Staff Papers Series

P85-3 January 1985

PALAY AREA RESPONSE IN THE PHILIPPINES: UNDER CONDITIONS OF TECHNICAL CHANGE

by

Kenneth W. Bailey

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

PALAY AREA RESPONSE IN THE PHILIPPINES: UNDER CONDITIONS OF TECHNICAL CHANGE*

by

Kenneth W. Bailey**

*Work on this research was completed under Minnesota Agricultural Experiment Station Project Mn 14-62: Productivity Growth in World Agriculture.

**The author is a research assistant in the Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, Minnesota. The author wishes to express his sincere gratitude to Dr. Vernon Ruttan for his course, which stimulated initial interest in the topic, and for his constructive comments and guidance in the preparation of this paper.

TABLE OF CONTENTS

Contents--continued

LIST OF TABLES

LIST OF FIGURES

Palay Area Response in the Philippines: under conditions of technical change

by Kenneth W. Bailey

Introduction

Rice is the traditional staple food for most Filipinos, and the supply and utilization of this commodity has a direct impact on their health and welfare. In terms of consumption, rice is a major component in the budgets of most Filipinos and changes in its price could have drastic impacts on real incomes. On the production side, palay (or rough rice) is a primary crop in the Philippines and is grown on more farms than any other single crop. In order to understand the enormous area devoted to palay compared to other crops, a summary of area planted is presented in table 1. In 1976/77, 30.10% and 28.17% of the crop land that year was devoted to palay and corn, respectivley, with 10.57% planted to other food crops and 31.16% planted to all export crops.

The first quantitative analysis of palay area planted was conducted in 1965 by Mangahas, Recto, and Ruttan (7,8). The analysis concentrated on the post war period, up to and including 1963/64. This was a time of significant expansion in area cultivated, and unfortunately accompanied by stagnant yields.

Table 1. Area planted to various crops, crop years 1953/54 to 1976/77 (thousand ha)

Type of Farm	1953/54	1963/64	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/1977
Total All crops	**6,146.6**	**7,955.5**	**8,946.5**	**9,096.8**	**9,381.8**	**9,217.0**	**10,117.0**	**10,751.0**	**11,487.9**	**11,787.50**
Food Crops	**4,591.6**	**5,868.5**	**6,406.4**	**6,345.3**	**6,561.1**	**6,348.8**	**7,124.0**	**7,628.9**	**8,043.1**	**8,114.20**
Palay	2,645.4	3,087.5	3,113.4	3,112.6	3,246.4	3,118.8	3,436.8	3,538.8	3,579.3	3,547.50
Corn	1,120.0	1,897.6	2,419.6	2,392.2	2,431.7	2,325.4	2,763.0	3,062.5	3,257.0	3,320.60
Rootcrops	267.9	287.9	252.4	246.0	258.5	266.3	314.0	351.2	388.9	450.0
Vegetables (including onion and potato)	95.2	53.3	62.8	58.5	65.9	65.5	65.9	75.2	69.2	71.2
Banana	159.0	216.4	235.2	227.1	243.8	247.5	211.8	233.3	292.7	299.3
Mango	53.6	48.6	45.5	40.5	40.8	40.0	43.5	46.6	35.8	33.2
Pineapple	24.7	26.7	28.9	28.0	29.6	27.6	28.4	30.5	35.2	36.7
Citrus	18.8	28.4	21.3	18.9	18.7	19.0	19.1	20.1	22.3	22.1
Beans and peas	66.1	61.1	50.0	49.2	44.6	46.7	44.9	52.2	62.8	62.3
Coffee	17.4	42.0	54.0	54.3	54.8	60.8	65.0	65.4	76.8	66.0
Cacao	6.8	9.2	8.4	7.4	6.9	7.1	7.0	6.6	4.0	4.4
Peanuts	28.2	25.2	32.5	32.5	32.8	33.2	36.8	54.8	60.6	62.7
Other foodcrops	88.5	84.6	82.4	78.1	86.6	90.9	85.2	71.2	83.8	88.1
Commercial crops	**1,555.0**	**2,087.0**	**2,540.1**	**2,751.5**	**2,820.7**	**2,868.2**	**2,993.0**	**3,130.7**	**3,444.8**	**3,673.3**
Coconut	990.0	1,482.9	1,883.9	2,048.5	2,125.5	2,133.3	2,206.0	2,279.5	2,521.2	2,714.0
Sugarcane	265.1	269.9	366.1	441.6	441.0	455.2	490.7	536.1	534.4	567.2
Abaca	238.6	210.5	173.0	155.3	145.2	163.3	170.1	179.7	243.8	250.3
Native Tobacco	43.5	61.0	54.0	46.6	45.7	51.9	58.6	48.7	51.9	48.5
Virginia Tobacco	4.7	34.5	33.4	29.0	31.9	32.1	28.5	36.0	34.4	30.8
Ramie	1.3	3.2	2.4	2.4	2.4	2.4	2.2	1.4	0.2	0.2
Rubber	5.0	19.8	21.8	23.0	24.7	26.1	33.2	45.4	55.1	58.5
Maguey	3.8	2.5	2.8	2.7	2.6	2.6	2.6	2.5	2.6	2.6
Kapok	3.0	2.7	2.7	2.4	1.7	1.3	1.2	1.0	0.7	0.7

