CONSIDERATIONS IN THE INTRODUCTION OF CROP INSURANCE TO RICE SECTOR IN KOREA

By

Kwan Yong Lee

Plan B Paper

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics
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CHAPTER I

INTRODUCTION

Agricultural production depends much on uncontrollable weather conditions, which often threaten farmers' livelihoods. Weather risks are especially important for farmers in developing countries where they are still cultivating with conventional methods and less well developed irrigation and drainage systems and equipment. Moreover, seasonality and cyclicality hinder growth of agricultural sectors and make farm households' incomes unstable.

Two measures for dealing with such problems in the agricultural sector include 1) governmental price intervention and the expansion of farming bases, and 2) the establishment of governmentally run agricultural disaster insurance. As stated later, even though government plays a major role in an agricultural insurance program in most developing countries through the subsidization of premiums for insurance, there is still little difference in the basic principles of insurance between developed and undeveloped countries.

Generally speaking, conditions for farming in Korea are never very good. Due to monsoons and

continental climate, Korea often is in the range of typhoons with heavy rains during summertime but with very dry weather in the springtime, which adversely affects paddy-crop farming. A crop insurance program for the purpose of stabilizing farm income fluctuation is discussed, along with the obstacles, in Chapter VII. These obstacles have repeatedly blocked the idea of introducing crop insurance programs for the agricultural sector.

This paper is the result of my strong desire to establish agricultural insurance programs in the rural area of Korea to help farmers enjoy more stable lives and contribute to agricultural production. Even though agriculture is decreasing in Korea as a proportion of the national economy, about ten million people still depend on the success of agriculture. Korean agriculture is still producing more than fifteen percent of the national GNP. I will specialize on crop insurance for rice which is Korea's major crop and probably the leading candidate for the introduction of crop insurance programs into Korean agriculture.

Background to the Study

Agricultural insurance is an institution to reduce uncertainty in the lives of farmers arising from unfavorable weather conditions. Therefore, it is important

to analyze the meteorological and geographical conditions related to farming as a precondition to studying agricultural crop insurance. But the study of natural conditions alone is not enough to understand the agriculture of a country. It is also important to study social and economic conditions which have significant effects upon agricultural production and the introduction of appropriate agricultural insurance schemes.

Population and Arable Land

Korea is one of the most densely populated countries in the world. As of the end of 1979, the total population of Korea was 37,605 thousand people with 10,884 thousand people, 29 percent of the total population, employed in the agricultural sector. As a result, population density over the national area was 3,770 persons per 1,000 hectares in the end of 1979, and the farm population density at the same time was 4,931 persons per 1,000 hectares over the arable land. Let us look at the cases of Japan and Belgium. The population density in Japan was 3,123 persons per 1,000 hectares and farm population density was 2,726 persons per 1,000 hectares of arable land as of the end of 1979. On the other hand, in Belgium, the total population density was 3,111 persons and the farm population density was only 392 persons per 1,000 hectares as of the end of 1979.

As shown in the above, Korea is the most densely

populated country in the world, and, especially, farm population density over the arable land in Korea is higher than that of the total population.

Even though the farming population decreased after the 1960s, it was 29 percent of the total population and in the case of farm-household, 27 percent by the end of 1979. The ratio of farm population to the total population in the U.S. was only 2.25 percent, that of Belgium was 3.25 percent, and the farm population in Japan was 11.5 percent of the total population at the end of 1979. Cultivated land per farm household in Korea was only one hectare as of the end of 1979. As shown in the next section, farming in Korea is subsistent farming in nature.

One characteristic of Korean agriculture is fragmentation of arable land. The average area of cultivated land per household was 1.02 hectare as of the end of 1979. This included 0.61 hectare of paddy and 0.41 hectare of upland. Even though this situation has gradually improved with industrial development, the farming populace is still in surplus numbers and the absolute area of cultivated land is so small that it is not easy to expand per household farm land in the short run.

As shown in Table 1.2, as of the end of 1979, the number of farm households with less than 0.5 hectare of cultivated land represented 29.8 percent of the total

TABLE 1.1

POPULATION AND LAND IN KOREA

	Population			No. of Household			Area			
	Total (A)	Farm (B)	B/A	Total (C)	Farm (D)	D/C	Total (E)	Farm (F)	F/E	F/D
	(Thou. Persons)		(%)	(Thou. Hectares)		(%)	(Thou. Hectares)		(%)	(ha)
1965	28,705	15,812	55.1	4,844	2,507	51.7	9,843	2,256	22.9	0.90
1970	32,241	14,422	45.9	5,856	2,483	42.4	9,848	2,298	23.3	0.93
1975	35,281	13,244	38.2	6,757	2,379	35.2	9,881	2,240	22.7	0.94
1978	37,019	11,527	31.1	7,256	2,224	30.7	9,896	2,222	22.5	1.00
1979	37,605	10,884	28.9	7,539	2,162	28.7	9,897	2,207	22.3	1.02

Source: Year Book of Agriculture and Forestry Statistics, MAF, 1980.

TABLE 1.2

NUMBER OF FARM HOUSEHOLDS AND AREA BY SIZE OF FARM LAND UNDER CULTIVATION IN 1979

	Less than 0.6 ha	0.5~1.0	1.0~2.0	2.0~3.0	More than 3.0 ha	No. of non-crop farm household
Total Area of Cultivated land	205,255 ha	560,825	756,843	212,200	110,384	--
Average Area of Cultivated Land	0.32 ha	0.73	1.36	2.36	4.12	--
Component Ratio of Cultivated Land	11.1%	30.4	41.0	11.5	6.0	--
No. of Farm-Household	643,877	764,203	555,630	89,733	26,778	81,900
Component Ratio of Farm Household	29.8%	35.3	25.7	4.1	1.2	3.8

Sources: 1) Year Book of Agriculture and Forestry Statistics, 1980.
2) Report on the Results of Farm Household Economy Survey, 1980, MAF

farm households and the area of the arable land they owned accounted for 11 percent of the total cultivated land. The number of farm households cultivating under 1 hectare represented 65 percent, and the total area of their cultivated lands accounted for 41.5 percent. The number of the farm households cultivating over 2 hectares represented only 5.3 percent and the arable land cultivated by them accounted for 17.5 percent of the nation's total.

In addition, farmlands are further fragmented and mingled with those belonging to others. Several years ago, a study of the number of separate pieces of land per household indicated six on the average, but there were also many households which had more than 17 separate pieces.[1] These characteristics of Korean agriculture are bottlenecks to modernization of agriculture and to the establishment of a crop insurance system as they inevitably increase operating costs.

Subsistence Farming Depending Mainly on Rice

Korean agriculture is composed chiefly of production of staple crops such as paddy rice, barley and vegetables with little attention to livestock products.

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[1] A Study of the Regional Characteristics of Korean Agriculture, College of Agriculture, Korea University, 1967, p. 58.

As shown in Table 1.3, in 1979 the number of farming households classified as rice farms represented 76.7 percent and the number of farm households classified as upland farms accounted for 10.2 percent. The number of farm households which produced staple crops constituted 87.9 percent. On the other hand, the number of farm households raising livestock represented only 1.2 percent, while the farm land area for food crops was 68.6 percent.

As for the sources of agricultural gross income, the receipts by food crops made up 61.4 percent of which 49.5 percent came from rice. The area under cultivation of food crops represented 42.4 percent and that of barley and wheat 16.8 percent, both overwhelmingly exceeding other crops in the areas cultivated.

As shown in Table 1.3, Korean agriculture can be characterized by grain crop farming without livestock. Also, the agriculture of Korea is characterized by family farming. And family farming is practised chiefly to supply food for the family, though some products are sold. The primary objective of such subsistence farming is not money or profit, but to maintain and improve a family life; that is, the subsistence farms are operated not so much for value in exchange as for value in use. In such a farming system, livelihood and enterprise are not separated from each other, but are parts of a whole. Furthermore, subsistence farming does not allow an

TABLE 1.3

FARMER'S INCOME, NUMBER OF FARM HOUSEHOLDS, AND UTILIZATION AREA BY CROPS IN 1979

	Average Gross Income Per Household		Farm Household		Utilization Area	
	Amount (in thou.)	Percentage	Number (in thou.)	Percentage	Area (in thou. ha)	Percentage
Total	2,027	100.0	2,163	100.0	2,909	100.0
Crops	1,624	80.1	2,063	95.4	--	--
Rice	1,004	49.5	1,659	76.7	1,233	42.4
Barley & Wheat	135	6.7	221	10.2	489	16.8
Vegetables & Fruits	380	18.7	133	6.1	554	19.0
Others	105	5.2	50	2.3	421	14.8
Non-Crops	127	6.3	100	4.6	--	--
Livestock	93	4.6	25	1.2	--	--
Sericulture	27	1.3	6	0.3	27	0.9
Others	7	0.3	69	3.2	180	6.2

Source: Year Book of Agriculture and Forestry Statistics, 1980.

adequate accumulation of capital for permanent expansion of production. In such a farming system, capital investment for increasing production is difficult, and this hinders agricultural development. As a result, crop insurance is not typically provided by private companies as farmers cannot afford to buy it.

Farm Income and Living Expenses

Farm income in Korea has increased gradually due to the increased productivity in grain crops,[2] increased cultivated acreages and the reduction of the farm population. The elevation of agricultural productivity since 1960 has mainly resulted from the improvement of seeds (especially rice), farming technology, and farm mechanization.

As shown in Table 1.4, 1968 farm income per household was 178.9 thousand won[3] and the per capital farmer's income was 29 thousand won in current prices. In 1979, farm income per household was 2,227.5 thousand won and per capita income was 442.8 thousand won. Comparing per capita farmer's income to per capita GNP was 54.1 percent in 1968, but in 1979 it had improved to 57.3

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[2]Sung Hwan Ban, Rural Development in Korea, Harvard University Press, 1980, p. 92.

[3]"Won" is the unit of Korean money. The exchange rate of Won per dollar was 281 won in 1968.

TABLE 1.4

FARMER'S INCOME AND PER CAPITA GNP (IN THOU. WON)

	Farmer's Income		No. of Family	Per Capita GNP (B)	A/B (%)	Exchange Rate Per Dollar
	Per Household	Per Capita (A)				
1968	178.9	29.0	6.17	53.6	54.1	281.5
1970	255.8	44.0	5.81	83.2	52.9	316.7
1975	872.9	156.7	5.59	277.6	56.4	484.0
1976	1,156.3	211.4	5.47	370.1	57.1	484.0
1977	1,432.8	268.3	5.34	467.2	57.4	484.0
1978	1,884.2	363.7	5.18	619.1	58.7	484.0
1979	2,227.5	442.8	5.03	773.1	57.3	484.0

Source: Report on the Results of Farm Household Economy Survey, 1980.

percent.

Now, I will compare agricultural income per household to living expenses by size of cultivated land in 1979. The less cultivated land the farm household has, the less agricultural income. The agricultural income of farm household with less than 1 hectare of cultivated land was not enough to cover family living expenses. Non-farming income in households of less than 0.5 hectare cultivated land is about 62 percent of total income. The voluntary demand of farmers with less than 1 hectare of cultivated land for crop insurance is not likely to be large.

Problems and Assumptions

The economy in Korea has developed rapidly due to a high growth policy for the industrial sector since 1962, at which time the first Five-Year Economic Development Plan was started. Even though many economic and social problems arose in the process of economic development under the fourth Five-Year Economic Development Plan, the national economy continued to grow, and social welfare improved. But, due to high growth in the industrial sector there has been unbalanced development between industries and unbalanced income growth among social strata, especially between the rural and urban areas. As a result, policies and programs have been required

TABLE 1.5

FARM HOUSEHOLD INCOME AND LIVING EXPENSES

(in thou. won)

	Farm Household Income				
	Total	Agri-Income(A)	Non-agri Income	Living Expenses(B)	A-B
Average	2,257	1,531	696	1,662	-131
Less than 0.5 ha	1,517	580	937	1,286	-705
0.5-1.0	1,906	1,256	650	1,489	-233
1.0-1.5	2,467	1,863	604	1,777	86
1.5-2.0	3,049	2,429	620	2,095	334
more than 2.0 ha	4,042	3,386	656	2,681	705

Source: Report on the Results of Farm Household Economy Survey, 1980.

to protect the livelihoods of lower income groups, to enlarge the agricultural investments, to raise income levels in the rural area, and to stabilize food supply, at least for such major Korean food grains as rice and barley.

Some developed countries leave protection against calamities up to individual savings and privately operated insurance schemes. Other developed countries socialize such bearing of protection against calamities to a high degree. Poorer, less developed countries find it difficult to follow either route. The government of Korea, as a rather rapidly developing country, now seems to be in position to render some assistance--particularly in farming where protection against natural calamities may serve to stabilize and expand food production as well as assist the poor and disadvantaged.

As will be discussed later, the climate in Korea is not favorable for farming; frequent calamities befall agricultural production and development. In addition, small scale farms have little power to overcome the effects of bad weather. This causes a reduction in agricultural productivity which brings forth an unstable national economy because of the decrease in agricultural production and the decrease in demand for industrial commodities.

In Korea, a law was passed in the late 1960s to subsidize farmers and protect agricultural production

activities from disasters. But this disaster relief program is not a stable welfare institution because it has shortcomings. For instance, it reacts slowly in case of disasters and it depends too much on changeable government budgets. For example, subsidies or support for recovery from agricultural damages due to natural disasters during 1965-1979 covered only 3.7 percent of total agricultural damages. As a result, it has become necessary to establish a steady and stable welfare institution in the rural areas to reduce farmers' income instability and to help them continue their production activities. As shown in many cases in developing countries, an agricultural insurance program is an appropriate kind of institution to meet such objectives. Some Korean agricultural leaders have often proposed the introduction of a crop insurance program for agriculture, covering, at least, rice.

Establishment of crop insurance in Korea has progressed to the point of establishing in 1975 a pilot program of crop insurance by the National Agricultural Economic Institute. This pilot program was planned to start during the fourth Five-Year Economic Development Plan, but its establishment was stopped due to governmental budget problems involving the expected premium subsidization and a shortage of crop insurance specialists. Recently, two sharp reductions in rice production (1978 and 1980)

due to crop diseases and cold temperature, respectively, resulted in strong voices requiring the establishment of a crop insurance scheme.

In studying a crop insurance program to reduce income variability, several problems should be considered:

1. What types of crop insurance would be the best in Korea? Is it possible to have a self-sustaining program for crop insurance including administrative expenses?

2. What should be considered in making an appropriate premium-indemnity schedule? What kinds of obstacles are to be expected when introducing crop insurance in Korea?

3. What benefits are to be expected from introducing a crop insurance program? What policy alternatives to a crop insurance program should be considered?

I will analyze some natural and social conditions of Korean agriculture, and I will discuss obstacles to the introduction of crop insurance in Korea and policy alternatives to crop insurance in order to find an effective capital resource allocation.

But also on the basis of general theory of crop insurance, I assume that a farmer's response to an insurance program is based on the maximization of expected utility and that crop yield distributions can be estimated statistically. The exact premium rate is an important factor for crop insurance to be established successfully,

even though it is government-run insurance. When a compulsory contract is used, expected utility analysis helps indicate how much subsidy is required to reduce opposition to a compulsory scheme to an acceptable level.

CHAPTER II

NATURAL CONDITIONS FOR KOREAN AGRICULTURE

In studying agricultural insurance, which is an institution to stabilize farmers' livelihoods against partial or complete crop failure due to adverse weather or to related adverse physical crop conditions which are beyond control, the factors affecting agriculture should be considered first of all. I have analyzed the socio-economic conditions of Korean agriculture which influence the introduction of agricultural insurance as an institution. Here, I will review the natural conditions including climate and topography.

Topographical Conditions

Agricultural production is influenced by natural conditions to a greater extent than any other field of modern industry, because it uses biological processes for producing products from plants and animals. Land itself is a part of nature on which agricultural production is based. Therefore, location, topography, soil and meteorological conditions have definite influences upn agricultural production, comprising such elements as kind of products, cropping system, cultivation method

and productivity.

Korea is a penninsula located between the Asian continent and the Pacific Ocean. It plays the role of a land bridge between the continental and oceanic countries, namely, Japan across the East Sea and the Mainland of China across the Yellow Sea. To the north it is connected with Manchuria of China and the inshores of the Soviet Union by the Yallu and Tuman River. The peninsula is narrow east to west and long south to north.

Even though there are no high mountains, Korea is a comparatively mountaineous country. Korea (South) had 9,897 thousand hectares as of the end of 1979, less than 23 percent of which was cultivated. About 67 percent was in forests and mountainous areas. The rest was land for urban people and factories.

The parent material which constitutes the strata of the land of Korea is composed largely of granite and gneisses occupying two thirds of the entire land. The parent material has decomposed usually into sandy soil or loamy sand, but most of the soils in Korea are undeveloped and reflect many characteristics of the parent material. The top soil is also rather shallow. The soil in Korea is mostly acid and lacks alkali. Therefore, the soil in Korea generally lacks fertility and good chemical elements. Paddy rice crops, however, have stronger resistance to acid than other crops,

providing the possibility of farming on a waterfield rice planting method.

As shown on the map of agricultural zones of Korea, the low fields around the rivers are mainly the zones for paddy crop. The mountainous zones are used for upland crops. Semi-mountainous areas are cultivated for both paddy and upland crops. Especially, in the southern part of South Korea, two-crop farming is practiced: rice during the summer and barley during the winter. And along the Tae Back Ranges in the eastern part of Korea, there is an upland crop region in which potatoes and corn are grown mainly during the summer season.

