THE STOCHASTIC BASIS AND DETERMINATION OF INSURANCE PREMIUM IN HANGING OYSTER CULTURE

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I. Introduction

Oyster culturists ofren face a variety of yiele, resource, and price risks, which make their incomes unstable from year to year and from region to region. In many cases, oyster farmers are exposed to the risks of catastrophic disasters. Culture crops and facilities could be destroyed in large by natural hazards such as typhoons, insects, red tides, etc. The types and severity of the risks vary with oceanic biological and climatological conditions. The production risks tend to affect more seriously the culturists' incomes than price risk. Such risks are particularly burdensome to small scale family oyster famers who have little additional resources for reproduction (Park and Shin 1987).

In order to alleviate the natural hazard–induced fishery production risks, an anti–storm and flood policy has been exercised under the government directions. Since, however, the policy covered only large scale damage from storms and floods, it did not help family sea–culture farms at all. This policy limitation led to developing a sea–culture insurance program. A key issue in this context is to determine an appropriate insurance premium.

The main objectives of this research are to develop a stochastic basis for damage occurrances and to determine appropriate insurance rates for culture crop and facility damage with or without safety loading considerations. This study contains five sections. Section two develops a stochastic basis and criteria which can distinguish the normal and the abnormal parts from the basic damage rate. In the third section sample statistics are described and empir-

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ical analyses are made in section four. In the last section summary and conclusions are made.

II. The Stochastic Basis

1. Poisson Probability Distribution and Goodness–of–Fit Test Statistic

The Poisson probability distribution arises when we count the number of occurrences of an event that happens relatively infrequently, given the number of times it could happen (Ryan, Joiner and Ryan Jr. 1985).

For example, let the random variable k denote the number of red–tide occurrences during the number of interval of time. With an appropriate parameter value, k may be assumed to have a Poisson distribution. This instance can be thought of as a process that generates a number of changes in a fixed interval of time or space. In many cases, such a process leads to a Poisson probability distribution, which is called a Poisson process.

Let $P(k,d)$ denote the probability of k changes in each interval of length d. Furthermore, let the symbol $\phi(\varepsilon)$ represents any function such that $\lim[\phi(\varepsilon)/\varepsilon]=0$; for example, $\varepsilon^2=\phi(\varepsilon)$ and $\phi(\varepsilon) = \phi(\varepsilon) + \phi(\varepsilon)$. Some assumptions that ensure a Poisson process are the following (Hogg and Craig 1979):

(a) $P(1,\varepsilon) = r\varepsilon + \phi(\varepsilon)$ where r is a positive constant and $\varepsilon>0$

(b) $\sum_{k=2}^{\infty} P(k, \varepsilon) = \phi(\varepsilon)$

(c) The numbers of changes in nonoverlapping intervals are stochastically independent.

Assumptions (a) and (b) state that the probability of one change in a short time interval ε is independent of changes in other nonoverlapping intervals and has a linear relationship with the length of the interval. The eseence of assumption (b) is that the probability of two or more changes in the same short interval ε is essentially equal to zero. If $k = 0$, $P(0, 0) = 1.0$. According to postulates (a) and (b) the probability of at least one change in an interval of length is $r\varepsilon + \phi(\varepsilon) + \phi(\varepsilon) = r\varepsilon + \phi(\varepsilon)$. Therefore, the probability of zero changes in an interval of length $(d + \varepsilon)$ is, in accordance with postulate (c), equal to the changes in an interval of length d and the probability $[1 - r\varepsilon - \phi(\varepsilon)]$ of zero changes in a nonoverlapping interval of length ε.

Using some notations, the product of the two probabilities can be written as

$$P(0,\ d+\varepsilon) = P(0,\ d)\,[1 - r\varepsilon - \phi(\varepsilon)]$$

Then

$$\frac{P(0,\ d+\varepsilon) - P(0,\ d)}{\varepsilon} = -rP(0,\ d) - [\phi(\varepsilon)\,P(0,\ d)]/\varepsilon$$

Taking the limit as $\varepsilon \to 0$, we have

$$P_d\ (0,\ d) = -\ rP(0,\ d).$$

The solution of this differential equation is

$$P(0,d) = ce^{-rd}$$

The condition $P(0,0) = 1$ implies that $c = 1$; so

$$P(0,d) = e^{-rd}$$

If k is positive integer, $P(k,0) = 0$. The assumptions imply that

$$\begin{aligned} P(k,\ d+\varepsilon) &= P(k,\ d)[1-r\varepsilon-\phi(\varepsilon)] \\ &\quad +[P(k-1,\ d)]\,[r\varepsilon+\phi(\varepsilon)]+\phi(\varepsilon) \end{aligned}$$