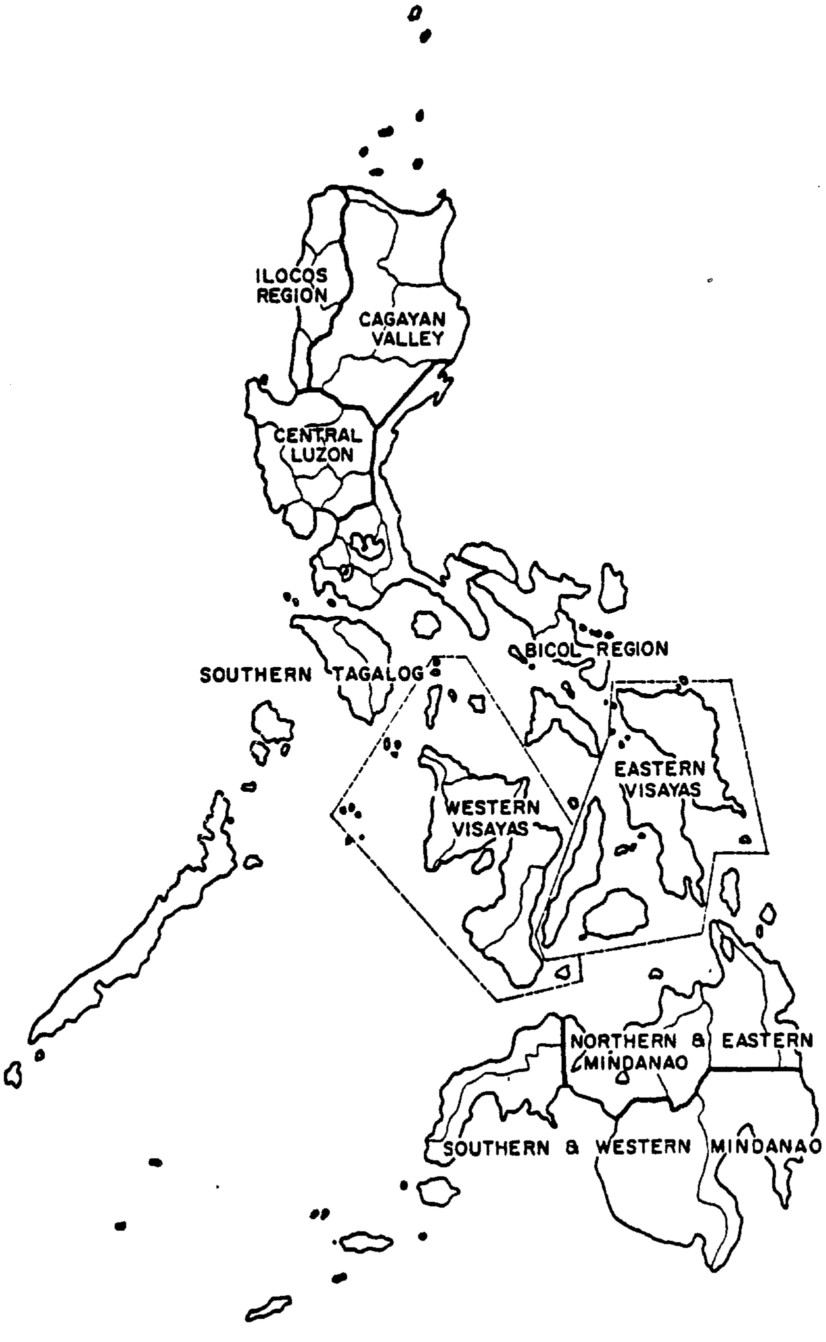


Figure 1. Map of Philippine provinces

Increases in production could almost exclusively be attributed to area expansion, predominantly in the frontier regions of the Cagayan Valley and the two Mindanao regions (figure 1). The years following this study realized a green revolution in Philippine agriculture, with significant structural changes occuring in the rice sector.