Climatic Conditions

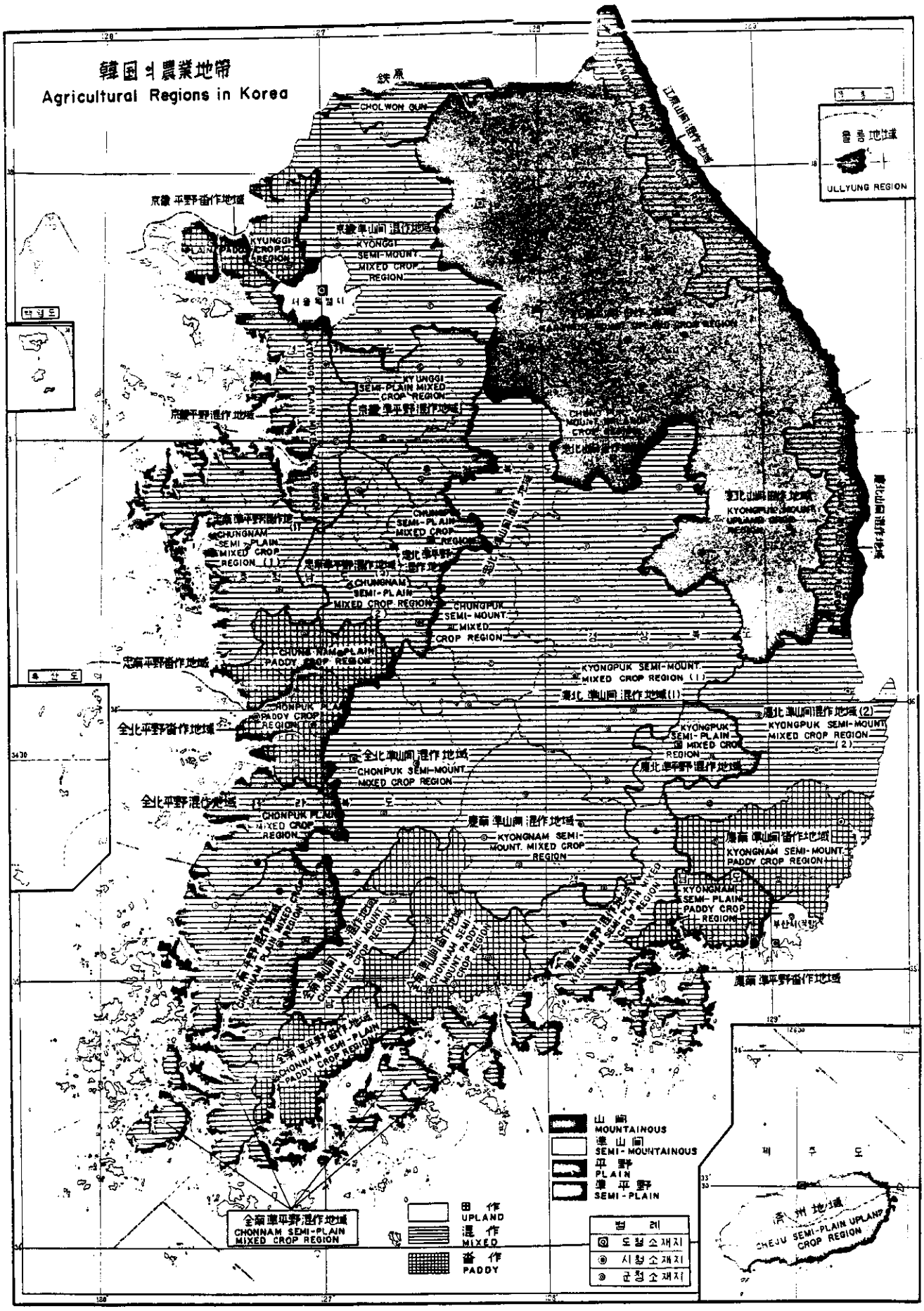
Since the climate of Korea is continental, the temperature is usually high in summer throughout the country with little climatic refraction between the southern and northern parts of the country. On the contrary, it is very cold in winter with remarkable climatic refraction between the two parts. Since Korea is located between a continental climate and an oceanic climate, the climate of Korea is often referred to as intermediate. But actually, since Korea is connected with the continent and its skeleton mountains are in the east with a steep slope to the East Sea, the climate of Korea is more influenced by the continent than by the ocean. To the west,

the Yellow Sea is surrounded by the Continent and the Korean Peninsula, and has little oceanic effect on the climate of Korea.

Korea also has a monsoon climate. In winter, Korea is exposed to the monsoon which blows from the continent to the ocean due to influences of a high anticyclone generated in the vicinity of Baikal of Siberia and throughout outer Mongolia and cylcones originating in the Pacific Ocean. In addition, monsoons make the air very cold, dry and unclouded for many days. In summer, the southeast monsoon blows from the ocean toward the continent because of the powerful anticyclone generated in the ocean and the cyclone of the continent. The monsoon is accompanied by a great quantity of moisture creating clouds which bring heavy rain during this season.

The major elements affecting temperature are monsoons, latitude, and geographical status effects of an ocean current in the neighboring sea. The annual average centigrade temperature of the southern coastal zone is about 14 degrees, 11 degrees in the central zone and 8 degrees in the northern zone.

As shown in Table 2.1, the annual average rainfall of the country is some 1,200 millimeters to 1,300 with extensive seasonal fluctuations. In the dry season of six months from October to Marcch each year, rainfall constitutes only 15 percent of the annual total, while


韓国의農業地帶
Agricultural Regions in Korea
鉄原
CHOLWON GUN
京畿 平野畓作地域
KYUNGGI PLAIN PADDY CROP REGION
京畿準山間 混作地域
KYONGGI SEMI-MOUNT. MIXED CROP REGION
서울특별시
KYUNGGI SEMI-PLAIN MIXED CROP REGION
京畿準平野混作地域
京畿平野混作地域
忠南準平野混作地域 (1)
CHUNGNAM SEMI-PLAIN MIXED CROP REGION (1)
忠北準平野混作地域
CHUNGNAM SEMI-PLAIN MIXED CROP REGION (2)
CHUNGPUK SEMI-PLAIN MIXED CROP REGION
CHUNGPUK SEMI-MOUNT MIXED CROP REGION
忠南平野畓作地域
CHUNGNAM PLAIN PADDY CROP REGION
KYONGPUK SEMI-MOUNT MIXED CROP REGION (1)
慶北準山間混作地域(1)
全北平野畓作地域
RONPUK PLAIN PADDY CROP REGION
慶北準山間混作地域(2)
KYONGPUK SEMI-MOUNT MIXED CROP REGION (2)
KYONGPUK SEMI-PLAIN MIXED CROP REGION
慶北準平野混作地域
全北準山間混作地域
CHONPUK SEMI-MOUNT MIXED CROP REGION
全北平野混作地域
CHONPUK PLAIN MIXED CROP REGION
慶南準山間混作地域
KYONGNAM SEMI-MOUNT. MIXED CROP REGION
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全南準平野混作地域
CHONNAM SEMI-PLAIN MIXED CROP REGION
全南準平野畓作地域
CHONNAM SEMI-PLAIN PADDY CROP REGION
울릉 地域
ULLYUNG REGION
山間
MOUNTAINOUS
準山間
SEMI-MOUNTAINOUS
平野
PLAIN
準平野
SEMI-PLAIN
田作
UPLAND
混作
MIXED
畓作
PADDY
범례
도청소재지
시청소재지
군청소재지
제주도
濟州地域
CHEJU SEMI-PLAIN UPLAND CROP REGION

TABLE 2.1

ANNUAL AND MONTHLY RAINFALL IN KOREA, 1979, BY DISTRICT
(in millimeters)

Districts	Total	Monthly											
		1	2	3	4	5	6	7	8	9	10	11	12
Seoul	1,279.4	19.6	32.6	60.3	138.6	116.0	354.4	204.3	237.8	46.8	3.5	30.0	35.5
Kang nung	1,189.5	149.8	111.9	96.6	78.9	90.2	219.0	115.4	165.2	51.7	92.0	2.0	16.8
Pusan	1,708.3	75.4	65.2	48.1	142.0	166.8	336.3	225.2	317.1	213.2	19.2	27.1	72.9
Taegu	1,017.6	17.5	60.4	50.9	68.0	127.1	132.6	132.5	218.2	174.9	3.6	7.4	24.5
Yeosu	1,619.6	20.4	73.5	62.5	134.5	140.9	229.1	245.4	442.5	176.9	0.0	24.1	70.0

Source: Year Book of Agriculture and Forestry Statistics, 1980.

it accounts for 85 percent in the humid season from April to September. In particular, rainfall in three rainy months (June, July and August) makes up about 60 percent of the annual total.

Meteorological Calamities in Agriculture

In Korea, major meteorological calamities for agricultural production (rice) include drought, which usually occurs during the springtime--rice-transplanting season, storms and floods during summertime, cold temperature and frost, hail and tidal waves. These all damage agricultural production. Low temperatures during the planting season in 1980 reduced the rice production by half.

According to an analysis of the effect of meteorological calamities on agriculture, 1904-1970, heavy rain was shown as the most frequent (annual average - 4.1 times), storms were the second main cause (3.4 times) and drought the next.

Monthly average frequencies of the above calamities indicate that heavy rain usually came during summer, storms during February - April, droughts during spring and August. Typhoons occurred during summer, cold temperature and frost mainly in May, September and October, and hail in the spring.

As previously stated, topographically and climatically Korea has poor conditions for agriculture. In

TABLE 2.2

ANNUAL AVERAGE FREQUENCY OF METEOROLOGICAL DISASTER ON RICE (1904-1970)

	Number of Total Occurrence	Annual Average Occurrence
Heavy Rain	273	4.1
Storm	231	3.4
Drought	118	1.8
Typhoon	79	1.2
Cold temperature and frost	41	0.6
Hail	32	0.5
Tidal Wave	32	0.5

Source: National Meteorological Station, 1971-1972.

order to lessen the extent of damage from bad weather, especially flood and drought, it is necessary to expand irrigation and drainage facilities.

In recent years, numerous large or small scale dams have been constructed, but only 70 percent of the paddy fields benefitted from irrigation facilities as of the end of 1979.

Annual agricultural damage from bad weather during the 1965-1979 period averaged 248 thousand hectares, which was 11.2 percent of the total farm area. The average annual damage for the same period of agricultural products reached 305 thousand metric tons.

TABLE 2.3

MONTHLY AVERAGE PERCENTAGE OF METEOROLOGICAL CALAMITIES ON RICE
(1904-1970)

(in percentage)

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Heavy rain	0.4	0.7	0.7	4.5	2.8	13.6	36.9	26.1	10.8	2.4	0.4	0.7	100.0
Storm	9.0	12.6	13.9	11.7	7.7	6.8	6.3	4.0	6.3	6.8	7.7	7.2	100.0
Drought	2.9	4.4	13.6	12.6	12.6	9.7	9.2	11.2	6.3	10.2	6.3	1.0	100.0
Typhoon	-	-	-	-	1.3	3.9	16.9	46.7	28.6	2.6	-	-	100.0
Cold temperature and frost	-	-	6.3	6.3	25.1	-	-	6.3	18.7	37.4	-	-	100.0
Hail	-	-	-	-	16.2	54.1	5.4	8.1	8.1	5.4	2.7	-	100.0
Tidal wave	7.7	3.8	-	7.7	3.8	3.8	11.6	26.9	23.1	-	11.6	-	100.0

Source: National Meteorological Station, 1971-1972.

TABLE 2.4

ANNUAL AGRICULTURE DAMAGE AREA AND QUANTITY

	Total Agricultural Product		Rice			
	Area(A)	Quantity(B)	Area(C)	Quantity(D)	C/A	D/B
	(Thou.ha)	(thou. M/T)	(thou.ha)	(thou.M/T)	(%)	(%)
1965	144.8	65.6	122.3	59.9	84.5	91.3
1966	97.3	119.7	60.8	67.2	62.5	45.1
1967	430.6	810.0	236.0	424.4	54.8	52.4
1968	503.4	897.2	331.8	552.5	65.9	61.1
1969	227.0	265.4	156.1	221.9	68.8	83.6
1970	334.3	225.2	238.8	123.2	71.4	54.9
1971	249.0	122.6	220.6	71.0	88.6	57.9
1972	198.8	151.3	139.4	99.8	70.1	66.0
1973	76.9	61.6	56.0	52.6	72.8	85.4
1974	295.1	159.2	102.7	69.3	34.8	43.5
1975	192.5	78.8	75.7	28.8	39.3	36.5
1976	108.3	52.6	66.5	40.0	61.4	76.0
1977	581.3	902.0	78.7	26.1	13.5	2.9
1978	89.2	89.2	58.0	65.9	65.0	73.9
1979	187.0	569.9	160.5	344.3	85.8	60.4
Av.	247.7	304.7	140.3	149.8	56.6	49.2

Source: "Study About the Introduction of Crop Insurance," Korean Rural Economy Institute, 1980.

This average of 305 thousand metric tons was about 3.8 percent of the total agricultural production in 1979 of 8,112.2 thousand metric tons. Rice damage from bad weather in the 15 year period was 56.6 percent of the total damage area and 49.2 percent of the total quantity of damage. The annual average area of rice damaged in the same period was 140 thousand hectares or 10.7 percent of the total paddy area, 1,311 thousand hectares. The average annual damage in quantity of rice was 150 thousand metric tons, or 3.4 percent of average annual rice production during the same period.

CHAPTER III

THEORETICAL REVIEW RELEVANT TO CROP INSURANCE

Insurance is an economic institution that reduces or mitigates risk of loss for the individual through the combination of a large number of similarly exposed individuals who each contribute premium payments sufficient to make good the loss caused to any one individual.[1] The primary function of insurance is thus the elimination of the risk of loss for the individual. Crop insurance is the application of the principles of general insurance to cover and provide compensation for the risks involved in agricultural production for the purpose of reducing the income fluctuations of farmers.

Here, I will review some theories related to insurance based on the assumption that firms or households pursue the maximization of profits or utility under uncertain future events, agricultural risks and conditions of insurability for agricultural risks, and specific benefits of crop insurance.

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[1]Mark R. Greene, Risk and Insurance, Cincinatti: South-Western Co., 1977, p. 56.

Decision Making Under Uncertainty

When farmers or managers in the firm make the decision to produce products and to allocate resources, they base their decisions on information about future events, consciously or unconsciously. Sometimes, farmers may know a future event with certainty, but, in most cases, future events related to decision making are uncertain; e.g., weather, techniques, the prices of inputs, and product prices.

It is useful to consider a few concepts and principles in farmers' decision making, as they contribute to a further discussion of crop insurance.

Risk and Uncertainty

The term "risk" is used in everyday conversation and economic problems without exact specification of meaning. In this case, risk means a measurable event, while at other times, it is used to refer to something impossible to measure.

Knight[2] referred to risk as being "a measurable uncertainty" and used the term "uncertainty" to refer to cases of the non-quantitative types. Hart[3] distinguished

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[2]Frank E. Knight, Risk, Uncertainty and Profit, London: London School of Economics and Political Science, 1937, p. 19.

[3]Albert G. Hart, "Risk, Uncertainty and the Unprofitability of Compounding Probabilities," Readings in the Theory of Income Distribution, Philadelphia: The Blakiston Co., 1946.

risk and uncertainty substantially following Knight; "risk is taken to denote the holdings of anticipations which are not single-valued but constitute a probability distribution having known parameters. On the other hand, "uncertainty" is taken to denote the holdings of anticipations under which the parameters of the probability distribution are themselves not single-valued. Actually, the future of a single case may be completely uncertain, but when many cases are grouped together, the feature of the group as a whole may become predictable, which usually takes the form of a probability distribution.

Glenn Johnson[4] classified uncertainty and risk by suggesting that a farmer is operating in an uncertain situation when he must make an allocative decision before he has enough information to complete a more or less subjective statistical test of the relevant hypothesis about the future, and, on the other hand, is in a risk situation when he makes a decision on the basis of enough information to complete a more or less subjective statistical test of relevant hypothesis about the future.

In an insurance sense, risk is often considered a chance of loss. Farmers are prone to classify all outcomes which may lead to losses as risks. Risk arises from

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[4]Glenn L. Johnson, "Allocative Efficiency of Agricultural Prices--as Affected by Changes in the General Level of Employment," Unpublished dissertation, University of Chicago, 1949, pp. 32-44.

uncertainty of expectations concerning relevant future events. I am uncertain about tomorrow's weather, but I really don't care; hence, this lack of knowledge involves no risk to me. But the weather on next Sunday is of concern to me if I want to go on a picnic with my family, and if it rains, I won't be able to go. If I know that it will rain, I will not go. Hence, my evaluation of the probability of next Sunday's weather affects my decisions. This illustrates that risk and uncertainty are very different things. Uncertainty is lack of knowledge about some specific future event; risk is my education of how badly the actual event may affect me and my well-being when it occurs, and this evaluation influences my present action and planning.

In addition, as a characteristic of risk, the sample must contain a large number of observations; the losses must be repeated in the population, and the losses must be independent and randomly distributed. The ability to establish parameters of the probability distribution for outcomes distinguishes risk elements from uncertainty elements. Uncertainty is entirely of a subjective nature--it refers to anticipating of the future held by the individual. Thus, risks are insurable, as will be discussed later, but uncertainty is not.

Risks in Agriculture

Risks in agriculture take many forms but may be classified broadly into property risks and personal risks according to the object of incidence of uncertainty. Here I will deal with risks in agricultural property, especially crop yields. These may again be divided into roughly three categories following Ray's classification:[5] 1) price risks, 2) natural risks, and 3) other market risks.

Prices, theoretically, are determined by demand and supply of goods; that is, prices vary in accordance with changes in income level and consumer tastes, the actions of producers and commodity cycles. But in the case of agricultural products, we can say that price risk is a function of the short-run elasticity of the agricultural production affected by major weather factors. As mentioned before, agricultural prices reflect the seasonability and cyclicality of agricultural production. Even though the reduction of price fluctuations for agricultural products prices would be important elements in stabilizing farmers' incomes it is, generally, recommended that a crop insurance program not cover price risks because prices are considered a market phenomenon

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[5]P. K. Ray, Agricultural Insurance, Elmsford, N.Y.: Pergamon Press, 1967.

rather than an uncontrollable natural phenomenon. In fact, agricultural price variations can be modified by reducing the seasonality of supply which can be done by storing and processing agricultural products. In addition, price fluctuations can be dealt with more effectively in other ways or through policies other than crop insurance.

Agricultural production is affected much by natural and controllable disasters. Most agricultural policies in Korea, like those in most developing countries, place emphasis on the reduction or elimination of production instability by weather, for example, the expansion of irrigation and drainage systems, or the development of new seeds able to endure hot or cold weather. Generally natural risks affecting agricultural production fall into three categories: 1) uncertainties of natural elements--deficiency in moisture, excess of moisture like floods or inundations, cold temperature, hail, wind, and natural fire and lightening; 2) plant and animal disease, 3) the spread of harmful insects and other pests. Even though there are technologies available to reduce these natural risks in agriculture, these hazards are, for the most part, largely beyond the farmers' control, and these risks contribute to fluctuations in agricultural production and instability of farm income. As a result, these natural risks are suitable factors to

be insured, that is, insurable risks. In the case of Korea, heavy rains brought by storms or a typhoon, and drought are the most important factors causing reduced crop yields. Recently, plant diseases have become another major natural disaster.