Thus, we have

$$\frac{[P(k,\ d+\varepsilon)-P(k,\ d)]}{\varepsilon} = -rP(k,\ d)+rP(k-1,\ d)+\frac{\phi(\varepsilon)}{\varepsilon}$$

and

$$P_d(k,d) = -\ rP(k,d) + rP(k-1,d),$$

for $k = 1,\ 2,\ 3, \cdots$, K. It can be shown, by mathematical induction, that the solution to these differential equations, with boundary condition $P(k,\ 0) = 0$ for $k = 1,\ 2,\ 3, \cdots$K, are respectively,

$$P(k,\ d) = \frac{(rd)^k\,e^{-rd}}{k\,!},\quad k=1,\ 2,\ 3,\ \cdots,\ \mathrm{K}.$$

Hence the number of changes k in an interval of length d has a Poisson distribution with parameter $\lambda = rd$, that is,

$$(1)\quad P(k) = \frac{\lambda^k\,e^{-\lambda}}{k\,!}$$

An important characteristic of a Poisson distribution is the fact that mean(μ) is equal to variance (σ^2). Since its moment generating function is given by

$$M(t) = \sum_k^{\infty} e^{tk}\,P(k) = \sum_{k=0}^{\infty} e^{tk}\frac{\lambda^k e^{-\lambda}}{k\,!}$$

for all real values of t. Taking the first and second dervatives with respect to t, we can get

$$M'(t) = e^{\lambda(et-1)}(\lambda e^t)$$

and

$$M''(t) = e^{\lambda(et-1)}\lambda(e^t) + e^{\lambda(et-1)}\lambda(e^t)^2$$

Then at $t = 0$

$$\begin{aligned} \mu &= M'(0) = \lambda \\ \sigma^2 &= M''(0) - \mu^2 \\ &= \lambda + \lambda^2 - \lambda^2 \\ &= \lambda \end{aligned}$$

Thus, a Poisson probability distribution has $\mu = \sigma^2 = \lambda > 0$ and is frequently written as

$$\begin{aligned} P(k) &= \frac{\mu^k e^{-\mu}}{k!}, \quad k=0,\ 1,\ 2,\ \cdots,\ K \\ &= 0 \end{aligned}$$

Since, however, goodness–of–fit of the model is a question in conjunction with real applications, the model acceptability should be tested at first. Whenever sample data represent counts of various outcome, the χ^2 (chi–square) test can be used to test the singnificance of the difference between the obtained and the expected frequencies. Because available data can often be expressed in the form of counts, even though more precise methods of measurement were originally used, the χ^2 test is versatile in its application as a hypothesis–testing procedure (Kamier 1978).

Essentially, for the null hypothesis to be accepted, the observed differences between the obtained and the expected frequencies must be attributable to chance (sampling) variability. The formula used to compute the value of χ^2 test statistic is

$$\chi^2_{(k-1)} = \sum_{k=1}^{K} \frac{(f_k - F_k)^2}{F_k}, \quad k=1,\ 2,\ 3,\ \cdots,\ K$$

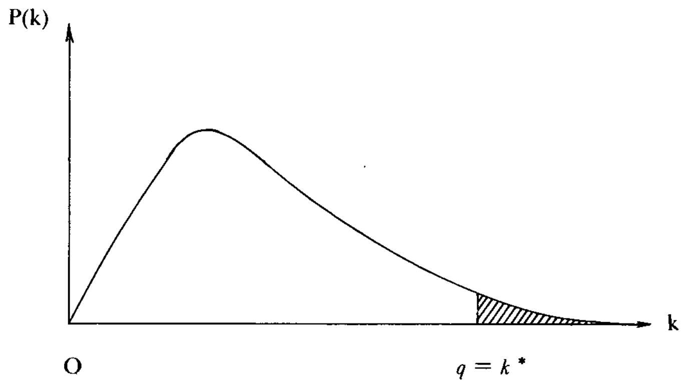
where f_k and F_k denote the observed and the expected frequencies, respectively. With the reference to the formula, the value of χ^2 can never be negative and its degrees of freedom is (K − 1) where K is the number of classes.

2. The Normal Standard Damage Rate

Often fishery disasters cause extremely large damage to culture crop and facilities at the same time over a vast area. Such events occassionally prevent a direct insurer from making sufficient claim payment. Hence, the state(e.g., Japan, U.S.A., etc.) functions as a reinsurer responsible for catastrophic disasters.

An important question is what damage rate is to be chosen to determine a threshold point to decompose the basic damage rate into the normal and the abnormal parts. Let the threshold be "q". The q is a reference point which determine the area included in the significance level (α) of a poisson probability distribution (Figure 1).

