stocks remain at the appropriate level throughout the projection period.

7 Conclusion

Import liberalization policy and rapid economic growth led to emigration of the young population from rural areas. The numbers of the agricultural labor force have been declining and the proportion of old agricultural worker has been increasing. Acceptance of the Minimum Access rice import has further increased the anxiety of rice farmers and had a negative effect on their desire to produce rice. Rice acreage started to decline rapidly at the beginning of the 1990s, bringing a sharp decline in rice production. Rice consumption has also began to decrease since 1987. Both production and consumption of rice will continue to decrease in the future. If domestic rice production keeps declining at its present rate there is a possibility that South Korea will have to import more rice than required in MA scheme. Hence it is important to make projections about rice supply and demand, and to examine the balance between them.

Under the current Food Grain Management system, distribution and prices of rice and barley are managed both through free market and government control. Import and export of rice is under the control of the government, and the price levels of the free market are affected by the quantity and price levels of government controlled rice. South Korea starts MA rice import in 1995, starting at 51 thousand tons and increasing to 205 thousand tons in 2004. Since the proportion of imported rice will be limited, MA rice import itself may not affect domestic rice prices very much. However, the producers' nominal price will not continue to increase as in the past, due to the Uruguay Round agricultural agreement. Domestic

nominal prices are expected to stay at a constant level, and in real terms rice prices will continue to decline in the future. The rate of increase in per capita income will also slow down because the GNP growth rate is expected to decrease in the future.

Rice acreage response function and rice yield function were estimated in order to forecast rice production. The acreage elasticity with respect to rice price was 0.165. It was found that rice yields respond negatively to the ratio of farm wages and rice prices. Per capita rice demand function was estimated both for farm households and non-farm households. The own price elasticity of per capita rice demand was -0.117 and -0.209 for non-farm household members and farm household members, respectively. The value of income elasticity has been declining over time, and became negative in 1977 for non-farm households and in 1985 for farm households, indicating that rice became an inferior good for both farm households and non-farm households. In addition, farm populations and non-farm populations were predicted, and future total rice demand was calculated by using the projections of per capita rice demand and population.

Future rice production is predicted to decrease because of the rapid decline in rice acreage. Decrease in rice acreage is attributed mainly to the aging and reduction of the agricultural labor force, and to the expansion of residential areas. The trend of rice acreage is the most crucial factor in the projection of future rice production. Although rice yields will continue to increase in the future, the rate of increase will slow down since the expected increase in the ratio of farm wages and rice prices

will depress the economic incentive to increase rice yields.

Future rice demand will depend mainly on per capita income, rice prices, and the composition of farm population and non-farm population. Decline in the growth rate of per capita income will decelerate the reduction in rice demand, while decline in real rice prices, other things being equal, will increase rice consumption. The declining trend in future rice consumption will slow down because of these two economic factors. On the other hand, the proportion of the agricultural population is predicted to keep decreasing rapidly due to the emigration of the labor force from rural areas. The reduction in the proportion of the farm population contributes to the decreased total rice demand significantly, because per capita rice consumption of farm household member is about 45 percent higher than that of non-farm household member. The major findings in supply/demand projection are as follows:

- 1) Projections of supply/demand of rice are carried out for 5 scenarios. Scenario 2 seems the most likely to be realized in the future. According to the scenario 2 projection, rice yields are predicted to increase by 2.7 kg per annum, and will be 500 kg per 10 ares in 2010. Rice acreage is predicted to decrease by 20 thousand ha per annum, and will be 795 thousand ha in 2010. Total rice production is predicted to decrease by 40 thousand tons per annum, and will be 4,077 thousand tons in 2010.
- 2) Per capita rice demand is predicted to decrease by 1.5 kg per annum, slowing down from 3.1 kg annual reduction during the past year of 1990–1993. The major reason for this is the slower growth of per capita income. The total

rice demand is predicted to decrease by 51 thousand tons per annum, and will be 4,635 thousand tons in 2010. This is 1,254 thousand tons less than the consumption level of 1993.

- 3) The annual supply/demand balance is predicted to be negative throughout the projection period. As a result ending rice stocks will continue to decline, but will remain positive until 2005, becoming negative after that. South Korea may import rice in addition to MA rice import in the middle of the 2000s.
- 4) If the economic growth rate is higher than the assumption used for the baseline projection or the growth rate of rice yields is higher than the projection of scenario 2, then there is some chance of a positive supply/ demand balance, and of positive rice stocks.

NOTE

- 1) As regards income from non-rice production activities, there are two kinds: income from non-rice agricultural production and income from non-farm activities. Based on the fact that there are few crops from which farmers can earn a similar amount of income per 10 ares of paddy field, income from non-rice agricultural production activities is not included in the explanatory variable. Since income from non-agricultural activities can be considered as the opportunity cost for rice production, it is included in the explanatory variable. The wages of all industries are used as a proxy variable for income from non-agricultural activities.
- 2) Future per capita real income is calculated from the projection of the growth rates of Gross National Products. Per capita real income is regressed on per capita real GNP using the time series data of the period 1975–1992. The estimated results of per capita

income of farm households and non-farm households are as follows:

$$\ln y_{ft} = -420.724 + 0.884 \text{gnp}_t \quad \dots\dots(11)$$

(-9.733) (43.391)

$$R^2 = 0.991 \quad \text{D.W.} = 0.766$$

$$\ln y_{nft} = -439.808 + 0.969 \text{gnp}_t \quad \dots\dots(12)$$

(-8.547) (39.944)

$$R^2 = 0.989 \quad \text{D.W.} = 1.407$$

where, y_f , gnp , y_{nf} stand for real per capita income of farm households, per capita real GNP, real per capita income of non-farm households. The fit of the model is considerably good; the coefficient of determination and absolute values of t-statistics are large, and all estimated parameters are different from zero at the 5 percent significance level.

Future per capita income of farm households and non-farm households are calculated by using the estimated parameters and projections of per capita GNP. As for future GNP projections in "The Seventh Five Year Economic and Social Development Plan 1992-1996" of the Korean Government, and projection by the Korean Development Institute are used. Figure below shows the projection result of per capita GNP and per capita income. This projection of per capita income is named as case A.

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