Continuing to explain the classifications of Ray, social conditions, as he defines them, also affect agricultural production and distribution. Examples include the variability in the distribution of goods and market services, the supply of other inputs for production, and imperfections in the market, such as war, strikes, etc. Furthermore, agricultural production is related to the different degrees of farm management of farmers,[6] such as the application of fertilizers, pesticides and insecticides, the acceptance of new technology, and accessibility to irrigation and drainage systems. The differences in the degrees of farm management are very important factors for establishing crop insurance programs. Sometimes, differences in management quality or farming practices affect the demand for crop insurance.

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[6]Moral Hazard - An uncertainty due to the personal factor involved in management, that is, moral delinquency from an act of omission of the insured, is called in the language of insurance a "Moral Hazard." Difficulties in management quality or the differences in farming practices in developing countries create many technical problems in establishing crop insurance.

Especially, under compulsory crop insurance, poor managers may receive indemnities more frequently than good farm managers. This may cause a reduction in agricultural production, while good farm managers restrict their inputs in order to receive indemnities in the year when expected crop yield is bad. In developing countries with great management and farm practices, the moral hazard problem is a big obstacle to the successful establishment of a crop insurance program.

Methods of Meeting Agricultural Risks

In agriculture, it is clear that there is no escape, present or future, from the presence of uncertainty in managing farms. Much has been and is being done to reduce uncertainty of the future by exercising control over the future. The elimination of the risk requires the elimination, not of the loss or damage itself, but of the uncertainty concerning its time or place or extent. Usually this involves the payment of a certain, known, and small amount of money for protection against an uncertain large loss. This cost, for instance, may consist of the cost of a safety device which can reduce risk, or it may be the cost of an investigation to remove the uncertainty.

Hardy[7] analyzed methods of dealing with risks in the administration of business into the following types: 1) elimination of risk, 2) assumption of risk, and 3) transfer of risks to others.[8] Ray[9] also divided methods to reduce or to mitigate agricultural risks into these three groups: 1) avoidance, 2) prevention, and 3) assumption. Further, he explained that "assumption" is a way to meet the unavoidable risks. Risk assumption methods include self-insurance, mutual insurance and specualtion and insurance.

Basically, there may be two main approaches in dealing with risks and uncertainties in agriculture.[10] One is to provide for financial arrangements for keeping the farmer solvent when losses occur, and the other way is to reduce the frequency and size of risk losses. The

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[7]Charles O. Hardy, Risk and Risk-Bearing, Chicago: The University of Chicago Press, 1923.

[8]Hardy suggested specific ways to meet risks as follows: A) Elimination of risk by prevention of the harmful events, forecasting, or research to remove the uncertainty, combination of risks, accumulation of reserves to provide for meeting the risks, and compensation or offsetting of risks; B) Assumption of risk by owner-managers, investors and speculators, and by laborers; C) Transfer of risks to others; transfer to entrepreneurs from laborers or capitalists, contracting out, hedging, insurance and guaranty or underwriting, etc.

[9]Ray, Agricultural Insurance, op. cit., pp. 12-15.

[10]Rainer Schickele, Socioeconomic Aspects of Risk and Uncertainty in Agriculture, North Dakota Experiment Station Bulletin 400, 1953, pp. 14-29.

first is applicable particularly when the sources producing risk are largely outside of the farmer's control, such as the weather. And the second can be used as a method to deal with risks, where the risk sources are amenable to human control, such as prices and farming techniques.

Adjustment in Financial Arrangements. Even though savings by farmers are needed for current investment in capital goods in order to increase the resources and to allow fuller utilization of the farmers' labor force and managerial capacities, many family-type farmers live at income levels which do not permit substantial rates of saving. As a result, it is impossible for them to accumulate sufficient reserves to meet risk losses. Some measures to solve these problems are required such as group actions offering shared risk in poor years. There are generally two kinds of institutional and financial arrangements to reduce the impacts of risk losses upon farmer's solvency: emergency credit and crop insurance.

Emergency credit provides some power to solve risk losses by giving the farmer access to credit. It requires two basic conditions in order to meet risk losses efficiently; one is the flexibility in the time schedule of debt payments for old as well as new loans, and the other is the availability of adequate amounts of loans

for preserving farm business and family household as unimpaired going concerns.

Crop insurance protects the farmer's solvency before the risk loss has occurred, by collecting from him annual premiums for a contingency fund out of which he will get paid an indemnity to meet or lighten the burden of a risk loss when it occurs. The crop insurance program has the advantage of having the burden of risk losses not only spread over time, but over a large population as well. And, psychologically, an insurance program provides self-discipline for the farmer to save to meet losses, but the pressure to do so is less than under a credit program.

Prevention of Risk Losses. Unlike weather, prices can be controlled to a considerable extent by group action and institutional arrangements. Risk losses due to price uncertainty can be reduced by various means of reducing price uncertainty. As in the case of yield risk, the critical aspect of price uncertainty consists of risk losses from prices falling below the expectation upon which farmers based their production plans. A price support at a level which will keep farmers solvent at normal yield levels, therefore, is an effective means for meeting price risks.

Small farm businesses usually have a higher critical yield and price limit with respect to their solvency than

larger farms. This means that yields and prices are likely to fall below critical limits more frequently and to fall farther than on adequate size farms. Therefore, one way of reducing the frequency and size of risk losses is to enable farmers with inadequate land and capital resources to expand their operations. This may require access to credit where credit is the least available under traditional arrangements. And the expansion of farming bases, such as irrigation and drainage facilities, may be necessary in order to reduce frequency and size of risk losses.

Individual Approaches to Meet Risk and Uncertainty

At times, imperfect knowledge places a farmer or a business manager in danger of losing income or assets. At other times, they create the possibility of gaining income or assets. In this case, how much losses are feared and gains valued is related to the utility attached to income and wealth. The utility attached to different levels varies from person to person and from asset to asset. So the value of gains and losses depend on who and what as well as how much.[11]

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[11]This section draws heavily on the resource allocation theory in L. A. Bradford and G. L. Johnson, Farm Management Analysis, New York: John Wiley and Sons, Inc., 1953, pp. 391-410 and Glen L. Johnson, "Allocative

So in order for us to understand the nature of individual wants and preferences, we first should analyze the utility and disutility which people attach to gains and losses in income and wealth. Individuals engaged in managing a farm or business have wants and preferences that exist in the presence of imperfect knowledge, and these wants and preferences grow as a result of their managerial activity.

This information about individual wants and preferences is generally needed in order to understand managers' or farmers' activities, and to formulate insurance programs in relation to such individual wants and preferences. Some concepts of insuring and the utility of income in relation to the learning process of farmers will now be discussed.

Insurance. Most people having income earning power try to maintain it in the presence of risk and uncertainty. In general, two processes are used to insure their income; one is the formal, contractual method such as buying insurance, and the other is an informal and noncontractual method like private savings against certain

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Efficiency of Agricultural Prices--As Affected by Changes in the General Level of Employment," op. cit., pp. 15-50, and Glen L. Johnson, Learning Processes--The Individual Approach, North Dakota Experiment Station Bulletin 400, 1953 and Milton Friedman and L. J. Savage, "The Utility Analysis of Choices Involving Risk," Journal of Political Economy, 56, Aug. 1948, pp. 279-304.

expected events or against the expected "rainy" days. But both types of insurance are basically the same in the sense that both have costs; premium payments in the case of formal insurance and losses in average income in most informal insurance schemes.

People ordinarily insure because they prefer an insured position to an uninsured position, not because they are going to profit by insurance. The decision to buy insurance is usually made upon an appraisal of the utility attached to the insurance service. In a case where a person buys insurance service from an insurance company, he has to pay a certain amount of net premium, loading and profits to the company. Further, total premium payments during a long period exceed total payments as indemnities by the company because of the operating costs and profits of the insurance company. Nevertheless, people desire to buy insurance. Why is that?

The Friedman-Savage hypothesis concerning insurance demonstrates that a person need not have a positive preference for stability in order to insure. All that is necessary is for the importance of losses in assets or income to increase at an increasing rate. This is the same as postulating increasing marginal disutility of losses in assets and income.

Before insuring, a person is running some change (P) of receiving a lower income which we will refer to

as I_2 as well as a chance (I-P) of not incurring a loss and retaining his present income which is labelled as I_1 in Figure 3.1. The concave line indicates the utility derivable from each income.

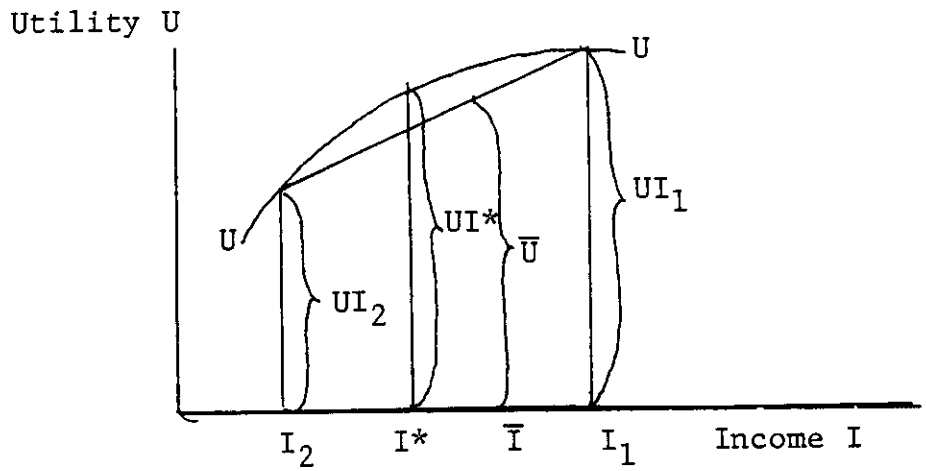

Figure 3.1 Illustration of Utility Analysis of Choices Involving Risk

In a case where he buys insurance, his income position will be reduced to I*, and become less than $\bar{I}$, which indicates the average of I_1 and I_2. But if a person decides to take out some insurance he will buy because the utility (UI*) of the guaranteed income I* is greater than the average of the utilities ($\bar{U}$), is given by the equation

$$\bar{U} = P(UI_2) + (I-P)(UI_1).$$

This utility is not measured from the utility line because it is the average of two other utilities, UI_1 and UI_2

weighted by the probabilities of their occurrences. If the importance or utility of an insured situation producing a non-risk income I* is greater than the expected non-insured income, a person takes out the insurance. In the absence of risk aversion,[12] it is important to note that UI* cannot be greater than $\overline{U}$ if utility fails to fall at an increasing rate to the left of I_1; that is, the losses must increase in importance at an increasing rate as they increase in size if insurance is to be possible ($UI^* \geq \overline{U}$).

Apparently most people who are adjusted to possession of a given amount of assets or income-producing power tend to fear the loss of that power.[13] Insurance becomes particularly important when the losses involved are large enough to bring about a change in social status. When such losses are possible, people appear willing to make considerable sacrifice in average income in order to gain protection.

Utility of Income. Many farmers or managers buy insurance to overcome situations of uncertainty and risk. Sometimes, they exchange a certain situation for an

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[12]This term is used in the Friedman-Savage sense--not in the ambiguous sense common to much current (1982) literature which confuse "risk aversion" with concavity of the utility function.

[13]Johnson, Farm Management Analysis, op. cit., pp. 405-406.

uncertain one involving the possibilities of gain. Actually those behaviors of individuals appear to be normal. In order for a person to both insure and take chances, a unique shape must be assumed for the individual's utility function. This function must have increasing marginal disutility for losses, and increasing marginal utility for gains. In Figure 3.2, assuming present income as illustrated, the individual would willingly insure against large losses and gamble to get large gains.

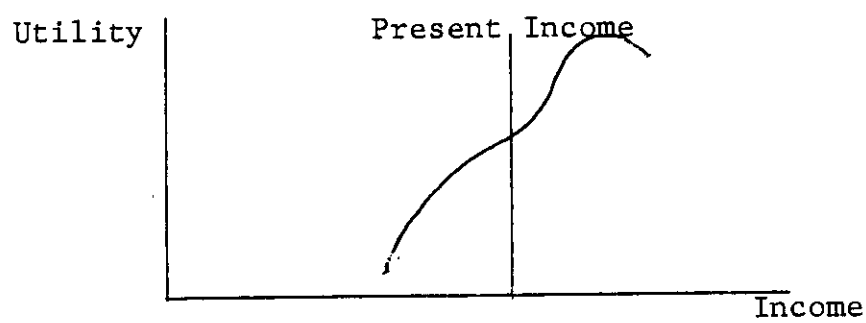

Figure 3.2 Individual's Utility Function

This utility function, sloped as it is around the present income, will allow the individual to gamble for small stakes at fair odds, but not at unfair odds. It allows him to take long chances for big gains and insure against major losses, but refuses to take small chances or enter into petty insurance schemes. An individual may willingly take a large gamble at quite unfavorable odds, as indicated by the utility function, if, by winning, he were

to move into a higher socio-economic class.

But we are not sure that individuals are actually cognizant of their hypothetical utility functions and with the odds concerned. And not all individuals would be expected to have the kinked utility function. However, the Friedman-Savage hypothesis can rationally explain how farmers can pay unfair odds to an insurance company for protection while simultaneously purchase land at what would seem to be poor odds in order to change the scale of operations.

Therefore, it would appear that individuals are willing to insure if their income utility, after paying the insurance premiums, is greater than the average utility of the income they would receive if they faced the chance event according to its probability of occurrence. The individual who maximizes expected utility will theoretically insure until the utility of his next dollar spent for insurance premiums is equal to the utility of that dollar spent for other uses.

Insurability of Agricultural Risks[14]

Insurance is a social device which aims at reducing the uncertainty of loss through a combination of a large

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[14]This section is written on references of P. K. Ray, Agricultural Insurance, op. cit., pp. 16-23, H. G. Halcrow,, "The Theory of Crop Insurance," Unpublished Dissertation,

number of similar uncertainties and through the use of accumulated funds, distributing the burden of loss, should there be any, over space and time.[15] According to the legal definition, insurance is a contract in which the insurer agrees to make good any financial loss an insured may suffer within the scope of the contact in consideration of the premium paid by the insured. That is, the primary function of insurance is the elimination of the uncertain risk of loss for the individual.

The first essential condition for insurance is that the risk must be accidental or random. Insurance not only reduces uncertainty through the combination of a large number of similarly exposed individuals, but, in the case of a loss, evens out its burden among such individuals. Thus, the second important point in insurance is that the uncertainty is, to a large extent, eliminated through a combination of a large number of similar risks.

Ray[16] considered insurable risks as having the following conditions: 1) A risk must be one which has some uniformity of behavior so that it is possible to measure

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The University of Chicago, 1948, and T. J. Reed, "Crop Insurance to Stabilize Wheat Growers' Incomes," Unpublished Thesis, Iowa State University, 1947.

[15]Ray, Agricultural Insurance, op. cit., p. 18.

[16]Ibid., pp. 18-19.

and predict the probability of loss in the future; 2) The peril should be one that cannot be willfully caused to occur without involving some sacrifice on the part of the insured. That is, insurance is available primarily against physical hazards and not moral hazards, although in actual practice it may not be possible for insurance offices to avoid the moral hazards altogether; 3) The loss following from the risk should be large enough to cause a substantial reduction in income or investment; 4) Both the subjective and objective conditions should be favorable for insurance. That is, there should be a psychological urge amongst a number of persons engaged in some economic pursuit for insuring themselves against possible risks, and they should also have the necessary financial capacity to bear the costs of insurance.

The third consideration for a thing to be insurable is that the probability of the occurrence of the risk should be capable of being determined by statistical measurement. That is, the risk should belong to a class large enough to conform to the theory of probability and the percentage of loss to total should be calculable to find the amount of coverage required and the premiums to be charged.

Another important condition for a thing to be insurable, especially in developing countries, is that the cost of insurance must not be too high. The price for

agricultural insurance in developing countries tend to be costly compared to those in developed countries because of high operation costs for insurance due to the large number of parcels of land per farm and the cost for protecting against the moral hazards. As a result, insurance for agriculture in developing countries tends to be compulsory insurance having the characteristics of social security. The subsidization of government to crop insurance in developing countries is indispensable. As Ray said,

> a crop insurance program in developing countries is therefore in reality a combination of insurance and public relief.
>
> Whereas crop insurance in Japan is partly insurance and largely government relief, in the U.S., it is largely insurance and only partly relief.[17]

Objectives of Crop Insurance

In general, crop insurance provides a method by which the farmer can stabilize his income from year to year, eliminating much of the loss of income and protecting his investment in years when crops fail.[18] Besides, crop

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[17] P. K. Ray, "Crop Insurance and the Problems of Its Application to Underdeveloped Countries," in Ray, "Crop Insurance as a Measure of Agricultural Support," Indian Journal of Agricultural Economics, 3:15, 1960.

[18] Ibid., pp. 27-30; T. J. Reed, op. cit.; P. R. Crawford, "Crop Insurance in Developing Countries," Unpublished Thesis, Madison: The University of Wisconsin,

insurance may facilitate investment in the agricultural sector, and this may result in the increase in agricultural product supply and an increase in aggregate farmer's income which thus improves rural welfare.

Another benefit of crop insurance is the protection provided agricultural creditors which, in turn, stabilizes agricultural credit institutions. But the benefits from crop insurance referred to above are not fully tested and the degree of insurance benefits may differentiate according to country or rural conditions.

Income Stabilization

The ultimate objective of crop insurance from the standpoint of the farmer is that of income stabilization. However, most crop insurance programs are operated in terms of quantities of the insured crop and guarantee an established percentage of the average yield. So, a crop insurance program should be related to existing price legislation in its effect on the farm economy. That is, it should assure the farmer that he would have a minimum quantity of the commodity to "market" and thus realize the benefit of the price assistance.

At this point, in relation to the effect of income stabilization, the amount of coverage which should be

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1977; Pan American Union, Considerations on Establishing Crop Insurance in Latin America, 1966.

offered under a crop insurance program should be considered. One of the main objectives of any true insurance program should be to provide protection against loss to the insured and not provide him an opportunity to profit directly from his insurance. According to the previous analysis of the theory of insuring (under the assumption that expected utility is maximized) coverage at a level more than sufficient to protect against catastrophic loss may be so costly as to require extremely high premiums and, hence, considerable subsidization in order to get wide participation of farmers.

Effects on Agricultural Production

Crop insurance may provide farmers with greater confidence to venture upon some attempts to increase agricultural production. First, formerly uncultivated marginal land may be brought under cultivation if crop insurance is available. Secondly, farmers may adopt improved farming methods, as well as make greater investments in order to improve crop yields and agricultural production. It could also encourage farmers to try growing crops with which they are unfamiliar. By encouraging self-help and mutual aid, crop insurance may also promote attitudes amongst farmers which are favorable to cooperative efforts.[19]

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[19]Crawford, op. cit.