FIGURE 1 The Normal Standard Damage Rate at the Signigicance Level α



If q is the lower limit of $k(k'$, the probability area included in $k^{k}*<k$ $<\infty$ is

$$\int_{k^*}^{\infty} P(k)\,dk = \alpha * \sum_{k=1}^{K} F_k$$

In the given range, k is determined by the less than relative cummulative frequency distribution.

3. Safety Loading Factor

The safety loading is an important factor from the insurer's point of view. In fact, since the insurer faces a variety of risks, he needs a certain device which can reduce the risks and uncertainties (Beard, Pentikainen and Pesonen 1984). One way to do this is to determine an appropriate safety loading factor. Its magnitude depends on both the mean and the standard deviation of damage rate. The standard deviation is a particular concern to the insurer because it provides some objective information about expected outcomes.

Even if the estimate of the population mean has the usual statistical properties of unbiasedness, efficiency, and consistency, the sample mean of damage rate has a sampling error so that the mean estimate has a certain interval. Interval estimates are generally preferred over point esitmates because the latter provide no information concerning how much error they are likely to contain. Interval estimates, on the other hand, do provide such information(i.e., confidecde interval)(Mansfield 1983).

The confidence interval of the population mean can be estimated by either normal distribution or t–distribution approximation, depending upon sample size (N). If sample is greater than or equal to 30 and the sample mean of damage rate is D^{-}, normally distributed with a mean of μ and a standard deviation of $\sigma / \sqrt{N}$, an interval estimate for the population mean is

$$\bar{D} - Z_{\alpha/2} \frac{\sigma}{\sqrt{N}} < \mu < \bar{D} + Z_{\alpha/2} \frac{\sigma}{\sqrt{N}}$$

where $Z_{\alpha/2}$ is the value of the standard normal variable that is exceeded. with a probability of $\alpha/2$. The probability that the value of the population mean lies between $(\bar{D} - Z_{\alpha/2} \frac{\sigma}{\sqrt{N}})$ and $(\bar{D} + Z_{\alpha/2} \frac{\sigma}{\sqrt{N}})$ is denoted by

$$P[\, \bar{D} - Z_{\alpha/2} \frac{\sigma}{\sqrt{N}} < \mu < \bar{D} + Z_{\alpha/2} \frac{\sigma}{\sqrt{N}} \,] = 1 - \alpha$$

However, where σ is unknown and sample is small, a confidence interval must be constructed on the basis of a sample where N is less than 30. In such cases, no longer can we simply substitute the sample standard deviation for the population standard deviation. It is possible to construct a confidence interval for the population mean even if the sample size is 30 or less. Such a confidence interval is based on the t distribution. If the confidence coefficient is set equal to $(1 - \alpha)$, the confidence interval for the population mean is

$$\bar{D} - t_{\alpha/2} \frac{S}{\sqrt{N-1}} < \mu < \bar{D} + t_{\alpha/2} \frac{S}{\sqrt{N-1}}$$

where α denotes a sample standard deviation and $t_{\alpha/2}$ is the value of a t variable with degrees of freedom that is exceeded with a probability of $\alpha/2$. Based on the t distribution, the safty loading factor for one–side case (Sr) can be computed by

(3) $Sr = t_a \dfrac{S}{\sqrt{N-1}}$

However, *Sr* should be adjusted so as to reduce a financial risk with which an insurer is faced. The adjustment factor is called an uncertainty index. Letting the index be *R*, we can rewrite *Sr* as follows:

(4) $Sr = t_a \dfrac{S}{\sqrt{N-1}} R,\ 0 < R < 1.0$

The magnitude of R is affected by many socio–econmic factors such as culturist's income, government subsidy policy, and opportunities of alternative risk spreading–out mechanisms.

Ⅲ. Statistical Data

The damage records of hanging oyster culture are available for the only 8 year period from 1980 to 1987. The data set consists of two variables:one is oyster crop damage data and another is culture facility damage rates.

During the period the national year average damage rate of oyster crop is 5 percent (Appendix Table 1). The bays which have damage rate higher than 5 percent are Jinhae–Kwangdo, Yongnam–Wonmoonpo, Tongyoung, Dongdae–Jinju, Jangsu, and Haechang, while the ones lower than the national average are 12 bays. Of these, Jinhae–Kwangdo bay experienced the highest damage rate of 18.06 percent : the lowest is Jinhae–Sadung, 1.28 percent. Appendix Table 1 shows that there are large variations between the bays. From the time–series observations we can find that there is a increasing trend of damage rate, approaching the recent years.

Especially, in 1987 most of oyster–culture areas were attacked by an A–class typhoon and experienced the catastrophic disaster which resulted in the national average damage rate of 16.01 percent. The Jinhae–Kwangdo and Jangsu bays were the most severely affected areas. Their damage rates were 73.6 and 42.6 percent, respectively.