Thirdly, crop insurance is an important link in the chain of diverse measures to stabilize the agricultural industry. That is, it is complementary to activities designed to strengthen the base of agriculture, namely, irrigation, drainage, land reclamation and other means of increasing agricultural productivity and, on the other hand, to price and other income support measures. By offering protection to farmers against the physical failure of crops due to weather and other unavoidable natural hazards, crop insurance advances the process of stabilizing the agricultural industry to the stage of making production processes more comprehensive, effective and useful.[20]

Effects on Agricultural Credit

A contractual right to assistance in the event of crop failure further enables farmers to improve their credit by using the insurance policy as collateral for loans or extensions of credit. At the same time, bankers and others including co-operative credit institutions that extend such credit are provided with the opportunity for making larger and better loans since their borrowers are expected to have more stable incomes and can offer

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[20]Ray, "Crop Insurance As a Measure of Agricultural Support," op. cit.

more tangible security for such loans--that is, if the crop is protected by insurance, payable jointly to the creditor and the farmer, the mortgage or lien for obtaining credit protects the credit if the crop is successful and the insurance protects it if the crop fails. Farmers may increase their chances of obtaining credit by buying crop insurance payable jointly to the creditor and the farmer. It is called collateral assignment in technical language.[21]

Especially in developed countries in which crop insurance is provided on the principle of private business as in the United States, crop insurance can reduce the government's obligation to provide relief in case of crop diaster. But in developing countries where the government may need to subsidize a part of the premiums, this effect may be doubtful.

Effects on Public Welfare

The general public has an interest in the prosperity of each segment of the community. If crop insurance can contribute to the economic stability of a producing area, then the public welfare in the rural area can be served through a program of crop insurnace. Crop insurance can contribute as a form of relief in areas of widespread

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[21]Pan American Union, op. cit., p. 36.

crop insurance failure. If wide participation in a crop insurance program would considerably eliminate or reduce the need for using public funds for direct relief, such funds might be used to reduce the cost of crop insurance to the farmer and thus secure wider participation.

In developing countries, the difference of living level between the urban and the rural area is greater than that in the developed countries due to crowded farm population and lack of cultivatable land, but as crop insurance is operated by government subsidization in those countries, differences in income levels can be reduced.

And crop insurance will help maintain the dignity of farmers by eliminating their dependence upon handouts from the government when their crops fail.[22] Over time, various methods have been developed in most countries to assist the farmer in overcoming crop losses due to natural calamities. These methods are usually reduction or suspension of land taxes, moratorium on agricultural debts, or direct relief from the government. But these measures cannot be regarded as a right and are dependent upon the policies and resources of the government for this concession. On the other hand, crop insurance legally defines and guarantees indemnities in the event of a crop failure. The farmer's premium provides him with the right

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[22]Crawford, op. cit., p. 36.

to compensation for the loss of his crops and he need no longer rely on government concessions. This is in accordance with the principle of insurance--self-help--and farmers can keep their dignity against the crop losses even though crop insurance is operated by some part of government subsidization.

CHAPTER IV

TYPES OF CROP INSURANCE

In order for a crop insurance program to be established successfully in a country, it is important to determine the most appropriate type of crop insurance. I already reviewed the agricultural situation and conditions in Korea which should now be considered in order to determine the type of crop insurance needed. Now, I turn my discussion to types of crop insurance best suited for Korea.

Crop insurance may be voluntary or compulsory according to whether the insurance contract requires or does not require farmers to participate. An advantage of voluntary insurance is that it maintains the economic freedom helpful in maintaining a democratic system. But a voluntary system has some shortcomings such as: 1) this type cannot ensure enough demand from farmers for the insurance scheme to be successful; 2) there is the danger that only high-risk farmers will participate in the program, and 3) some problems of additional costs may arise, that is, the sale problem of insurance to farmers.

On the other hand, a compulsory insurance program

may be disfavored by farmers who experience low risk. Since premium rates, under compulsory insurance, are determined by the ability of marginal farmers, the premium-indemnity schedule may be unattractive to many farmers. As a result, this program sometimes needs subsidized premiums, which are a big obstacle to the introduction of crop insurance for the agricultural sector in most developing countries.

But the principal consideration in selecting between voluntary and compulsory contracts should be which one promises more success considering the special conditions of the country where it is applied. For example, compulsory insurance programs may be essential in a country with large numbers of small scale illiterate farmers.

Crop insurance can also be classified by the number of crops to be covered by insurance: single-crop or multiple-crop insurance. In order to stabilize farmers' incomes and livelihoods which are the main objectives of crop insurance, the application of multiple-crop insurance would be reasonable. But most existing crop insurance schemes cover a single crop, the major crop grown in the country. Under multiple-crop insurance, crops are not insured separately but are grouped together as a unit and indemnities are payable only when the combined yields fall below the protected level.

We can also classify crop insurance according to the hazard insured against--specific-risk insurance such as hail insurance, and combined-risk insurance covering all the risks incurred in crop production. The specific-risk insurance can find its demand in the area where crop yields depend on one distinct weather factor. On the other hand, in such crop areas where many weather factors, like precipitation, temperature, winds, hail etc., affect the harvest of a crop, combined-risk insurance may be more suitable.

The most important method for classifying crop insurance is according to the way of determining insurance coverage level and the calculation of premiums and indemnities. This classification was pioneered by Halcrow in his dissertation, "The Theory of Crop Insurance"[1] and has generally been accepted and used. I will now investigate the assumptions of each category and recommend the appropriate type of crop insurance on the basis of Korean agricultural characteristics referred to in the previous chapters.

All-Risk Crop Insurance

Whereas crop insurance against specific hazards has long been practiced in different countries

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[1]Halcrow, op. cit.

comparatively successfully, crop insurance against risks of damage by combinations of most or all natural hazards is still in a developmental stage. Even though combined-risk insurance and all-risk crop insurance are very similar in that they combine two or more specified hazards in one policy, the concept of combined-risk insurance is usually contrasted to specific-risk insurance. On the other hand, all-risk crop insurance encounters problems in determining coverage and premium rates. The basic assumption of all-risk crop insurance encounters problems in determining coverage and premium rates. The basic assumption of all-risk crop insurance is that an individual premium rate is established for each farm. A base yield is determined on the basis of the average yield calculated for each farm. And the coverage level of yields by crop insurance is determined as some specific percentage of the base yield, i.e. 75 percent of the average yield for 30 years. The premium rate is dependent upon the coverage as a percentage of the base yield for each farm.

When the U.S. established an all-risk crop insurance program, two options of coverage level for crop insurance were offered. But in the case of Canada, each district was able to choose the coverage level in the range not to exceed 80 percent of the average crop yield in the

area or on the farm whichever is the greater.[2] The reason for determining coverage level as a percentage of the base yield is to eliminate defects due to errors in recording yields.[3]

Theoretically, all-risk crop insurance should be based on the assumption that during the period of calculating the base yield farming practices and technical and technological conditions are the same on all farms. If this assumption is not true, the method of determining the base yield and premium rate should be adjusted according to factors influencing crop yields.

Area Yield Insurance

Area yield crop insurance establishes the base yield on the basis of area average crop yields experienced in certain periods. Coverage levels and premium rates are based on a specific percentage of the base yield in an area during base yield periods. And indemnities are paid on the differences between the area base yield and the actual yield per acre for any insured farmers in any year. That is, if the area base yield is 400 kilograms of rice per acre and a farmer is insured for 80 percent

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[2]Shih-ping Sun, "An Evaluation of the Actuarial Structure of the Crop Insurance Program," Unpublished dissertation, Winnepeg, Canada: Manitoba University, 1974.

[3]Halcrow, op. cit., p. 420.

of the area base yield, his coverage level by crop insurance is 320 kilogram per acre. And if his actual yields per acre in a year is 290 kilograms per acre, he receives 30 kilogram per acre as an indemnity.

In this type of crop insurance, it is important for the crop used to compute the same base yield to be homogeneous with respect to farming conditions such as topography, climate, the quality of soil, and management practices; that is, the mean yield in a year in an area should reflect crop producing conditions faced by the farmers in the area. If a farmer finds that increasing his yields has a small effect on the determination of the area base yield, he will not buy crop insurance because relatively, his level of coverage is decreasing each year, and he may try to find another way to protect himself against weather uncertainties.

Weather-Crop Insurance

Crop insurance is a method to reduce the dependence of a farmer's livelihood on natural factors. Usually the results of weather vagaries appear as a reduction in agricultural production. The previous two types measure the results of weather vagaries by the quantities of agricultural production. But, in weather-crop insurance,

> premiums and indemnities are based on the weather records of the locality in which insurance is to be sold. Indemnities would be paid to any insured farmers in any year in which the weather, in terms of some measurable criterion, is beyond certain limits of tolerance.[4]

That is, in a certain area, if precipitation is a predominant factor determining crop yields and there are records of annual precipitation for long periods, a crop insurance program based upon the possibility of occurrence of deficiency or excess of precipitation can be established. For example, if the average annual precipitation in an area were 1400 millimeters, which would be near the optimal level for crop production, a farmer could be offered a crop insurance schedule such that indemnities are paid in the case of less than 1000 millimeters or more than 1800 millimeters.

This weather-crop insurance may be an appropriate type of crop insurance in an area in which one or only a few weather factors have a significant effect on crop yields. If many weather factors affect crop yields in an area, the determination of premiums and indemnities, based on all weather factors, would be too complicated for farmers to understand it. Especially, weather-crop insurance is of little value in the area where crop yields are severely affected by risks such as the spread

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[4]Ibid., p. 422.

of insects or crop diseases.

Attempts to Recommend an Appropriate Type of Crop Insurance for Korean Agriculture

As suggested in the title of this paper, the objective of this paper is to investigate some considerations in introducing a crop insurance scheme in Korean agriculture which would determine the insurance type suitable, techniques for calculating premium rate, and possible obstacles in establishing this scheme. As discussed in Chapters 1 and 2, under the present agricultural situation in Korea, crop insurance programs should be compulsory and it would be necessary to subsidize premiums in order for all the farmers to be benefitted. I think that a Korean crop insurance program should be considered partly as a social security and partly as an economic policy for increasing agricultural production. As proposed in the title, I would like to confine crop insurance to the rice sector at first, and then to enlarge gradually to cover all the crops considering government budget for subsidizing premiums. In fact, if the objective of crop insurance is to improve rural welfare, it should cover most of the crops related to the farmers' incomes.

And, in consideration of the characteristics of topography, climates and farming style in Korea, the

type of Korean crop (rice) insurance, I think, should be the one to cover all the natural risks affecting the crop harvesting--all-risk crop insurance. Area yield insurance cannot be applied in Korean agriculture because the topographical conditions for farming are very heterogeneous, even for a village. And it is very difficult to introduce weather-crop insurance because of the many weather or climate factors influencing Korean farming. Even though the actuarial techniques of all-risk crop insurance are complicated, I think that it is necessary to establish a crop insurance program based upon all-risk crop insurance structure--that is, covering all the natural risks and calculating the coverage level and the premium rate for each farm.

CHAPTER V

ACTUARIAL TECHNIQUES OF ALL-RISK CROP INSURANCE

The most important problem encountered in the adoption of a crop insurance program is the determination of the premium rate. An inappropriate premium rate can be the main source of failure of a crop insurance scheme, either due to over-payment of indemnity or loss of participants. As a matter of fact, disagreement on the possibility of crop insurance arises mainly from difficulties in deriving an appropriate premium rate. If this problem is solved reasonably, the obstacles to introduce crop insurance in Korea will be reduced.

Whereas the insurance of growing crops against specific hazards, like fire and hail, has long been practiced in different countries with a considerable measure of success, that of crops against risk of damage caused by a combination of most or all natural hazards is a comparatively recent development. All-risk crop insurance has been devised to protect farmers against uncertainties of crop yields arising out of practically all factors beyond their control. First factors are vagaries of weather such as drought, hot winds, excess moisture, storms, hail, frost,

earthquake and land slide, and the second factor is crop failures by plant diseases, pests, and insects.

In this chapter, I will review the theoretical bases for computing premium rates and determining insured yield levels.

Basic Principles of Premium Ratemaking in All-Risk Crop Insurance

For all-risk crop insurance a basic yield is established for each farm, and insurance is offered to cover some specified percentage of the base yield. If the actual yield in any year falls below the insured yield, an indemnity which is equal to the difference between the insured yield and the actual yield is payable to the insured farmer. As a result, premium rates, which are based on probabilities of crop yields falling below the insured levels, are very important to insured farmers.

Crop insurance is not a free good.[1] The insured farmer has to pay a premium for entitlement to indemnity in the event of crop loss. The institution which underwrites crop insurance has to charge premiums in order to recoup the cost of operating the scheme and to make profits. In other words, insurance premiums play a very important role in the market for crop insurance. An

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[1]Shih-ping Sun, op. cit., p. 6.

insurance premium is a "price" which may or may not equalize the quantity of insurance demanded and the quantity supplied. Although crop insurance programs in most countries are subsidized by governments, these programs generally proceed with the expectation that they can be carried out under the basis of self-sustaining growth over a period of time. Fulfillment of these provisions necessitates a sound statistical base for estimating the premium rate, not only to ensure the financial viability of the crop insurance program but also to satisfy the demand for the program from the insured's standpoint.

The crop insurance program is an actuarially-based program. In principle, it is supposed to be self-sustaining. The premiums paid by farmers should bear a close relationship to the risk involved and the level of coverage selected. Pure premiums are calculated for each homogeneous group as well as for each crop in such a way that total premiums collected should equal total indemnities paid over a long-run period.

Theoretically, the annual pure premium rate per unit of land to be paid by farmers should be equal to the expected annual loss cost per unit of land to the insurance agency due to crop failure over a period of years.[2]

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[2]M. H. Yeh and R. Y. Wu, "Premium Ratemaking in an

This annual premium rate per unit of land varies directly with the degree of risk in the insured crop yield. For each particular unit of land, loss costs occur when the actual yield falls below the provided level of protection or coverage. If the coverage is designated by C, and the yield less than C by X_i, then the theoretical premium rate is equal to the mathematical expectation of loss cost, $(C-X_i)$, that is,

$$(1) \quad L = E(C-X_i) = \Sigma f(X_i)(C-X_i), \; 0 \leq X_i < C$$

The above equation shows that the theoretical premium rate can be estimated if the frequency function, $f(X_i)$, is known. It also indicates that the level of theoretical premium rate is generally influenced by two factors; the level of coverage per unit of land and the frequency and magnitude of occurrence of those yields per unit of land below the average.

The level of coverage is usually designated by the insurance agency or government policy. Therefore, the problem of obtaining the theoretical premium rate depends on the estimate of the frequency function, $f(X_i)$, which may be approximated by using the past records of crop yield.

For a particular ith year, if the yield data, X_{ij},

All-Risk Crop Insurance Program," Journal of Farm Economics Vol. XL, No. 3, August, 1958.

and those yields below the coverage, X_{ik}, are available, the estimated premium rate per unit of land or average annual loss cost in the particular ith year may be approximated by

$$(2) \quad \hat{L}_i = \frac{1}{M_i} \sum_{k=1}^{m_i} (C-X_{ik}), \; 0 \leq X_{ik} \leq C; \; m \leq M$$

where M_i = total acreage used on computing the average of yields per unit of land for a particular ith year and M_i = number of land units of those yields below the coverage X_i, in the particular year.

If the n year records are available, the estimated average loss cost, $\bar{\hat{L}}$, over a period of years can be calculated by:

$$(3) \quad \bar{\hat{L}} = \frac{1}{n} \sum_{i=1}^{n} \hat{L}_i$$

This equation is used to approximate the theoretical average annual loss cost per land unit of L as shown in equation (1) and may also be used to establish the premium rate for the future.

Generally, the insurance contract is made with the individual farmer. Consequently, the appropriate data required for estimating the distribution of crop yields is the actual yield data collected on the individual farm. However, if yield data for each individual farm are not available, regionally aggregate averages for

yield data are used. This assumes that different farms in a homogeneous region, usually classified in accordance with soil fertility, topography, and the history of crop production, have not only the same productivity but also the same yield variability as the average for crop yields for an area over a period of years. And it is further assumed that the crop yield data are normally distributed. These simplifications are currently employed by most crop insurance programs for the purpose of determining the premium rate schedule.

Statistical Bases for Calculating Coverage Level and Premium Rate in All-Risk Crop Insurance

To determine the level at which the production of a crop should be guaranteed and the premium that needs to be charged for such a guarantee in all-risk crop insurance, crop yield records for each farm in a long period are required. But it is difficult to get reliable yield data for each farm for long periods, not only in developing countries but also in developed countries. Instead, it is quite easy to get aggregate area average crop yield data by the unit of district. When the Federal Crop Insurance Corporation in the United States was established for all-risk crop insurance in the nineteen thirties, it developed a technique to determine the coverage level and the premium rate for crop insurance,

called the actual loss-cost tehnique. This technique establishes costs on the basis of simulation of what would have been incurred in the past.

The other method is a more statistically theoretical one, which assumes that the actual yields per unit of land over time follow the normal distribution and calculates premium rate for all-risk crop insurance by using normal distribution theory.

K. Pearson developed the crop yield distribution system on his experience as a biometrician by first showing that the frequency distribution of the actual yield per unit of land over time is not a special type such as normal distribution but several types of distributions. After that, this theory was developed and used by actuarial statisticians.

Now I will explain the characteristics of each method and show the process used to calculate premium rates for all-risk crop insurance.

Actual Loss Cost Method[3]

In the early stage of crop insurance programs, crop insurance agencies had very little experience which could be used as the basis for establishing a dependable

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[3]This section is drawn mainly from P. K. Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 245 and M. H. Yeh and R. Y Wu, op. cit., p. 1582.

premium-indemnity schedule. As a result, the United States Department of Agriculture developed a technique for determining the insured yield and the annual premium rate for its crop insurance program. This technique used the actual yields of an insurable crop over a number of years as the base for calculating the insurance coverages and the premium rates.

Premium Rate Estimation

The procedure used to calculate the coverage level and the annual premium is described as follows. First, information was collected with regard to the annual yield per planted acre of the insurable crop and an average annual yield was calculated therefrom. Second, an insurance protection up to a specified percentage (e.g. 25, 50 percent) of the average yield was input for each year under consideration. Third, the annual loss-cost per acre was determined for each of the years and such loss-costs, that is, the deficits by which annual yields failed to equal the imputed insurance coverage were added and their average was obtained by dividing the total loss-cost by the number of years considered. Finally, the total of annual deviations below the insurance coverage gave the average annual loss-cost which is the net annual premium.

Let Y_i be the recorded yield for the i-th year

and let C be the insured yield. The total loss cost over a period of time is the summation of $(C-Y_i)$ for all i, such that $Y_i<C$. Hence, the average annual loss cost or premium rate, P, is calculated by equation (4).

$$(4) \quad P = \Sigma(C-Y_i)/N \qquad 0 \leq Y_i < C$$

where N is the total number of annual yield observations. If there are n years where the yield falls below the coverage level, then equation (4) can be rewritten as below:

$$(5) \quad P = (n/N) \cdot C - \Sigma^{y}{}_{i}/N \qquad 0 \leq Y_i < C$$

In this equation n/N is equivalent to the probability that the actual yield will fall below the insured yield and Y_i/N is the average yield per unit of land when a crop loss does occur.

And the average annual loss-cost data for an individual farm thus determined were then adjusted, first, to the yield data with respect to the same farm over a longer period, found from other sources or by appraisal, and, secondly, to the average annual loss-cost data for the region determined from the loss experience of a number of sample farms within the region.

Limitations

The main limitation of this technique is that, under it, premium computations take account only of the variations in yield during the years when an indemnity would be paid, that is, when the yields fall below the coverage level (e.g. 75 percent) of the average yield for the farm or the area. But deviations from the average of such extent are likely to occur rather infrequently and the premium so calculated therefore may vary substantially from the actual experiences of the past period to which the data relate, unless, of course, the period is very long. With this technique there is a risk of underestimating the loss probability over the years.[4]

Another limitation is that premiums determined by this method do not make it quite clear to what extent the rate differentials are due to seasonal variability and merely accidental variations.

Normal Distribution Technique

Due to the inadequacy of the actual loss cost technique, the normal distribution technique is used in estimating the loss-cost ratio or net premium.

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[4]R. K. Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 248.

Basically, this technique assumes that yields in specific areas tend to be normally distributed over time around the area average. This technique is used when area yields are available but when little is known as to the distribution of farm yields around their average.[5]

The normal distribution technique was originally used by the United States Department of Agriculture for determining country premium rates. Since then, this technique has been widely used in various countries, mainly because most statistics tend to be normally distributed or their distributions converge to a normal distribution.[6] In statistical theory, various laws of large numbers and different versions of the central limit theorem have been derived to justify using the normal distribution to approximate an unknown population distribution. With respect to crop yield data, the law of large numbers and the central limit theorem may be applied as follows.

The recorded crop yield series frequently refer to the average yield either on a farm unit or for an area The central limit theorem states that the sample means tend to be normally distributed when the sample size

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[5]Ralph R. Botts and James N. Boles, "Use of Normal Curve Theory in Crop Insurance Ratemaking," Journal of Farm Economics, Vol. XL, No. 3, August 1958, p. 733.

[6]Shih-Ping Sun, op. cit., p. 58.

becomes large. The law of large numbers ensures further that the reliability increases as the sample size is increased. For a crop insurance program, the sample size becomes larger as more and more farmers join and stay in the program. Therefore, the use of a normal distribution for crop insurance premium rate determination seems statistically sound.

The Condition for Using a Normal Distribution

Under the normal-curve assumption of the actual yields over time, it is possible to approximate the average premium rate per unit of land for a particular area.[7] However, the applicability of the normal curve depends upon two assumptions, namely (a) whether the actual yields of a particular area are normally distributed and (b) whether the variance throughout the years is constant.

The normal distribution is applicable to many events, varying from the distribution of height and weight of the people within the same age group to the random error terms. In order to apply the normal distribution theory to the crop insurance program, homogeneous conditions of crop production, or the fact that the boundary of a crop-reporting district is well delineated, should be observed. Even though the soil productivity of the

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[7]Yeh and Wu, op. cit., pp. 1580-1586.

land within the district is the same, local variation of other factors may be so great as to render production in some sub-areas significantly different from that in others. Several factors influencing the delineation of the boundary of a homogeneous crop production area are: (a) local topography, (b) weather conditions, (c) soil productivity, (d) practices of land use, and (3) level of fertilizer use. Those croplands which are located within the boundary and which have the same fertilizer treatment and the same land use in the previous year could be considered as a homogeneous crop production area. The yield distribution from the land belonging to such a homogeneous crop production area might have a better possibility of being normally distributed. Of course, there is not a prior necessity that it should follow the normal distribution. Whether it does or not still depends on empirical evidence.

Premium Rate Estimation

The total amount of loss for an area in any year is the difference between the insured coverage multiplied by the acreage producing a return less than the insured coverage, and the actual returns on such areas. The average loss for an area is the total loss divided by the total planted areas. A simple form of mathematical

representation of the process would be as follows:[8]

$$(6) \quad L_t = a_i C - a_i Y$$

$$\text{Average loss} = \frac{a_i C - a_i Y}{A_t}$$

where L_t = total loss

a_i = area which reports a loss

C = insurance coverage

Y = actual yield from area reporting a loss

A_t = total area planted

The average of such losses over a series of years would be the net premium per unit of land.

Another method of computing the premium rate using the normal distribution technique was shown in the article of Botts and Boles.[9] They used more statistical methods to get the premium rate in all-risk crop insurance. As discussed above, the premium rate is calculated by the following formula:

$$(7) \quad L = E(C-Y_i)$$

$$= E(C-Y_i)f(Y_i) \text{ or } \int_o^C f(Y_i)(C-Y_i)dy_i, \quad 0 \leq Y_i < C$$

If the continuous yield variable, Y_i, is normally

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[8]R. K. Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 249.

[9]Botts and Boles, op. cit., p. 733.

distributed with mean, $\overline{Y}_i$, and variance, σ^2, then the probability density function of the normal distribution is expressed in the following form:

$$(8) \quad f(Y_i) = \left(\frac{1}{2\Pi\sigma}\right) \exp \; - \frac{1}{2} \frac{Y_1 - \overline{Y}_1}{\sigma^2} \; - \infty < Y_i < \infty$$

Both equations (7) and (8) are general forms used for the estimation of pure premium rate by using area yield. Even though premium rates do not only depend on the form of distribution, $f(Y_i)$, when this form of distribution is specified, a premium rate can be estimated with respect to each level of coverage, C.

In the present case, the form of yield distribution, $f(Y_i)$, is assumed to be normally distributed as shown in equation (8). Therefore, the estimated premium rate can be reduced to the following form:[10]

$$(9) \quad \hat{L}_i = \frac{L}{N_t} = \left(\frac{1}{N_t}\right) \int_o^c f(Y_i)(C - Y_i)\, dY_i$$

$$(10) \quad \hat{L}_i = A(C - \overline{Y}_i) + ds^{11}$$

where N_t = total acreages in a particular area

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[10] Yi-Min Wu, "An Economic and Statistical Evaluation of an All-Risk Crop Insurance Program," Unpublished thesis, Winnepeg, Canada: Manitoba University, 1965; Botts and Boles, op. cit., p. 734; P. K. Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 251, and Shih-Ping Sun, op. cit., pp. 61-65.

[11] The procedure of the derivation of equation (10) is shown in Appendix 1.

A_t = the proportion of the total acreages less than C

d = the height of the ordinate at C in Figure 5.1

σ = standard deviation of Y_i about the yields and assumed to be proportioned to the long-run average yield.

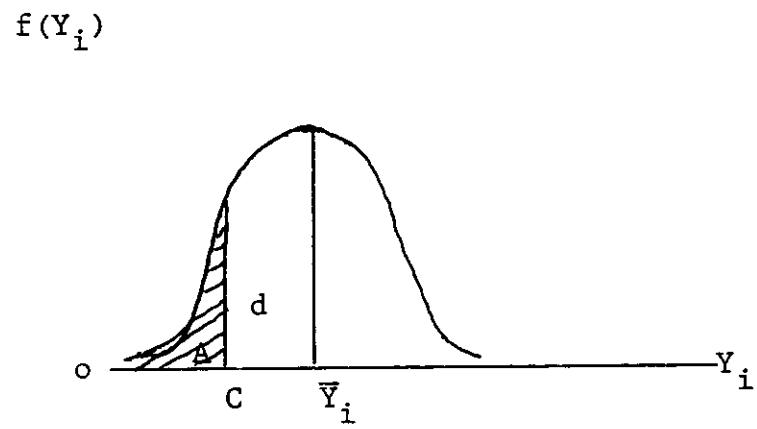

Figure 5.1 Theoretical Normal Distribution

In equation (10), the value of $\overline{Y}_i$ and σ are derived from the historical yield data, the level of C is pre-determined, A and d are given by the normal distribution table, then the estimated pure premium rate for a special year, $\hat{L}_i$, is uniquely determined.

Limitations and Further Implications

As shown above, the normal distribution technique is very convenient to apply. It only requires historical yield data on an area, which we can get easily over a period of years. Only two parameters, the level of

coverage and the magnitude of a constant standard deviation, need to be decided.

However, the important limitation of the normal distribution technique is the untested assumption that the actual yields of a particular area are normally distributed. Some studies about the normality of yield for a particular area showed that normal distribution of actual yields was the case only in exceptional instances.[12]

As long as the present premium rate is estimated by using past yield data, it is necessary to examine the discrepancy between the past and present yield risk. In a number of years several factors such as technological improvement in farming technique and innovation in mechanization along with better management have played an important role in the improvement of crop production. It also is possible that the existence of insects and plant diseases have effects on long-run crop production.[13] These changes may cause some problems in the assumption of homogeneous conditions in crop production, which is the basic condition in the assumption of normal distribution

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[12]Yeh and Wu, op. cit., p. 1585; Yi-min Wu, op. cit., p. 53; R. H. Day, "Probability Distributions of Field Crop Yields," Journal of Farm Economys, Vol. 47, 1965, pp. 1713-1739.

[13]P. K. Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 6.

of actual crop yields. There is no guarantee that the yield distribution of a risk area has to be normal. So, first, we should determine the frequency function type in order to establish a sound crop insurance program. Secondly, it does cause trouble in the delineation of the risk area if the yield in the area is not normally distributed. Thirdly, if the yield distribution of the same risk area changes from year to year, then no simplified procedures can be used for the estimation of the pure premium rate. That is, it relies heavily on the continuing collection of sample yield data over time.

The solution of the first and second problem is to compute premium rates for crop insurance using the Pearson distribution system, which is discussed in the next section. The third problem is solved by adjusting the premium crop yield for a particular area within a crop risk area.

Pearson Distribution[14]

An alternative system of density functions that take on a wide variety of forms was developed by Karl Pearson--a biometrician. For many years, biometricians

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[14]This section is written on the basis of theories included in W. P. Elderton and N. L. Johnson, Systems of Frequency Curves, London: Cambridge University Press, 1969, p. 24 and Day, op. cit.

used this system to represent a diversity of empirical frequency distributions of actual crop yields. It has been found that in many cases the Pearson distributions provide a remarkably good fit to observation. Believing that Pearson distributions can be used to estimate the actual distribution of crop yields for the purpose of crop insurance premium rate making, they have been used in actuarial work for a long time. For example, in 1937, Wold referred to the successful fitting of a Pearson distribution (Type III) to Swedish rural fire insurance company claim ratios, and in 1938, Rossman used the Type I Pearson distribution for the loss ratios distribution experienced by a French hail insurance company.[15]

The Pearson System

Pearson density functions are derived from differential equations:

$$(11) \quad \frac{dy}{dx} = \frac{Y(X-A)}{b_o+b_1X+b_2X^2} \quad \text{or} \quad \frac{X-A}{b_o+b_1X+b_2X^2}\, Y(X)$$

where X is the random variate. The integrations of the differential of equation (11) constitute the various members of the Pearson distributions. These integrals depend upon the roots of the quadratic denominator and can be shown to be of three main types designated by

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[15]Shih-ping Sun, op. cit., p. 83.

Pearson as types I, IV and VI. The remaining members of the systems are special cases of these three and are generally referred to as transitional and limiting forms. And the parameters of Pearson distribution can be estimated in terms of moments by the method of moments.[16]

As identification of a Pearson distribution depends on $h(x) = b_o + b_1X + B_2X^2$, it is important to represent the characteristics of this equation. Rewriting equation (11) as

$$(12) \quad \frac{dy}{dx} = \frac{X-A}{b_o(X-\alpha_1)(\alpha_2-X)} Y(X)$$

where α_1 and α_2 are the roots of the quadratic term, one derives by integration.

If the roots of equation h(X) are real and of opposite sign, then the integration of equation (11) gives the Type I Pearson distribution as follows:

$$(13) \quad Y = X_o(1+X/\alpha_1)^{m_1}(1-X/\alpha_2)^{m_2}, \quad -\alpha_1<X<\alpha_2$$

where $m_1/\alpha_1 = m_2/\alpha_2$ and with origin at the mode.[17]

The Type I Pearson distribution is a skewed distribution with a range from $-\alpha_1$ to α_2. The origin of the distribution is located at the mode. If the parameters

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[16]The method of moments are explained in Appendix 2.

[17]Elderton and Johnson, op. cit., p. 42.

m_1 and m_2 are approximately equal, the distribution is nearly symmetrical. The varieties of shapes in the Type I may occur depending upon the magnitudes of m_1 and m_2. If both m_1 and m_2 exceed zero, the distribution has a unique mode and vanishes at both ends. If either m_1 or m_2 is negative, the ordinate at the corresponding terminal is infinite and the distribution is J-shaped. If both m_1 and m_2 are negative, the distribution is U-shaped, starting and ending with infinite ordinates and having an anti-mode instead of a mode as the usual origin. Below figures are shown forms of Type I Pearson distribution.[18]

If the roots of equation, $h(X) = b_o+b_1X+b_2X^2$, are imaginary, the integration of equation (11) gives the Type IV Pearson distribution.

$$(14) \quad Y = X_o(1+X^2/\alpha_2)^{-m} e^{-v \tan^{-1}(X/\alpha_1)}, \quad -\infty<X<\infty$$

with origin at the mean + Va/r where r is 2m-2. The distribution is skewed and has limited ranges in both directions.

If the roots of equation, i.e. $h(X) = b_o+b_1X+b_2X^2$, are real and the same sign, then the integration of equation gives the Type VI Pearson distributions.

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[18]Day, op. cit., p. 729.

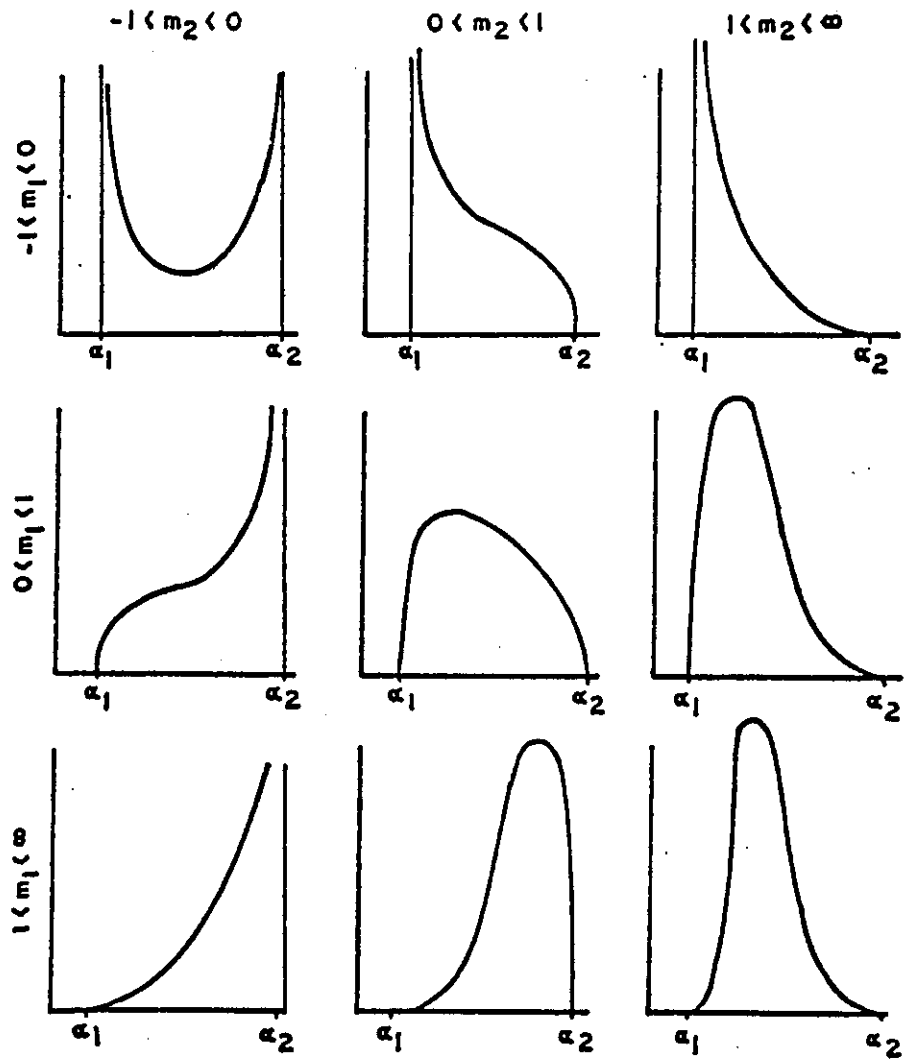

Figure 5-2. Forms of Pearson's Type I function[19]

[19] Ibid., p. 729.

$$(15) \quad Y = X_o X^{-m_2} (X-\alpha)^{m_1}$$

where $\alpha<X<\infty$ if α is positive and $-\alpha<X<\alpha$ if α is negative. The distribution is either skewed or bell-shaped, and when m_1 is negative, the distribution is J-shaped.

Identification and Implications of Pearson Distribution

The integrations of equation, $\frac{dy}{dx} = \frac{Y(X-A)}{b_o+b_1X+b_2X^2}$, which constitute the family of Pearson distributions, depend entirely upon the characteristics of the quadratic function of the random variable X. Therefore, Pearson distributions can be identified by the coefficient of the general function and written as a criterion, K, as follows:

$$(16) \quad K = b_1^2/4b_ob_2$$

For example, in a Type I Pearson distribution, the roots of the equation, $h(X) = b_o+b_1X+b_2X^2$, are real and opposite sign. Then, this condition is equivalent to the criterion, K, being less than zero. Similarly, in a Type IV Pearson distribution, the criterion is between zero and one, and in a Type VI Pearson distribution the criterion is greater than one.[20]

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[20] Shih-ping Sun, op. cit., p. 77.