In terms of culture facility damage rates, the national average during the same period was 3.74 percent. The areas higher than the national average included 8 bays while the lower were 10. In particular, Jinhae–Kwangdo bay was the most affected area ; the Dongdae–Jinju bay experienced the lowest damage(Appendix Table 2).

The above suggests that there are considerable differences in culture crop and facility damage rates among the bays. This fact implies that it would be desirable to discriminate insurance premiums by grouping the bays into several homogeneous areas. Thus, in this research all the bays are grouped into 4 large areas for both crop and facilities (Table 1).

TABLE 1 The Grouping of Bays

	Group	Year average damage rate(%)	Bay
Culture crop	A	below 2.75	Jinhae-Dangdong, Dosan, Koje-Ulpo, Jinhae-Sadung, Kaan-Jangmok
	B	2.76-5.00	Chungmu.W-S., Jukam, Hansan-Gabae, Kosong, Jaran, Sarang
	C	beyond 5.01	Jinhae-Kwangdo, Yongnam-Wonmoonpo, Tongyong, Dongdae-Jinju
	D	Chonnam	Kamak, Jangsu, Haechang
Culture facility	A	below 2.00	Dosan, Chungmu.W-S., Jinhae-Sadung, Kaan-Jangmok, Dongdae-Jinju
	B	2.01-4.00	Jinhae-Dangdong, Jukam, Hansan-Gabae, Kosong, Jaran
	C	beyond 4.01	Jinhae-Kwangdo, Yongnam-Wonmoonpo, Tongyoung, Koje-Ulpo, Sarang
	D	Chonnam	Kamak, Jangsu, Haechang

IV. Empirical Analysis

1. The Estimation of Normal Standard Damage Rates

The computation of the normal standard damage rates (q) is made based on a Poisson probability distribution. To do this, it is required to rearrange the basic damage data in terms of a frequency distribution. Since, however, the damage rates are a continuous random variable, its frequency is to be counted within a certain class or cell. Let the class variable with one percent interval be k ($k = 1, 2, 3, \cdots$, k.) where k denotes class k. Because k is a Poisson random variable, its values must be integer. Thus, k has the following values : k = the lower limit of class k minus the mid–point of the class plus 0.5.

For illustration, group B is taken as an example. The variable is continuous in the range of 0–4 percent, but thereafter discontinuity happens. Ignoring the damage rates higher than 5 percent, the mathematical mean (λ) is calculated by

$$\lambda = \sum_{k=1}^{4} (k * f_k)/\sum_{k=1}^{4} f_k, \quad k=1,\ 2,\ 3,\ 4.$$

Then the Poisson probabilities of k's are computed by substituting λ into equation (1). The expected frequencies (F_k) are obtained through formula $P(k)f_k$. Now, a question is whether the sample data can have a Poisson distribution. Using the test — statistic given in equation(2), we can perform a chi–square test. The result rejected the null hypothesis at the 5 percent standard significance level. In this case, the lower and/or upper class frequencies can be combined into the small number of wider classes so that the degrees of freedom is reduced. Here, the four classes are rearranged into two : one is 0–1;another is 2–4. These two cells have 28 and 7 frequencies, respectively. The corresponding expected occurrances are 31.06 for the first cell and 3.93 for the second (Table 2).

TABLE 2 Poisson Probability Distribution and Chi-Square Test for Crop Damage Rate of Group B

$K=k$	f_k		$P(k)$	$F_k(=P(k)*N)$		$\chi_B^2(=\Sigma\frac{(f_k-F_k)^2}{F_k})$	
0	27		0.5647	19.76		2.6527	
1	1	28	0.3228	11.30	31.06	9.3885	0.3015
2	3		0.0921	3.22		0.0150	
3	3	7	0.0176	0.62	3.93	9.1361	2.3982
4	1		0.0025	0.09		9.2011	
Σ	35(=N)						

The estimated chi–square statistic implies that there is no difference between the obtained and the expected frequencies. This result suggests that the null hypothesis is accepted at the 5 percent significance level with 1 degree of freedom. For the rest of the groups the χ^2 values also show that the null hypothesis can not be rejected at the 5 percent level.

Since the model acceptance significance level is 5 percent, q's are determined by

$$\int_k^{\infty} P(k)dk = 0.05 * \sum_{k=1}^{4} F_k = 34.99 * 0.05 = 1.75$$

where $F_k = P(k)*N$ and $N = \sum_{k=1}^{4} f_k$. Now we know that k^* is located between 0.62 ($k=2$) and 3.22 ($k=3$). k^* has the value of 2.39 and q is 2.89. The q's of other groups are in Table 3.