As mentioned, the knowledge of the probability of the variable exposed to risk is needed for the determination of the proper premium rate. Theoretical distributions such as poisson or normal distributions provide a simple way to represent a simple type of probability event. However, it frequently happens that the probabilities are not known a priori, and it is impossible to tell which theoretical distribution is the best to use in the analysis. What seems to be needed is an apparatus which has the capability of finding a distribution from the sample data and taking account of any case that may occur in practice.

Using Pearson distributions for estimating the unknown distribution has the advantage that there is no need for an a priori assumption about the algebraic form of the distribution. The type of Pearson distribution which approximates the unknown population distribution can be, as mentioned above, identified in the estimation process by the criterion, K, i.e., a function of the skewness and kurtosis coefficients of the unknown distribution. By this approach it is possible to reduce the errors caused by incorrectly specifying the form of the unknown distribution.

In statistical theory, the characteristic function determines the moments when they exist and the characteristic function also determines the distribution

function. It does not, however, follow that the moments completely determine the distribution, even when moments of all orders exist. Only under certain conditions will a set of moments determine a distribution uniquely, but those conditions are obeyed by all the distributions arising in statistical practice. Therefore, a knowledge of the moments, when they all exist, is equivalent to a knowledge of the distribution function. Consequently, it may be expected that one should be able to identify an unknown distribution by calculating the sample moments.

CHAPTER VI

ACTUAL CROP YIELD DISTRIBUTION AND PREMIUM RATEMAKING

For this study, Pearson distributions are applied to average rice yield data of the thirteen districts of Kyunggi-Do area for estimating the distributions of rice yields. Kyunggi area is located in the middle part of Korea, but in the northern part of South Korea. The rice yield districts are the same as administrative districts.[1] The reason that rice yield data in Kyunggi Area are chosen for analysis in this paper is that this area is the most homogeneous with regard to farming conditions: technological change, practices of farm managements and topographical conditions.

Seventeen-year (1965-1981) rice yield records for thirteen districts are used as the data base for estimating the distributions of rice yields. In Korea, the diffusion of new rice seeds and farming technology began with the so-called Green Revolution dating from the end of the 1960s. Therefore, the data to be used do not go back earlier than 1965. In order to get more

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[1]Administrative districts are constituted with Do→ Gun→ Myun (or up)→ Ri. Rice yield data used in this paper are average area rice yields in the level of Gun.

accurate estimates of the frequency distributions, it is necessary to use a lot of data; the greater the amount of data, the better the result. The delineation of homogeneous districts exposed to risk in these data may not reflect the truth.

Nevertheless, the above limitations do not destroy the usefulness of this study which is intended to investigate the use of Pearson distribution techniques for estimating distributions of yields for crop insurance premium ratemaking.

Estimated Distribution of Rice Yields in Korea

All of the Pearson distributions are determined by the first four moments, except for some of the transition types which can be determined by fewer than four moments[2] (i.e., normal distributions can be estimated by the first two moments - the mean and variance).

Results for determining the numerical values of the first four moments (i.e., mean, variance U_2, U_3, U_4) and the numerical values of the skewness and kurtosis coefficients (B_1 and B_2), and K values to judge the types

[2]This section is written and the calculation of coefficients is based upon 1) Elderton and Johnson, op. cit., p. 49, 2) Day, op. cit., pp. 713-730, and 3) Shih-ping Sun, op. cit.

of distributions are shown in Table 6.1.[3] The average rice yield for all crop districts is about 355 kilograms. The variance and standard deviation of the yields are shown in columns (3) and (7) respectively. The average standard deviation is about 2.1 kilograms per 10 ares.[4]

Based upon the first four moments, the B_1 and B_2 coefficients are calculated and shown in columns (8) and (9) of Table 6.1. However, none of the B_1 coefficients is exactly equal to zero and neither are the B_2 coefficients equal to three. Also, as shown in column (4), there are six out of the thirteen crop districts where the third moments, U_3, is negative. This suggests that the distributions for these seven districts should be considered to be skewed to the left. For the remaining seven crop yield districts, where the U_3's are positive, the distributions should be considered to be skewed to the right.

In the formulae that are given for the various types, the choice of sign for a square root depends on the sign of U_3.[5] If the frequency is concentrated more closely below the mean than above it, the mode is on the left-

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[3]Mathematical formulas for calculating these coefficients are shown in Appendixes 2 and 3.

[4]"Are" is the usual unit of land in Korea, which is 100 m^2 or one hundredth of hectare.

[5]Elderton and Johnson, op. cit., p. 50.

TABLE 6.1

BASIC CALCULATIONS FOR ESTIMATING PEARSON DISTRIBUTIONS

Districts (1)	Mean (2)	Variance (3)	U_3 (4)	U_4 (5)	Standard Deviation (7)	B_1 (8)	B_2 (9)	K (10)
Yang-Ju	334	4.741	-2.214	59.544	2.177	0.046	2.757	-0.056
Pyong-Taek	388	4.176	4.228	33.893	2.043	0.246	1.944	-0.075
Yeo-Ju	360	5.321	-4.087	58.177	2.307	0.11	2.05	-0.04
Hwa-Sung	369	3.691	1.124	30.590	1.921	0.025	2.245	-0.012
Yi-Chun	383	4.847	0.556	67.111	2.202	0.003	2.857	-0.008
An-Sung	376	4.241	0.382	32.114	2.053	0.002	1.785	-0.0006
Kang-Hwa	349	5.537	-5.416	67.617	2.353	0.173	2.205	-0.067
Kwang-Ju	339	3.193	0.757	25.478	1.787	0.018	2.499	-0.013
Si-Heung	362	4.062	-9.266	76.605	2.105	1.280	4.643	-2.290
Da-Ju	341	4.357	-2.521	45.112	2.087	0.077	2.376	-0.040
Yeon-Chun	341	2.705	0.053	18.897	1.645	0.0001	2.583	-0.0001
Yang-Pyong	337	4.329	0.142	34.676	2.08	0.0002	1.850	-0.00007
Yong-In	361	4.323	-3.172	31.696	2.249	0.125	1.696	-0.036
Average	355	4.271			2.071			

I used average area rice yield data from the Ministry of Agriculture and Fisheries, Korea, during 1965-1981. Data used are shown in Appendix 4.

hand side of the mean and U_3 is positive; the signs of U_3's can tell that the mode and mean may lie in their correct positions.

Column (9) of Table 6.1 shows the B_2 coefficients. These are all less than three, and this implies that the distributions have less slope than the normal distribution. In terms of statistical significance, there are several tests for normality which can be used. There are two tests due to E. Pearson: one is a skewness test using the square root of the B_1 coefficient, and the other is a Kurtosis test using the B_2 coefficients, though this test can be safely applied only to a minimum sample size of 200.[6] The null hypothesis of the test of normality should consist of two components simultaneously; namely,

$$Ho_i \; B_1 = 0 \text{ and } B_2 = 3$$

However, a joint probability distribution for this kind of test is not available yet.

Another test approach is the chi-square test which uses the comparison between the estimated normal distribution with the estimated Pearson distribution in terms of goodness of fit to the observed data.

The criterion, K, in column (10) in Table 6.1 identifies the type of Pearson distribution to be used to

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[6] Day, op. cit., p. 733.

represent the unknown distribution. The identification formula, equation 16 in the previous chapter, can be written in terms of moments as follows:

$$(1) \qquad K = \frac{B_1(B_2+3)^2}{4(2B_2-3B_1-6)(4B_2-3B_1)}$$

The criterion, K, may be of any value from negative infinity to positive infinity. The following diagram shows the different types of distribution which include all the possible values of the criterion, K, and do not overlap.[7]

K= ∞		K=0		K=1		K= ∞
	K negative		K>0 and <1		K>1	
	Type I		Type IV		Type VI	
Type III		normal curve when B_2=3 when B_2<3(>3) Type II (VII)		Type V		Type III

K's are shown in column (10) of Table 6.1. All the K's in column (10) are negative, suggesting that the Type I Pearson distribution should be used to represent the distribution of rice yields for all of thirteen crop districts.

Estimated parameters of the Type I Pearson distribution are shown in Table 6.2, and formulae for estimating

[7]Elderton and Johnson, op. cit., p. 49.

TABLE 6.2

PARAMETERS OF ESTIMATED TYPE I PEARSON DISTRIBUTION

Districts	α_1	α_2	m_1	m_2	Y_o	Origin
Yang-Ju	11.79	6.90	9.116	5.336	0.0726	334.30
Pyong-Taek	10.73	-3.21	0.228	-0.761	0.083	389.69
Yeo-Ju	12.26	5.63	7.249	3.329	2.826	301.53
Hwa-Sung	5.02	2.94	0.782	0.458	0.093	368.38
Yi-Chun	15.02	12.49	19.495	16.213	3.063	382.94
An-Sung	1.09	5.94	-0.011	-0.06	--	378.48
Kang-Hwa	8.61	1.03	0.836	0.101	0.079	351.58
Kwang-Ju	6.22	4.63	3.493	2.60	3.475	338.80
Si-Heung	35.90	1.80	22.472	1.12	3.978	363.32
Da-Ju	7.03	3.64	2.155	1.115	2.943	341.64
Yeon-Chun	5.87	5.71	4.758	4.63	2.068	340.99
Yang-Pyong	3.44	4.02	0.117	0.10	0.028	336.68
Yong-In	1.81	4.95	0.301	0.521	0.088	362.0

Type I Pearson Distribution takes the form

$$Y = Y_o(1 + \frac{x}{\alpha_\omega})^{m_1} (1- \frac{x}{\alpha_2})^{m_2} \quad -\alpha_1<x<\alpha_2$$

with origin at the mode.

them are presented in Appendix 3. The shape of the distribution can be recognized by the magnitudes of the parameters m_1 and m_2.[8] A bell-shaped Type I Pearson distribution occurs when m_1 and m_2 are both greater than one, as in Yang-Ju districts where m_1 is equal to 9.116 and m_2 is equal to 5.336. There are seven crop districts where the distribution of rice yields is bell-shaped. A cocked-hat-shaped Type I Pearson distribution occurs when either of m_1 and m_2 is between zero and one,[9] and the other is greater than one, or both of m_1 and m_2 are between zero and one. Among thirteen districts of rice yield, four crop yield districts are estimated as the cocked-hat shaped distribution. A J-shaped Type I Pearson distribution occurs when one of the parameters m_1 or m_2 is negative and the other positive. In case of Pyong-Taek districts, the distribution of rice yields is showing as the J-shaped type. When both m_1 and m_2 are negative, on U-shaped Type I Pearson distribution occurs as in the case of An-sung districts, where m_1 is equal to -0.011 and m_2 is showing as -0.06.

However, crop yields have a finite low limit and also a finite upper limit even under the most favorable circumstances. As a result, Type I Pearson distribution

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[8] Ibid., pp. 51-58.

[9] Ibid, p. 50.

are likely to have a cocked hat, or bell-shaped distribution rather than one which is J or U-shaped. In my study, a J-shaped and a U-shaped type occurred as the estimated distributions for Pyong-Taek and An-sung district respectively. But, I think that these mean the crop yield distributions of populations are, in fact, J-shaped or U-shaped. According to Day[10], these results may be due to sampling error, that is, samples drawn from a highly skewed and highly peaked population might appear to be from a J-shaped distribution. And if a part of the sample is drawn from a lowly peaked population and another part of the sample is drawn from a highly peaked population, the Type I Pearson distribution would tend to be U-shaped.

Suggestion for Premium Rating Each Farm

Until now, I tried to determine the crop yield probability functions, $f(X_i)$, for calculating premium rates using aggregate area yield data, and have shown that the rice yield probability function may take different forms. Specifically, it appears that rice yields are not normally distributed. As discussed, theoretically, in the equation: $P = \int_0^c f(X_i)(c-X_i)dX_i$, where X_i is below c, we can estimate the premium rate if the crop yield

[10] Day, op. cit., p. 732.

distribution function is determined and the insured or coverage level, c, is known.

A premium for all-risk crop insurance is charged for each individual farm. As a result, premium rating for each farm is necessary in order to charge a premium as an entitlement of indemnity. Under the homogeneous farming conditions in a district, we assume that the crop yield distribution function in a district is the same as that of a farm. In this case, even though the crop yield distribution function of a farm is assumed not to differ from that of a district, the insured level, c, of each farm in the district should be different for each parcel--that is, annual average yields should differ among farms because of different topography and soil productivity. So the insured or coverage level of each farm for crop insurance should be different from each other. As a result, the premium level for a farm should be calculatd on its own coverage level for crop insurance. But we don't know the experienced average yield for each farm because there are no available farm records at the initial stage to introduce crop insurance. We need another way to make a premium rating for each farm.

In the case of Korea, there are no available data to classify land specifically on the basis of quality according to topography and soil fertility, but there

is a land tax register which takes these factors into account. Even though this land tax register was framed a long time ago, it can be used for the base of premium rating for each farm with only slight revision. To develop a new register would be costly in money and in time.

After a crop insurance program is established, it is possible to adjust premiums according to the yield results during the crop insurance period.

Adjustment of Individual Premium by Experience

In most cases, the premium rate for a crop insurance program is charged on an area basis and aggregate data are used in estimating the premium rate. Further, I tried to calculate the premium for each individual farm based upon the land tax register to be framed on the degree of topography and soil fertility.

I assumed that, under the homogeneous farming conditions, each farm would have the same crop yield distribution function as that derived from the aggregate area average yield data, and, as a result, the same premium rate should be applied. That is, farmers in the same risk area and with the same soil productivity rating would pay the same amount of premium for the same coverage per unit of land, i.e., the average yield is the same for all the farms and the variation of yield

from this average is also the same for all. If average yields for all the farmers are not the same in the district, farmers with a low average yield receive more indemnities than farmers with a high average yield. And if the variation in yield differs among farms in the district, farmers with larger yield variations receive indemnities more often than the farmers with smaller yield variation. Therefore, in this case, the same premium to all farmers in the same area would discourage low risk farmers from participating in the crop insurance and, on the other hand, would encourage high risk farmers to buy insurance. As a result, a crop insurance program under a voluntary basis would involve a group of farmers with lower average yield and/or greater variation of yields than farmers who choose not to participate in the crop insurance program.

Because the hypothesis that rice yields of all the farms in the same district have the same average and variance from the average is not tested, it cannot be assumed that means of the rice yield distributions on different farms on the same soil type are equal. As discussed, since the all-risk crop insurance is contracted with the individual farm, the premium rate should be based upon the distribution of crop yields on the individual farm. However, at the initial stage of a crop insurance program, there may not be enough yield

information on an individual farm available to estimate the distribution of crop yields for setting the individual premium rate. How can this problem be dealt with? Here, I would like to introduce the method used in the United States Crop Insurance Corporation as reported by Bar and Dougan.[11]

Example of Current Approaches

In recognition of the several factors influencing the crop insurance premium rate, the insruance agency sets an initial premium rate and attaches an experience rating table to it, adjusting the premium as well as the corresponding insured yield according to the actual yields on the individual farm. By this method, the premium charged by the insurance agency will gradually reflect the risk involved in the operation of the insurance scheme. The U.S. Federal Crop Insurance Corporation has applied the good experience discount for all insured crops since 1960. That is, farmers earn a 5 percent discount on the premium after one or two consecutive years without a crop loss, 10 percent after three or four years, 15 percent after five years, 20 percent after six years, and 25 percent after seven or more years.

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[11] W. Bar and R. Dougan, "Crop Insurance", Agricultural Extension Service Publications, Ohio State University, 1960.

And a farmer with seven or more years of good experience reduces to an equivalent of four years of good experience when he is paid a loss indemnity, that is, he will receive a 10 percent discount on his next year's premium. Those with less than seven years good experience will be reduced to an equivalent of three years of good experience when they are paid a loss indemnity.[12]

By applying this method, the premium and the premium rate of a farmer can be adjusted in accordance with his actual yield distribution in the long run. But, with reference to the determination of current discount rates, there are some drawbacks. Firstly, there is no theoretical foundation for the determination of these discount or adjustment rates. It cannot be claimed, theoretically, whether the discount rate schedule adjusts the premium to a more equitable one or not. Secondly, the discount rate does not differentiate between a farmer with an average level of yield expectation and a farmer with a higher level of yield expectation. That is, what needs to be noted here is that the impact of future yield experience on the shape and the level of a distribution depends not only upon the frequency of yields falling above the insured yields but also, to a large extent, upon the level of these future yields. For example,

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[12]Ibid., p. 24.

a farmer with yield variation within a range of 20 percent of the average yield for the area should probably not be treated the same as a farmer with yields which always record above the area average yield. The latter farmer should probably get a larger discount than the former at the same level of coverage.

Proposed Theoretical Approach

Seal[13] classified experience rating systems in the field of insurance into two categories: retrospective and prospective. In the retrospective experience rating system, a risk-loaded premium P_1 is charged to the insured. Depending on individual experience, low risk insured are reimbursed by means of dividend or bonus payments. If P_1 is the loaded premium, then

$$(1) \quad P_1 = P + L$$

where P is the pure premium rate and L is the risk loading. Under this system, more premium than necessary is initially charged to the farmer so that a dividend can be returned to the contract holders based on their actual claims.

There is not enough yield data on individual farms for estimating an accurate individual premium at the start of an insurance program. On the other hand, the

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[13] H. L. Seal, Stochastic Theory of a Risk Business New York: John Wiley and Sons, 1969, pp. 56-89.

adjustments of estimated distributions for determining premium rates may be too costly to do every year. Under such a situation as Seal[14] suggested, a prospective experience rating system, which considers how an initial estimate of the probability distribution is changed when additional information is gathered, seems more appropriate. That is, an initial premium rate, P_i, is calculated using a base distribution, f(X). When additional yield data are available, a new distribution, $f(X/X_{t+1}\cdots X_{t+n})$, can be estimated where $X_{t+1}\cdots X_{t+n}$ are new information about crop yields. Then after n years, the new premium rate, P_n, is charged to the insured farmer.

$$(2) \quad P_n = \int_o^c (C-X) f(X/X_{t+1},\cdots X_{t+n})dx$$

By comparing the initial premium rate to the new one, the experience table can be established. That is, the experience rating system will consider not only the frequency of the indemnity claim but also the level of actual realized yields on the individual farm. Under such a theoretical structure, it is possible to make consistent adjustments to the premium rate charged to the individual farmer.

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[14]Ibid., pp. 61-70.