TABLE 3 The Normal Standard Damage Rates

unit = %

Group	Culture grop	Culture facility
A	2.06	2.00
B	2.89	2.07
C	1.72	2.09
D	2.11	1.96

2. Damage Rate Decomposition and Insurance Premium Estimation

The normal standard rates of individual groups provide the basis for distinguishing the basic damage into the normal damage rate (NDR) and the abnormal damage rate (ADR). Once a bay's crop or facility damage is separated into two parts, the mean and standard deviation of each part can be obtained for all the individual bays. The estimated NDR and ADR for culture crop are in appendix Table 3 and for culture facilities in Appendix Table 4.

Using the estimated standard deviations, we can compute the safety loading factors for the normal and the abnormal damage rates. Since the computational procedures are the same for all the crop and facilities for all the bays, Chungmu west–south bay is taken as an example for illustration. The means and the standard deviations of the normal and the abnormal damage rates are presented in Table 4. As shown in the table, the year average damage rate of culture crop (DLR) is separated into the normal and the abnormal parts, based on the normal standard damage rate, q = 2.89. The mean and the standard deviation of the normal crop damage rates are 1.33 percent and 1.36 percent and for the abnormal part 1.03 percent and 1.76 percent, respectively.

TABLE 4 The Normal and The Abnormal Damage Rates of Chungmu West-South Bay(Culture Crop):q=2.8g

unit=%

Year	Basic damage rate	Normal damage rate	Abnormal damage rate
1980	0.00	0.00	0.00
1981	0.00	0.00	0.00
1982	0.00	0.00	0.00
1983	3.14	2.89	0.25
1984	0.00	0.00	0.00
1985	7.69	2.89	4.80
1986	1.97	1.97	0.00
1987	6.08	2.89	3.19
Average	2.36	1.33(NDR)	1.03(ADR)
Standard Deviation		1.3595(Sr1)	1.7604(Sr2)

Now, since we know the information about the significance level and the standard deviation (α = 0.05 and s = 1.76), we can determine the safety loading factors for both the normal and the abnormal damage rates only if uncertainty index R is choosen. Let the uncertainty indices of the normal and the abnormal damage rates be R1 and R2, respectively. It is assumed that R1 = 1 and R2 = 0 and 0.5. Under this assumption, the safety loading factors of

Chungmu west–south bay for culture crop *LSr* can be calculated as follows:

(5) $LSr_1 = t_{0.05} \times \frac{S_1}{\sqrt{N-1}} \times R$

$= 0.9739$

○ for the normal damage rate (LSr_1), $R = 1$

(6) $LSr_2 = t_{0.05} \times \frac{S_2}{\sqrt{N-1}} \times R$

$= 0.6304$

○ for the abnormal damage rate (LSr_2), $R = 1/2$

By the same way the safety loading factors of all the bays for crop and facilities are calculated and presented in Appendix Tables 5 and 6. If, however, fishery insurance policy has welfare characteristics with a high level of government financial support, safety loading considerations may be of little importance from the insurer's point of veiw. Based on the estimated safety loading factors, oyster culture insurance premium (*M*) can be computed by the sum of the normal and the abnormal insurance premiums. The normal insurance premium (*M1*) is derived from the normal damage rate ; the abnormal (*M2*) from the abnormal damage rate. In case of culture crop. *M1* is calculated by

(7) $M1 = DLR1 + LSr_1$ where $R1 = 1.0$,

while *M2* is computed, under the assumption that $R2 = 0$ and $R2 = 0.5$, by

(8) $M2 = DLR2 + LSr_2$

Substituting the results in Appendix Tables 3 and 4 into equations (7) and (8), we can obtain *M1* and *M2* for both crop and facilities(Appendix Tabels 7 and 8).

As in the above tables, the safty loading factors do increase insurance premiums for the two insurance objectives. Regardless the safty loading factors, an important finding is that there are substantial premium differentials among the groups. Group C including Jinhae–Kwangdo, Yongnam–Wonmoonpo, Tongyoung, and Dongdae–Jinju bays, claims the highest premiums for both culture crop and facilities ; group A consisting of 5 bays (Jinhae–Dangdong bay, etc.) is the lowest premium area.

V. Summary and Conclusions

The main objective of this study is to determine the insurance premiums of culture oyster crop and facilities. It requires information about the normal stadard damage rate which distinguishes the normal and the abnormal damage parts, and some considerations on the safry loading factors.

To get the necessary information, a Poisson probability distribution model was developed as a stochastic basis. The goodness–of–fit test of the model was made based on the chi–square statistics. The chi–square test statistics showed that the null hypotheses are to be accepted at the 5 percent significance level. The damage data of hanging oyster culture crop and facilities were available for the only 8 year period from 1980 to 1987. The data reflected considerable damage differences in crop and facilities among the bays. This implies that it would be desirable to discriminate insurance premiums by grouping the bays into several homogeneous areas. Thus, all the bays were grouped into four large areas.

The estimated normal standard damage rate ranged 1.72 to 2.89 with the mean 2.195. Based on the normal standard damage rates, the basic damage rates were decomposed into the normal and the abnormal parts. Group C showed the highest normal and abnormal damage rates. In terms of the safty loading factors, the uncertainty indices were chosen somewhat arbitrarily and the results were simulated;the highest safety loading factor was put on group D. The insurance premiums, which were calculated based on the damage rates and the normal safery loading factors, ranged 2.48 to 10.32 for culture crop ; 1.22 to 8.33 for culture facilities. If the abnormal safety loadings are considered, the premiums would be much higher.

The above empirical results suggest (i) that the discrimination of insurance premiums would be desirable, (ii) that the safety loading considerations may have little importance under the high level of government financial support, and (iii) that the accuracy problem of the results should be alleviated by developing a more efficient, precise data collection system.

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APPENDIX TABLES

APP. TABLE 1 Damage Rates of Culture Crop, 1980-87

unit=%

Bay	Year average	1980	1981	1982	1983	1984	1985	1986	1987
Bay average	5.05	0.00	0.18	0.00	8.35	0.00	2.75	6.02	16.01
Jinhae-Dangdong	2.66	0.00	7.42	0.00	0.00	0.00	0.00	2.00	11.56
Jinhae-Kwangdo	18.06	–	–	0.00	0.00	0.00	2.30	10.42	73.60
Yongnam-Wonmoonpo	7.93	–	–	0.00	0.00	0.00	4.94	9.33	24.88
Dosan	2.70	–	–	0.00	7.87	0.00	0.00	2.64	6.22
Chungmu. W-S	2.81	0.00	0.00	0.00	3.14	0.00	7.69	1.97	6.08
Tongyoung	9.60	–	0.00	0.00	7.76	0.00	8.83	30.94	14.64
Jukam	4.64	0.00	0.00	0.00	2.48	0.00	4.70	2.31	31.03
Hansan-Gabae	3.95	0.00	0.00	0.00	0.36	0.00	3.13	12.05	8.64
Koje-Ulpo	2.74	0.00	0.00	0.00	3.84	0.00	6.15	0.39	12.14
Jinhae-sadung	1.28	0.00	0.00	0.00	0.65	0.00	0.00	2.15	5.06
Kaan-Jangmok	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.34
Kosong	3.92	0.00	0.00	0.00	6.01	0.00	0.00	7.10	11.55
Jaran	4.24	0.00	0.00	0.00	2.50	0.00	0.00	6.21	15.70
Sarang	3.93	–	–	0.00	0.00	0.00	0.00	3.94	16.91
Dongdae-Jinju	9.23	–	–	0.00	49.43	0.00	0.00	0.00	3.21
Kamak	3.14	0.00	0.00	0.00	26.09	0.00	0.00	0.66	4.18
Jangsu	10.12	0.00	0.00	0.00	15.18	0.00	0.00	19.90	42.56
Haechang	7.00	–	–	0.00	0.00	0.00	0.00	11.38	23.43

APP. TABLE 2 Damage Rates of Culture Facilities, 1980-87

unit = %

Bay	Year average	1980	1981	1982	1983	1984	1985	1986	1987
Bay average	3.74	0.00	0.50	0.00	0.00	0.00	1.96	6.00	17.06
Jinhae-Dangdong	3.46	0.00	5.87	0.00	0.00	0.00	0.0	0.00	28.26
Jinhae-Kwangdo	16.63	–	–	0.00	0.00	0.00	1.9	9.55	74.99
Yongnam-Wonmoonpo	9.80	–	–	0.00	0.00	0.00	7.3	3.87	38.10
Dosan	1.49	–	–	0.00	0.00	0.00	0.00	2.17	5.96
Chungmu. W-S	1.28	0.00	0.00	0.00	0.00	0.00	0.00	1.97	6.19
Tongyoung	8.35	–	0.00	0.00	0.00	0.00	9.64	31.26	14.17
Jukam	3.68	0.00	0.00	0.00	0.00	0.00	4.07	1.91	24.81
Hansan-Gabae	3.71	0.00	0.00	0.00	0.00	0.00	2.75	10.93	8.41
Koje-Ulpo	4.14	0.00	0.00	0.00	0.00	0.00	11.95	0.39	17.56
Jinhae-sadung	1.48	0.00	0.00	0.00	0.00	0.00	0.00	3.55	6.49
Kaan-Jangmok	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.92
Kosong	3.21	0.00	0.00	0.00	0.00	0.00	0.01	7.80	17.36
Jaran	3.74	0.00	0.00	0.00	0.00	0.00	0.00	7.66	22.70
Sarang	4.23	–	–	0.00	0.00	0.00	0.00	4.50	21.31
Dongdae-Jinju	0.25	–	–	0.00	0.00	0.00	0.00	0.69	0.00
Kamak	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.66	3.94
Jangsu	7.44	0.00	0.00	0.00	0.00	0.00	0.00	19.91	37.64
Haechang	5.62	–	–	0.00	0.00	0.00	0.00	11.38	17.32