The Necessity to Adjust the Premium Rate and Coverage Level Over Time

If the production level at the time of the initial premium rate calculation is equal to that in the future period, the premium rate calculated from the past yield data can be used as the premium rate to balance the insurance program. However, there is a difference in the future period; some adjustment is necessary. Agricultural productivity tends to increase over time through technological improvements and more capital use. The tendency for general productivity to decline over time is less common. Therefore, in order to introduce a crop insurance program to the Korean agricultural sector, it is useful to consider the adjustment of the premium rate in the case of upward yield trends.

As discussed earlier, major factors influencing the delineation of the boundary of a homogeneous crop production area are resource inputs like land, labor and capital, technology improvements, weather, and other factors. In this case, input factors and technology improvements may result in an increase in the production level over time.

Let us assume the original yield distribution function, $f(X_i)$, and the adjusted distribution function, $f(X_{i+t})$. The total coverage level, c, can be calculated by the following equation:

(3) $\hat{L}_m = \int_o^c f(X_i)(C-X_i)dX_i$

And the estimated pure premium rate based on the year, m, will be $\hat{P}_m = \hat{L}_{m/Nm}$ where N_m is the total acreage in the year m.

Since, at the year, m + t, the probability function, $t(X_{i+t})$, shifts to the right because of the increases in the production level. As a result, the loss cost in that year with the same coverage level, c, will be decreased. That is, the premium rate based on m year $\hat{P}_m$, is overestimated if it is applied to (m + t)th year. Therefore, the average premium rate estimated by yield data in the past m years is also overestimated if it is applied to the future t years.

According to Yeh and Wu,[15] one way to adjust the premium rate in accordance with the increase in the production level is to fix the amount of coverage level, c, and to reduce the size of the premium rate which is calculated by using yield data in the years, m.

The second way is that one fix the premium rate at the estimated level, but adjust the coverage level, c, in the next period. If the coverage level, c, is raised to c^1 by the distance, mb, the new loss cost, $\hat{L}^1_{m+t}$ with the coverage level, c^1, in year (m + t) will

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[15]Yeh and Wu, op. cit., pp. 1580-1586.

equal the loss cost, $\hat{L}_m$, with respect to yield data in year t and coverage level, c.

(4) $\hat{L}'_{m+t} = \int_o^{c+mb} f(X_{i+t})[(c+mb)-(X_i+mb)]dx_i$

(5) $P'_{m+t} = (1/N)\ \hat{L}'_{m+t} = (1/N)\hat{L}_t = \hat{P}_t$

(6) $\hat{P}' = (1/m) \sum_{t=1}^{m} P'_{m+t} = (1/m) \sum_{t=1}^{m} \hat{P}_t = \hat{P}$

As shown in the above equations, in this case the same rate $\hat{P}$, estimated from the past m years' yield data can be used for the next m years, with coverage level raised by mb where m is the number of years in each period and b is a coefficient of yield trend.

The third way to adjust is to use the concept of moving average. This method estimates the current premium rate and coverage level by using the yield data in immediately preceding years.

CHAPTER VII

PROBLEMS IN THE INTRODUCTION OF A CROP INSURANCE PROGRAM TO THE KOREAN AGRICULTURAL SECTOR

As discussed in Chapter II, the characteristics of Korean agriculture include little cultivated land per farm household, high density of farm population per unit of land, and monoculture farming even though cash crops and livestock are now increasing in the rural area. As shown in Table 2-6, 65 percent of farm households among all farm households owned land less than 1 hectare at the end of 1979. They can be said to be peasant agriculturalists whose occupation is a livelihood and a way of life, not a business for profit.

Subsistence farming can be said to exist when the farm family's goal of production is family food rather than for commercial sale[1] and production activities mainly depend on family labor. For the subsistence farm, there is a direct and close interrelationship between production and consumption. Some view a peasant economy as one in which its links between purchasers and consumers are more personal and more directly perceptible than in

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[1]Clifton R. Wharton, Jr. Subsistence Agriculture and Economic Development, Chicago: University of Chicago Press, 1970, pp. 14-25.

a more developed and complex economy. In relation to crop insurance, we cannot reasonably expect subsistence farms to make voluntary purchases of crop insurance from private companies.

Moreover, premium rates for crop insurance under the all-risk crop insurance tend to be high because such crop insurance covers all kinds of damages to the objective crops. In addition, the ability of subsistence farmers to pay a premium for crop insurance is limited due to their low income levels.

As a result, crop insurance in developing countries tends to be provided by the government or a governmental agency and to be compulsory by law. Typically, part of the pure premium and operating costs are subsidized by the government in order to reduce premium charges. That is, crop insurance in those countries is provided not as a business, but as part of a social security policy. Here, the greatest obstacle in establishing a crop insurance institution in developing countries is found--the problem of lack of financial resources to support crop insurance. While resources in developing countries are meagre, their requirements are acute, pressing and large. The opportunity cost of agricultural investments is considered as very high due to ambitious economic development plans. Developing countries have a common and persistent dilemma as their means are much less than

their needs.[2] As a result, they are constantly either prone to the temptation of over-ambitious planning which has its perils and pitfalls, or to a kind of inhibiting caution which acts as a drag on rapid development.

I will now discuss the problems which arise in introducing crop insurance for the agricultural sector in Korea and in other developing countries. I think that most of these problems are inherent pains encountered in the process of moving up to a stable level of agricultural production and rural welfare. Eventually, all countries can overcome these problems as in the cases of the United States and Japan.

Lack of Reliable Data

A serious initial difficulty in establishing a crop insurance scheme for a developing country is the scarcity of reliable long period data on crop losses and yields. In order to establish a sound actuarial basis of crop insurance for each crop and each homogeneous farming area, especially at the first stage, it is necessary to have long period yield data such as annual average yield, and loss experience data by natural elements, diseases, and pests. For a large majority of

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[2]V. P. Kapur, "Crop Insurance," Commercial Pamphlet, Series No. 50, Bombay.

developing countries such information usually is not available. The lack of reliable data greatly complicates the calculation of crop loss probabilities, premiums, and indemnities.

In the case of Korea, even though average area yield data are available from several years ago when the Agricultural Statistics Bureau was established in the Ministry of Agriculture and Fisheries, reliable actual yield loss data are not available for calculating premium rates for crop insurance. Again, it is important to note that a sound system of insurance can be built only on the foundation of accumulated experience gained from actual operations. No amount of advance work can secure the desired level of perfection. This can be attained by only a process of trial and error, that is, through actual yield experiences.[3] So, if there is a genuine need for crop insurance, it is advisable to begin to accumulate essential data of certain major crops. Also, in order that crop insurance should be tried in practice, a pilot program on a limited area is generally advisable.

Fragmented Land, Land Tenure and Records Problems

Fragmented holdings, vaguely defined tenure patterns, and the absence of land records may further hinder the

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[3]Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 83.

operation of crop insurance in developing countries.[4] As previously mentioned, cultivated lands in Korea are extremely divided. One reason is that most of the cultivated land is situated on the slopes of mountains, and, in addition, paddy rice is the major crop in Korea. Without leveling and bunding, it is impossible to cultivate paddy rice. Another reason, I think, is that generally Koreans attach importance to owning land; that is, traditionally land has been the most important inheritance and when a father leaves his property to his sons, he has to divide the land. But lately, the sizes of a parcel of land tend to be large because of the land rearrangement project which is an important project of Korea's agricultural plan.

The small-sized holdings characterizing many of the farm operations in developing countries greatly increase the administrative difficulties and costs of any scheme. Further, while the owner of a large farm can offset losses on some parts of his farm by gains or normal yields on other parts; this is not feasible in the case of many small farms.

The existing land tenure and land record systems in many developing countries constitute a handicap to the development of crop insurance. For example, if the

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[4]P. R. Crawford, "Crop Insurance in Developing Countries," Unpublished thesis, Madison: The University of Wisconsin, 1977.

relationship between the landlord and tenant is vaguely defined, it may be hard to determine which party should handle the insurance. Likewise with the areas of motivational holdings, and with frequent changes of actual cultivators of land, it is likely to be more difficult and expensive to apportion the amounts of insurance coverage, premiums and indemnities to individual farmers. In the case of Korea, there is no basis for drawing the line between the owner's cultivated land tenants because tenant farming is principally prohibited by law; it is difficult to discern it. Land tax registers may be used as land record for premium rate making to individual farmers. So improving the land tenure and land record systems is a precondition for introducing crop insurance for Korean agriculture. But these conditions are not insurmountable. On the contrary, the establishment of crop insurance can make the actual land tenure relationships clear and can be used as information for making other agricultural decisions.

Lack of Financial Resources

One of the largest hurdles in creating and maintaining a crop insurance program, as already observed, is the lack of financial capital. At the initial stages, even though policy makers already recognize the need to introduce crop insurance, the most important element

causing them to hesitate is the financial requirement. Further, what makes it worse is that this financial subsidy must continue every year in the future. If it is stopped once, there may arise much confusion in the rural area and reverse effects on the diffusion of agricultural policy in the future.

Moreover, as noted before, the opportunity cost of crop insurance may be higher in developing countries than in developed countries because those countries have not yet built up their infrastructure to satisfactory levels. As long as there is such a great need for irrigation facilities, adequate storage and marketing channels and the development of agricultural technology, these alternatives compete with crop insurance for both administrative and financial resources. In addition, those countries are usually tempted to invest in other industries. Examples of development by fast growth of the industrial sector can be found easily in the world. In fact, Korea is one example.

Some say that the financial problem in crop insurance can be overcome given the necessary efforts and with suitable preparation.[5] However, in the case of Korea, this problem, I think, is the greatest obstacle to the introduction of crop insurance. Also it was this same

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[5] Ibid., p. 283.

reason that India failed to establish crop insurance for the stabilization of farmers' livelihoods.

Heterogeneity of Farming Practices and Conditions

Agricultural practices often vary considerably from region to region even within the same country due to variations in soil and climate, the availability of water and drainage facilities, differences in technical ability and the resourcefulness of the farmers including the use of new methods of farming such as the application of chemical fertilizers, composts and manures, the use of improved seeds as well as of modern implements and also of pest and disease control measures. As I discussed before, such varied agricultural practices result in high variability in yields making it difficult to estalish insurance coverages and premium rates. In a voluntary scheme of insurance they are likely to give rise to greater "adverse selection," as farmers operating under high risk conditions or using backward practices may only buy crop insurance in the extreme case.[6]

Though in the long run crop insurance could contribute to a decrease in this heterogeneity, in the short

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[6]Ibid., p. 284 and Crawford, op. cit., p. 170.

run this characteristic would greatly curb the prospects for the success of a crop insurance program.

Under the heterogeneous farming practices and conditions, a moral hazard[7] problem arises from the necessity of having to deal with more numerous persons whose acts or omissions are likely to affect a crop insurance program. For example, moral delinquency problems like the short use of chemical fertilizers or pesticides can arise in a less developed society and in farms with very small, scattered and segregated risks. As a result, crop insurance can be established more successfully in a farming system with a well-organized technical diffusion system and extension system to help standardize production practices. Ray[8] suggests that the moral hazard be met by having the insurance scheme operated at the local level through farmers' organizations or village co-operatives and mutual associations, which are in a position to know their insured members intimately and to maintain a close vigilance over their activities, and, second, with premium rates adjusted at local and district levels on the basis of their own loss experience.

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[7]See Footnote 6, page 35, Chapter III.

[8]Ray, "Crop Insurance as a Measure of Agricultural Support," op. cit., p. 285.

Lack of Support and Cooperation of Farmers

The successful operation of a crop insurance program requires that both objective and subjective factors should be favorable. Thus, a lack of effective demand for crop insurance on the part of peasant farmers will be another factor limiting its success. This effective demand is composed of purchasing power, understanding of the concept of crop insurnace, and need for insurance.[9]

In the majority of developing countries there is little visible demand for insurance among farmers because of their low capacity to pay premiums. Further, if they are suspicious of crop insurance, this may progress into a state of distrust between government and farmers under a compulsory crop insurance scheme.

Others

Non-cultivating farmers cannot benefit from a crop insurance program. As a result, this program would enlarge the difference of living level between land-owning farmers and non-farming farmers in the rural area. This may generate social problems as the present two-price policy of agricultural products has the shortcoming of favoring large farmers or having people rather

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[9]Crawford, op. cit., p. 172.

than non-having people in the rural area.

Another problem in establishing crop insurance in developing countries is the lack of suitably trained personnel and suitable equipment which may delay the establishment of crop insurance shcemes. But these problems can be solved in a longer run with training and experience.

The lack of education may lead to many communication problems and misunderstandings between the farmer and the crop insurance agency. Besides, we can anticipate many problems in establishing crop insurance programs in developing countries, but I think that minor problems can be dealt with smoothly by communication with each other and experience.

CHAPTER VIII

POLICY ALTERNATIVES AND CONCLUSIONS

The ultimate goal of crop insurance is not simply to protect the farmer's livelihood from crop failures due to bad weather or even to decrease adverse effects of agricultural uncertainty on the outcome of his farming plan decision making. The overall objective of crop insurance is, generally, the development of agriculture and the maintenance and the increase of farmers' incomes. In this sense, a crop insurance program is either an economic institution or a social welfare program. The Japanese program of crop insurance is, in fact, a combination of insurance and public relief.

In general, risks in agriculture occur regionally widely and more frequently compared to the objects in other insurances. Especially, in all-risk crop insurance which covers all the risks arising in growing crops, this characteristic may be very clear, but not in the case of special-risk crop insurance such as hail-crop insurance. As a result, the pure premium rate for crop insurance generally tends to be very high. In addition, as discussed, the high operating cost of crop insurance is another cause to raise total charges of

farmers for insuring their crop because of fragmented lands and complicated land tenures.

As analyzed in the first chapter, Korean agriculture can be described as made up of small sized subsistence farms compared to most developing countries. Under these conditions, we cannot expect farmers to participate voluntarily in a crop insurance program because they do not have the ability to pay costly premiums for crop insurance. Therefore, I can conclude that private insurance in the agricultural sector cannot be established successfully in Korea, even though small farmers want to protect their incomes from the uncertainty more eagerly than large farmers. Small farmers are exposed to many natural disasters. As a result of these characteristics of Korean agriculture, Korean crop insurance schemes should probably have both the public relief and security objective. Further, such programs should probably be compulsory and subsidized because of farmers' limited abilities to pay premiums.

When the government makes policy decisions with limited capital resources, the opportunity cost of an alternative policy should be considered. Even though the objectives of crop insurance are highly valued, we may find that more efficient means exist for reaching relief and security objectives than all-risk crop insurance. The crop insurance program should compete with

other policy options for capital, administration capacities, educational resources, and other inputs. Therefore, we may not make a valid judgement in favor of crop insurance without comparing the costs and benefits with those for alternative programs and policies. Before we can compare policy alternatives, more complete information is required on the analyses of the effectiveness of crop insurance programs and the other alternatives. The comparison of crop insurance to other programs is based on benefits and the cost of establishing crop insurance schemes. A public crop insurance program is a part of an agricultural development policy. The agricultural sector, in turn, competes with many programs which are parts of policies for the industrial sector, national defense, fishery industry, education, and other social welfare programs under the whole national plan. Within the agricultural sector, a crop insurance program also competes with other agricultural development programs such as the agricultural base expansion including irrigation and drainage facilities developments, the establishment of efficient agricultural marketing systems, the diffusion of farm machineries, and the expansion of farming technology and techniques extension services. Each alternative program has its own potential to contribute to the national economy and social development.

Comparing the effectiveness of alternative programs

is beyond the scope of the present study. To do so would be difficult because values obtained by each program are hard to reduce to a common denominator. Here I restrict the scope of discussion to policies designed to protect farmers' incomes and livelihoods from natural disasters and to contribute to the development of agricultural production and the rural development directly or indirectly; namely agricultural disaster relief and agricultural credit policies.

Even though the above classifications are not well-organized the comparisons between those programs and crop insurance programs can clarify benefits and defects of crop insurance. It should be kept in mind that those alternatives including crop insurance programs are not completely substitutable, but sometimes are complementary. But combining those policy alternatives, the ultimate goal of a crop insurance program can be accomplished more effectively.

Disaster Relief Payment

At present, a relief or recovery program from natural diasters in Korea is provided by two kinds of law; one is "The Law of Prevention and Recovery from Storms and Floods," and the other is "The Law Against Agricultural Disasters," which was established (1) to increase

agricultural productivity by preventing or swiftly restoring damages due to natural disasters like drought, flood, cold temperature, and the spread of insects and disease in agricultural plants, and, ultimately, (2) to stabilize farming and farmers' livelihoods. The objective of the first law is to protect all land, lives and capital from natural disasters; therefore, the law has a wider jurisdiction than "The Law Against Agricultural Disasters," which is mainly related to the prevention and recovery of only agricultural disasters.

The content of the latter law will now be discussed. According to this law, the Minister of the Ministry of Agriculture and Fisheries can subsidize disaster relief payments for the restoration from the agricultural damages, and finance short-term or long-term loans for farmers to continue agricultural production activities.

The usual types of disaster relief payments by the government are numerous and include reparations to subsidize farmers' livelihoods, the use of emergency loans for continuing production activities, the deferment of land taxes and the repayment of agricultural credits, the release of government rice, and the construction of public works to give opportunities to earn money. But, as I mentioned in the introduction of this paper, the reparation for agricultural damages owing to natural disasters was only 3.7 percent of total agricultural

damages during fifteen years (1965-1979) because of the shortage in the government budget. Thus, such programs are quite inadequate to relieve farmers from disasters.

The shortcomings of disaster relief programs result mainly from a shortage in the government budget compared to agricultural damages. There is not enough money to stabilize farmers' livelihoods and maintain their production activities. Further, there is the delay of payments because of the complicated procedures. In the event of a massive crop failure, the burden of the government budget for providing tax concessions, emergency food release, distress loans and other relief measures to farmers and the rural population, in general, would be heavy. Another shortcoming of disaster relief payments is that they are not positive measures but passive, especially with respect to increasing agricultural production. Even though relief programs might be designed which are most cost-effective and more easily targeted to the needy than a comparable crop insurance program, such a relief program cannot be a steady policy to support the welfare for rural people. That is, a relief program would not be automatically activated in the event of a crop failure.

But if funds to operate such a program have to be set aside prior to the time of disaster, the disaster relief program may be a policy to stabilize rural lives

enough to ease the burdens on farmers. In addition, relief programs of this type would have one crucial advantage over crop insurance. It would directly benefit rural residents who do not have lands.[1] As stated before, one of the shortcomings of the crop insurance program is that benefits of a crop insurance program go primarily to those who own or have a tenancy right to the land that they farm.

Considering that crop insurance and disaster relief programs have similar objectives, that is, the increase in rural welfare and the continuity of agricultural production, both programs may be used complementarily. Especially, disaster relief programs should apply to farmers who are too small to be covered by a crop insurance program and who farm in very high risk areas.

Agricultural Credit Programs

The principal objectives of government subsidized agricultural credit programs, generally, are to provide resources for increasing agricultural production to farmers. These funds are usually provided only to those farmers whose incomes or asset holdings are very low to provide an investment opportunity that would not otherwise be available. Such income gains of small

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[1]John W. Mellor, The New Economics of Growth: A Strategy for India and the Developing World, Ithaca: Cornell University Press, 1976.

TABLE 8.1

TOTAL AMOUNTS OF AGRICULTURAL DAMAGES AND PERCENTAGES OF SUPPORT IN KOREA DURING 1965-1979

	Total Amount (Thou.M/T)	Total Price (Mill. Won)	Subsidizing Amount (Mill. Won)	Percentages of Support(s)			
				Reparati	Subsidy for recovery	Loan	Total
65	65.6	2,528.7	293.7	1.7	7.7	2.3	11.6
66	69.7	2,849.7	22.8	--	0.8	--	0.8
67	492.2	21,232.8	89.5	--	0.4	--	0.4
68	755.5	36,453.1	283.6	--	0.8	--	0.8
69	249.6	15,407.1	420.1	0.1	0.5	2.1	2.7
70	199.3	14,312.8	1,678.4	5.3	1.0	5.4	11.7
71	116.7	10,616.4	253.3	0.4	0.1	1.8	2.4
72	151.3	16,513.3	357.3	--	2.3		2.3
73	58.7	8,020.0	50.4	--	0.6	--	0.6
74	159.1	24,062.9	1,384.9	5.7	0.1	--	5.8
75	78.8	14,092.2	324.3	2.2	0.1	--	2.3
76	52.7	13,717.2	572.2	3.1	1.1	--	4.2
77	902.0	186,028.2	2,908.1	1.5	0.1	--	1.6
78	89.3	30,357.3	2,260.9	6.1	1.4	--	7.5
79	569.9	222,395.8	959.9	--	0.4		0.4
Total	4,010.4	--	--		--		--
Av.	267.4	102,353.1	3,787.1	1.7	--	--	3.7

Source: The Ministry of Agriculture and Fisheries, Korea.

farmers from the credit program may be regarded as the way to generate equality in consumption levels and a more just distribution of economic opportunities. Besides, Donald[2] cited the following items as other potential benefits to farmers from agricultural credit programs: improved nutrition, release of farmers from dependence on extortionate money-lenders, a strong position in the markets, increased self-respect and hope for the future, improved social status, access to wider educational and occupational opportunities for the farmer's children, etc.

Credit can be categorized according to different criteria. First, agricultural credit can be classified into public credit and private credit by lending institutions. Second, according to the length of loan periods, credits can be classified into short, medium, and long-term credit. Even though it is not easy to distinguish between short and long-term, in the case of Korea, short-term credits are provided for a farmer's urgent demand for livelihood stabilization and for agricultural production assistance such as purchases of fertilizers and other farming materials. On the other hand, mid-term or long-term agricultural credits are usually used for the purpose of promoting a specific agricultural product

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[2]Gordon Donald, Credit for Small Farmers in Developing Countries. Boulder, Colorado: Westview Press, 1976, p. 18.

such as apples, hops, livestock, etc. and supporting the diffusion of agricultural development policy such as the enlargement of farm machinery and promoting small-sized irrigation facilities by farmers.

Another classification is that of general and emergency credit. Emergency credit is provided in high risk areas and when farmers' incomes fall as a result of crop failure. As one poor crop year frequently occurs, the repayment of the debt over a relatively short period is somewhat uncertain. In this case, in conjunction with the relatively high degree of uncertainty due to high income fluctuations, private credit agencies are reluctant to loan to farmers. Therefore, the government or its agencies have to provide public credit to assist farmers after periods of crop failure or other natural disasters. This emergency credit program can maintain farmers' production activities, helping replace production facilities and stabilize their livelihoods. This emergency credit program permits low interest and long-period repayment plans as a social security policy.

In Korea, emergency credit was institutionalized by the "Law Against Agricultural Disasters", that is, "The Minister of the Ministry of Agriculture and Fisheries can arrange to provide emergency credits to farmers, and deferred repayment for agricultural credits." Because emergency agricultural credit programs have

similar characteristics to crop insurance programs on stabilizing farmers' incomes and promoting agricultural production activities, an emergency credit program can substitute for a crop insurance program if it is established institutionally.

An emergency credit program has the advantage that it can be operated with less administrative costs than a crop insurance program. This program can be administered with the present government administration capacities in most countries; in contrast crop insurance programs require other special institutions. And if this emergency credit provides low interest rates and a long loan period, it can be regarded as a subsidy to disaster stricken farmers by the government without the payment of premiums for insurance. But as Barber and Thair[3] point out, such programs tend to depend on the limitations of administrative discretion and the amount of available funds.

I would like to introduce another policy option which spreads risks like crop insurance. The first is crop-credit insurance. Whereas crop insurance guarantees a minimum yield to the farmer, crop-credit insurance provides coverage only up to the value of the credit

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[3]E. L. Barber and D. J. Thair, Institutional Methods of Meeting Weather Uncertainty in the Great Plains, p. 401.

extended.[4] Therefore, crop-credit insurance offers less support to the cultivator, and does not provide sufficient funds to carry him through to the next harvest. It merely negates his credit obligations against the public credit agency. This system has some advantages in that, by limiting crop insurance to those farmers receiving institutional credit, the insurer can reduce the problem of adverse risk selection and ensure that the majority of participants in its program are relatively progressive. But farmers would have some hardships after the crop failure because this insurance does not provide sufficient funds to carry the farmer to the next harvest.

In those developing countries with private credits, an important service is being provided farmers, and loan insurance or loan guarantee programs constitute another means of reducing uncertainty.[5] The objective of loan insurance is to encourqage credit institutions to provide credit to farmers. Whereas both crop insurance and crop-credit insurance work directly with the borrower and indirectly insure the lender, a loan insurance directly protects the lender in order to insure agricultural credit provisions.

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[4]Nelson Maurice, Mexican and Costa Rican Agricultural Insurance Programs, p. 1.

The major advantage of loan insurance is that it can be administered easier than crop insurance. On the other hand, one problem of loan insurance is that it may default on loans on the part of farmers. That is, the lender may be less willing to expend the time necessary to force to repay the loan because he can receive compensation from the guarantor. This may result in the misuse and squandering of credit and the bankruptcy of the guarantor.

Conclusions and Suggestions

Crop insurance is an economic and social measure to help farmers reduce the fluctuations of their incomes from weather vagaries and to be able to continue agricultural production activities even after severe crop failure. As a highly advanced human institution, insurance has been used to provide protection against future disasters in numerous sectors and social activities. Agriculture, which is exposed to many unfavorable events, should not be an exception. In principle, farmers, especially small-sized farmers who are more frequently exposed to natural risks, can expect some assistance from the government in the bearing of these risks.

In spite of the above, both government and farmers alike have been slow to consider crop insurance. Why

is that? First, natural disasters in agriculture occur frequently over wide areas in scales too large to be covered by private insurance schemes. Secondly, Korean farmers usually are one of the most precarious groups in the Korean economy due to the small subsistent nature of Korean farms and their low productivity. The economically restricted abilities of Korean farmers do not permit them to care much about the future; they have to live in the present.

How is Korea solving this predicament? There is "Government" with responsibilities for the welfare of Koreans which is organized by all the people. As a result, government now has to establish necessary and sufficient conditions to maintain the welfare and productivity of Korean farmers. In this paper, after analyzing socio-economic situations and climatic conditions of Korean agriculture, I found that conditions in Korean agriculture justify governmental establishment of a crop insurance program. I recommend that a Korean crop insurance for rice sector be made compulsory and that it cover all risks in rice production. I also conclude that the government should subsidize a considerable part of the premiums which, in principle, should be paid by farmers.

Here arises the predicament that the government does not have enough financial resources to cover the

costs of such a program. Even though the present budget of the disaster relief program is transferred to the subsidy in the premium for crop insurance within the agricultural sector, the introduction of a crop insurance scheme may result in the increase in the investment of government to the agricultural sector. This may result unavoidably in the decrease in the investment to other sectors such as industrial sector, national defense, education, and etc. And then, does the agricultural sector contribute enough to the national economy or the social stabilization to justify such a subsidy? If I answer "yes" to this question, I may be accused of prejudice in favor of farmers and crop insurance. As a matter of fact, the investment priority of the governmental budget is closely related to the political opinion of the highest policy-decision maker dependent on the social requirements. As a result, the above question exceeds my ability to answer it. And under the assumption that the social requirements to stabilize farmers' livelihoods and agricultural production in spite of natural disasters are on the high tide, here I have restricted the scope of my discussion to a comparison of crop insurance programs with disaster relief and emergency credit programs, which also protect farmers against disasters and maintain their incomes.

Even though disaster relief programs can give

farmers some relief from natural disasters without heavy burdens of costs, this program's limitation is the restricted governmental budget. As a result, usually such programs only cover farm incomes at low levels, while failing to maintain production activities and then only after extended delayed payment because of complicated administrative procedures. But an advantage of this program is that it can be run to favor small farmers and landless farm people. On the other hand, this program encourages farmers to expect too much from government. Lastly, even though a disaster relief program can be operated within the capacity of the present administration without establishing another government agency, its problem is that it usually is a passive measure to meet disasters, not a positive program.

Agricultural emergency credit programs impose a lesser burden on governmental budgets and can be offered within the present government or government agencies at lower operating costs than a crop insurance scheme. If offered on a low interest, long-term basis, an agricultural credit scheme is a kind of subsidy. But its fatal limitation is that it depends too much on governmental budgets. It, as is the case in disaster relief programs, also enlarges the range of administrative discretion.

As we can see in the above, disaster relief payments and agricultural emergency credit are temporary ways of handling natural disasters rather than a stable situation. Even though the bases of these programs are in the law, farmers cannot claim income subsidies and recovery of damages from natural disasters. Instead, they must wait for government action. On the other hand, farmers can participate in a crop insurance program not only by paying premiums but also through project planning crop insurance schemes which reflect their needs and opinion. It may be very hard to start a crop insurance program because of the competition from establishing other agencies, the complicated principles of insurance, and delays in decision making. However, if a crop insurance program is established, I believe it will increase rural welfare more at less cost than the other two programs. Even though many obstacles will be encountered in establishing a crop insurance program in a developing country, I think that those problems in introducing crop insurance are not insurmountable and a crop insurance program, at last, can be established successfully by gaining from the experiences of successful countries. And I believe that whether a crop insurance program is established successfully or not depends on a strong will on the part of decision makers, a concern about stabilizing farm income and a desire to increase

rural welfare.

Anyway, even though the crop insurance program raises the administration costs and maybe (or maybe not) the burdens of government budget, it has such advantages as: 1) being a stable institution to protect farmers' incomes and to increase rural welfare, 2) enabling farmers to plan their future farming in spite of uncertainties resulting, maybe, in an increased adoption of new farming techniques and technologies, 3) raising farmers' social levels and facilitating farmers' access to agricultural credit, and 4) protecting the repayment of government's credit to farmers.

APPENDIX 1

(1) $L = E(C-Y_{ii}Y_i<c) = \int_o^c (C-Y_i)f(y_i)dy_i$

(2) $f(y_i) = (\frac{1}{\Pi\sigma} \quad \exp \quad -\{\frac{1}{2}\frac{Y_i-\overline{Y}_i)^2}{\sigma^2}\} \quad -\infty<y_i<\infty$

(3) $L = \int_o^c (C-Y_i)(\frac{1}{2\Pi\sigma})\exp\{-\frac{1}{2}\frac{(Y_i-\overline{Y}_i)^2}{-\sigma^2}\}\, dy_i$

(4) $L = C\int_{-oo}^c (\frac{1}{2\Pi\sigma})\exp\{-\frac{1}{2}\frac{(Y_i-\overline{Y}_i)^2}{\sigma^2}\}\, dy_i$

$- \int_{oo}^c (\frac{1}{2\Pi\sigma}) \exp\{-\frac{1}{2}\frac{(Y_i-\overline{Y}_i)^2}{\sigma^2}\}dy_i$

(5) $L = CA - \int_{oo}^c Y_i(\frac{1}{2\Pi\sigma}) \exp\{-\frac{1}{2}\frac{(Y_i-\overline{Y}_i)^2}{\sigma^2}\}\, dy_i$

where $A = \int_{-oo}^c (\frac{1}{2\Pi\alpha}) \exp\{-\frac{1}{2}\frac{Y_i-Y_i)^2}{\sigma^2}\}\, dy_i$

(6) Let $Z = \frac{Y_i-\overline{Y}_i}{\sigma}$, $Y_i = GZ + \overline{Y}_i$ $dy_i = \sigma dz$, and

$K = \frac{C-\overline{Y}_i}{\sigma}$, then

$L = CA - \int_{-oo}^k (\sigma z + \overline{Y}_i) \quad \frac{1}{2\Pi\alpha} \exp(-\frac{1}{2}Z^2)\, \sigma dz$

$= CA - \frac{\sigma}{2\Pi}[-\exp(-\frac{1}{2}Z^2)]_{Z=\infty}^{Z=K} + \overline{Y}_i A$

$= CA - [-cd + \overline{Y}_i A]$

$= A(C-\overline{Y}_i) + d\sigma$

APPENDIX 2

METHOD OF MOMENT

The nth moment of a particular frequency is defined as the product of the frequency and the nth power of the distance of the frequency from the vertical about which moments are being taken, or the nth moment of any ordinate y of a frequency-curve about the vertical through a point distance X from it, is YX^n, and the nth moment of the whole distribution treated as a series of ordinates is $Y_iX_1^n + Y_2X_2^n + ----$, where $Y_1 + Y_2-----$ is the total frequency.

The method of moments is a general method of finding the constants in a formula suitable to a particular statistical example, and it consists of equating the values of $\Sigma f_{(n)}X$ nt to similar expressions obtained from the graduation formula.

In this paper, I use the summation method to calculate moments, which was suggested by Sir G. F. Hardy.

$$S_2 = d$$

$$V_2 = 2S_3 - d(1+d)$$

$$V_3 = 6S_4 - 3V_2(1+d) - d(1+d)(2+d)$$

$$V_4 = 24S_5 - 2V_3\{2(1+d)+1\} - V_2\{6(1+d)(2+d)-1\} - d(1+d)(2+d)(3+d)$$

Then,

First moment is mean value

Second moment, $U_2 = V_2 - \frac{1}{12}$, is variance

Third moment is the same as U_3

Fourth moment is calculated by

$$U_4 = V_4 - \frac{1}{2} + \frac{7}{240}$$

A ratio in which the numerator and the denominator are moments or simple functions of moments. In certain cases the moment-ratios may be interpreted as characteristics of the frequency distribution. For example, the most common of the moment-ratios are those referring to the shape of the distribution.

A measure of skewness: $B_1 = U_3^2/U_2^3$

A measure of kurtosis: $B_2 = U_4/U_2^2$

More general ratios of this type, due to K. Pearson:

$$B_{2n+1} = \frac{U_3 U_{2n+3}}{U_2^{n+1}}$$

$$B_{2n} = \frac{U_{2n+2}}{U_2^{n+1}}$$

APPENDIX 3

ESTIMATION OF THE PARAMETERS OF TYPE I

Type I Pearson Distribution:

$$Y = Y_o(1 + \frac{x}{a_1})^{m_1} (1 - \frac{x}{a_2})^{m_2} \qquad -a_1 < X < a_2$$

where $m_1/a_1 = m_2/a_2$

The values to be calculated in order are as follows:

1) $r = G(B_2-B_1-1)/(6 + 3B_1 - 2B_2)$ where $B_1 = U_3^2/U_2^3$ and

$B_2 = U_4/U_2^2$

2) $a_1 + a_2 = \frac{1}{2} \; U_2 \; B_1(r+2)^2 + 16 \; (r+1)$

3) The m's are given by

$$\frac{1}{2} \; [r-2 \pm r(r-2) \; \frac{B_1}{B_1(r+2)^2 + 16(r+1)}$$

4) $$Y_o = \frac{N}{a_1+a_2} \cdot \frac{m_1^{m_1} \cdot m_2^{m_2}}{(m_1+ m_2)^{m_1+m_2}} \cdot \frac{\Gamma(m_1+m_2 + 2)}{\Gamma(m_1+1) \; \Gamma(M_2+1)}$$

5) $$\text{Mode} = \text{Mean} - \frac{1}{2} \cdot \frac{U_3}{U_2} \cdot \frac{r+2}{r-2}$$

APPENDIX 4

AVERAGE RICE YIELD DATA IN KYUNGGI-AREA (1965-1981)

	Yang-Ju	Pyong-Taek	Yeo-Ju	Hwa-Sung	Yi-Chun	An-Sung	Kang-Hwa	Kwang-Ju	Si Heung	Da-Ju	Yean-Chun	Yang-Pyong	Yong-In
1965	209	203	213	258	252	270	227	247	229	210	157	231	234
1966	251	326	286	319	306	323	290	291	307	269	242	288	293
1967	292	326	305	324	313	315	312	300	315	309	261	298	305
1968	258	300	259	285	300	298	226	294	312	231	248	276	309
1969	298	380	346	357	361	374	330	317	348	340	281	302	335
1970	305	364	364	371	396	341	348	306	353	351	309	309	404
1971	324	334	325	343	344	336	345	328	345	322	332	327	331
1972	287	348	300	335	348	334	260	320	323	290	347	322	320
1973	339	412	404	377	414	378	369	369	390	358	356	373	423
1974	392	403	408	391	429	423	371	352	385	365	369	345	420
1975	408	390	429	402	441	430	366	407	415	374	370	402	424
1976	374	481	434	443	460	452	384	383	375	385	398	365	399
1977	457	495	467	470	517	487	444	471	431	426	515	436	445
1978	408	510	471	475	485	471	424	392	402	413	411	430	424
1979	458	437	394	426	438	435	437	373	445	452	435	412	414
1980	256	356	314	324	314	325	370	245	340	327	364	243	274
1981	357	438	396	381	398	401	424	376	436	377	397	372	383
Av.	334	388	360	369	383	376	349	339	362	341	341	337	361

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