APP. TABLE 3 NDR and ADR of Culture Crop

unit = %

Group	Bay	Damage			
		Normal Standard	Total	NDR	ADR
A	Average	2.06	2.22	0.68	1.54
	Jinhae-Dangdong	2.06	2.60	0.77	1.83
	Dosan	2.06	2.79	1.03	1.76
	Koje-Ulpo	2.06	2.69	0.82	1.87
	Jinhae-Sadung	2:06	0.99	0.60	0.39
	Kaan-Jangmok	2.06	1.30	0.26	1.04
B	Average	2.89	3.33	1.15	2.18
	Chungmu. W-S	2.89	2.36	1.33	1.03
	Jukam	2.89	5.06	1.32	3.74
	Hansan-Gabae	2.89	3.02	1.13	1.89
	Kosong	2.89	3.07	1.08	1.99
	Jaran	2.89	3.06	1.04	2.02
	Sarang	2.89	3.47	0.96	2.51
C	Average	1.72	10.01	0.86	9.15
	Jinhae-Kwangdo	1.72	14.38	0.86	13.52
	Yongnam-Wonmoonpo	1.72	6.49	0.82	5.67
	Tongyoung	1.72	10.20	0.98	9.22
	Dongdae-Jinju	1.72	8.77	0.57	8.20
D	Average	2.11	6.54	0.70	5.84
	Kamak	2.11	3.87	0.61	3.26
	Jangsu	2.11	9.70	0.79	8.91
	Haechang	2.11	5.80	0.70	5.10

APP. TABLE 4 NDR and ADR of Culture Facility

unit=%

Group	Bay	Damage			
		Normal Standard	Total	NDR	ADR
A	Average	2.00	1.00	0.41	0.59
	Dosan	2.00	1.36	0.67	0.69
	Chungmu.W-S	2.00	1.02	0.50	0.52
	Jinhae-Sadung	2.00	1.26	0.50	0.76
	Kaan-Jangmok	2.00	1.12	0.25	0.87
	Dongdae-Jinju	2.00	0.12	0.12	0.00
B	Average	2.07	3.57	0.62	2.95
	Jinhae-dangdong	2.07	4.27	0.52	3.75
	Jukam	2.07	3.86	0.76	3.10
	Hansan-Gabae	2.07	2.77	0.78	1.99
	Kosong	2.07	3.15	0.52	2.63
	Jaran	2.07	3.80	0.52	3.28
C	Average	2.09	8.02	0.86	7.16
	Jinhae-Kwangdo	2.09	14.42	1.03	13.39
	Yongnam-Wonmoonpo	2.09	9.90	1.05	8.85
	Tongyoung	2.09	9.18	1.05	8.13
	Koje-Ulpo	2.09	3.74	0.57	3.17
	Sarang	2.09	4.31	0.70	3.61
D	Average	1.96	4.13	0.48	3.65
	Kamak	1.96	0.58	0.33	0.25
	Jangsu	1.96	7.19	0.49	6.70
	Haechang	1.96	4.78	0.65	4.13

APP. TABLE 5 Safety Loading Factors of Culture Crop

Group	Bay	Sr	
		LSr 1	LSr 2
A	Average	0.2623	0.4291
	Jinhae-Dangdong	0.7075	1.2012
	Dosan	0.9282	1.0543
	Koje-Ulpo	0.6929	1.1760
	Jinhae-Sadung	0.6236	0.3539
	Kaan-Jangmok	0.4879	0.9806
B	Average	0.3433	0.6412
	Chungmu.W-S	0.9737	0.6304
	Jukam	0.9551	3.3088
	Hansan-Gabae	0.9805	1.1899
	Kosong	1.0020	1.0618
	Jaran	0.9603	1.5119
	Sarang	1.2278	2.3255
C	Average	0.3068	3.0950
	Jinhae-Kwangdo	0.7750	11.8443
	Yongnam-Wonmoonpo	0.7750	3.7344
	Tongyoung	0.7307	4.5000
	Dongdae-Jinju	0.7307	7.9656
D	Average	0.3650	2.0052
	Kamak	0.6387	2.8154
	Jangsu	0.7316	4.8836
	Haechang	0.8964	3.6072

APP. TABLE 6 Safety Loading Factors of Facility

Group	Bay	Sr	
		FSr 1	FSr 2
A	Average	0.2253	0.2273
	Dosan	0.8497	0.6599
	Chungmu.W-S	0.6156	0.4962
	Jinhae-Sadung	0.6202	0.5372
	Kaan-Jangmok	0.4737	0.8195
	Dongdae-Jinju	0.2317	0.0000
B	Average	0.2542	0.8840
	Jinhae-Dangdong	0.6419	3.0699
	Jukam	0.7000	2.6755
	Hansan-Gabae	0.7177	1.1852
	Kosong	0.6414	1.8408
	Jaran	0.6419	2.4383
C	Average	0.3092	2.2472
	Jinhae-Kwangdo	0.9245	12.0536
	Yongnam-Wonmoonpo	0.9418	5.7994
	Tongyoung	0.9418	4.7149
	Koje-Ulpo	0.6344	2.0271
	Sarang	0.8879	3.1715
D	Average	0.3067	1.6166
	Kamak	0.4683	0.2345
	Jangsu	0.6078	4.4506
	Haechang	0.8327	2.7429

APP. TABLE 7 The Insurance Premiums of Culture Crop

unit : %

Group	Bay	Primium					
		With Sr2			Without Sr2		
		M	M1	M2	M	M1	M2
A	Average	2.91	0.94	1.97	2.48	0.94	1.54
	Jinhae-Dangdong	4.51	1.48	3.03	3.31	1.48	1.83
	Dosan	4.77	1.96	2.81	3.72	1.96	1.76
	Koje-Ulpo	4.56	1.51	3.05	3.38	1.51	1.87
	Jinhae-Sadung	1.96	1.22	0.74	1.61	1.22	0.39
	Kaan-Jangmok	2.77	0.75	2.02	1.79	0.75	1.04
B	Average	4.31	1.49	2.82	3.67	1.49	2.18
	Chungmu. W-S	3.96	2.30	1.66	3.33	2.30	1.03
	Jukam	9.33	2.28	7.05	6.02	2.28	3.74
	Hansan-Gabae	5.19	2.11	3.08	4.00	2.11	1.89
	Kosong	5.13	2.08	3.05	4.07	2.08	1.99
	Jaran	5.53	2.00	3.53	4.02	2.00	2.02
	Sarang	7.03	2.19	4.84	4.70	2.19	2.51
C	Average	13.42	1.17	12.25	10.32	1.17	9.15
	Jinhae-Kwangdo	27.00	1.64	25.36	15.16	1.64	13.52
	Yongnam-Wonmoonpo	11.04	1.64	9.40	7.31	1.64	5.67
	Tongyoung	15.43	1.71	13.72	10.93	1.71	9.22
	Dongdae-Jinju	17.47	1.30	16.17	9.50	1.30	8.20
D	Average	8.92	1.07	7.85	6.91	1.07	5.84
	Kamak	7.33	1.25	6.08	4.51	1.25	3.26
	Jangsu	15.31	1.52	13.79	10.43	1.52	8.91
	Haechang	10.31	1.60	8.71	6.70	1.60	5.10

APP. TABLE 8 The Insurance Premiums of Culture Facility

unit : %

Group	Bay	Primium					
		With Sr2			Without Sr2		
		M	M1	M2	M	M1	M2
A	Average	1.45	0.63	0.82	1.22	0.63	0.59
	Dosan	2.87	1.52	1.35	2.21	1.52	0.69
	Chungmu. W-S	2.14	1.12	1.02	1.64	1.12	0.52
	Jinhae-Sadung	2.42	1.12	1.30	1.88	1.12	0.76
	Kaan-Jangmok	2.41	0.72	1.69	1.59	0.72	0.87
	Dongdae-Jinju	0.35	0.35	0.00	0.35	0.35	0.00
B	Average	4.70	0.87	3.83	3.82	0.87	2.95
	Jubgae-Dangdong	7.98	1.16	6.82	4.91	1.16	3.75
	Jukam	7.24	1.46	5.78	4.56	1.46	3.10
	Hansan-Gabae	4.68	1.50	3.18	3.49	1.50	1.99
	Kosong	5.63	1.16	4.47	3.79	1.16	2.63
	Jaran	6.88	1.16	5.72	4.44	1.16	3.28
C	Average	10,58	1.17	9:41	8.33	1.17	7.16
	Jinhae-Kwangdo	27.39	1.95	25.44	15.34	1.95	13.39
	Yongnam-Wonmoonpo	16.64	1.99	14.65	10.84	1.99	8.85
	Tongyoung	14.83	1.99	12.84	10.12	1.99	8.13
	Koje-Ulpo	6.37	1.20	5.17	4.37	1.20	3.17
	Sarang	8.37	1.59	6.78	5.20	1.59	3.61
D	Average	6.06	0.79	5.27	4.44	0.79	3.65
	Kamak	1.28	0.80	0.48	1.05	0.80	0.25
	Jangsu	12.25	1.10	11.15	7.80	1.10	6.70
	Haechang	8.35	1.48	6.87	5.61	1.48	4.13