One of the objectives of this study is to econometrically estimate area response functions for palay. Area response functions are derived by maximizing profit with respect to land and then explicitly solving for an input demand function for land. The area response functions in this study were estimated regionally, using the same regions specified in the Mangahas et al. study. The other objective of this study is to compare the price elasticities estimated during the 1958/59-1977/78 period, denoted here the MV period, with those from the pre MV period of the Mangahas et al. study. The hypothesis concerning this comparison will be made following a brief discussion of the history of agricultural development in the Philippines, and a review of the literature concerning area response estimation.

Historical Perspectives

Before stating a hypotheses on how structural changes have impacted on the price responsive behavior of filipino rice farmers, it is useful to review the historical changes in agricultural growth that has emerged as a result of population changes in the Philippines (5). Prior to and during the early period of the Mangahas et al. study, agricultural development in the Philippines could be characterized by Hla Myint's "vent-for-surplus" model (9). He contended that in the presence of expanding cultivated area, surplus peasant labor, and new export markets opened up by lower transportation costs, peasant farmers were able to rapidly expand production while faced with stagnant technology. As a result of these new export markets, incomes and population grew and in turn induced an increase in area planted to food staples such as rice and corn. Given the stagnant yields of palay and corn at the time, increased food demand resulting from the income and population increases was met predominantly by a rapid expansion of the cultivation frontier. The growing population could have been absorbed into the agricultural labor force as long as this trend in land use continued, but the supply of cultivatable land became progressively exhausted toward the end of the 1950's. Table 2 reveals that the relative contribution of cultivated land area and cultivated land area per farm worker decreased during the pre MV and MV periods. It was during this time period that irrigation development was accelerated , in order to offset the impact of the closing cultivation frontier.

Table 2. Contribution of area and land productivity to the growth in output and labor productivity in Philippine agriculture (%).

	1948-52 to 1958-62		1958-62 to 1968-72		1968-72 to 1978-82	
	Annual growth rate (%)	Relative contribution	Annual growth rate (%)	Relative contribution	Annual growth rate (%)	Relative contribution
Total agricultural output	5.1	100	3.2	100	6.2	100
Cultivated land area	3.3	65	1.4	44	-0.6	-10
Output per ha of cultivated land area	1.8	35	1.8	56	6.8	110
Agricultural output per farm worker	2.7	100	0.8	100	3.8	100
Cultivated land area per farm worker	0.9	33	-1.0	-125	-3.0	-79
Output per ha of cultivated land area	1.8	67	1.8	225	6.8	179

Source: Cristina C. David, Randolph Barker, and Adelita Palacpac, "The Nature of Productivity Growth in Philippine Agriculture, 1948-1982," paper presented at the Symposium on Agricultural Productivity Measurement and Analysis, APO, Tokyo, Japan, October 2-8, 1984.

Confronted with this decrease in the expansion of cultivatable land, huge investments in land infrastructure, and an increasing demand for food resulting from a constant rate of population increase, came the development of the modern fertilizer responsive rice varieties (MV) which increased yields per hectare. In table 2, yield per hectare incresed from an annual rate of 1.8 during the pre MV period, to an annual rate of 6.8 during the MV period. The adoption of the MV, along with an increased use of fertilizer, heralded in the green revolution and created a basic change in the direction of growth in Philippine agriculture.

Literature Review

Mangahas et al. (7,8) estimated the first area response functions for palay and corn in the Philippines . National and regional models were estimated over the pre and post WWII periods. The authors initially hypothesized that palay and corn production would be more price responsive in the frontier regions, than in the older and more intensively cultivated regions. The statistical results revealed that palay and corn prices, factor prices, and technology and trend were important explanitory variables in area response estimation. The authors concluded that while the empirical results did not support their preliminary hypothesis, they suggested that production changes in regions where cultivated area expanded rapidly had apparently been dominated by autonomous forces associated with yield trends, and or time. Sison et al.(17) hypothisized that a closing cultivation frontier should reduce the price elasticity of area reponse for the MV period when compared to the post war period. Ryan (15) criticized the hypothesis of Sison et al. by noting that although the physical land frontier in the Philippines is being approached, the data presented does not indicate that it has affected areas planted to palay. One could support Ryan's arguement by noting the increased practice of double cropping over the MV period, and the ability to substitute crop areas between palay and other food and export crops. Ryan then hypothesized that the advent of the MV in the Philippines would produce no change in the price responsive behavior of palay farmers.

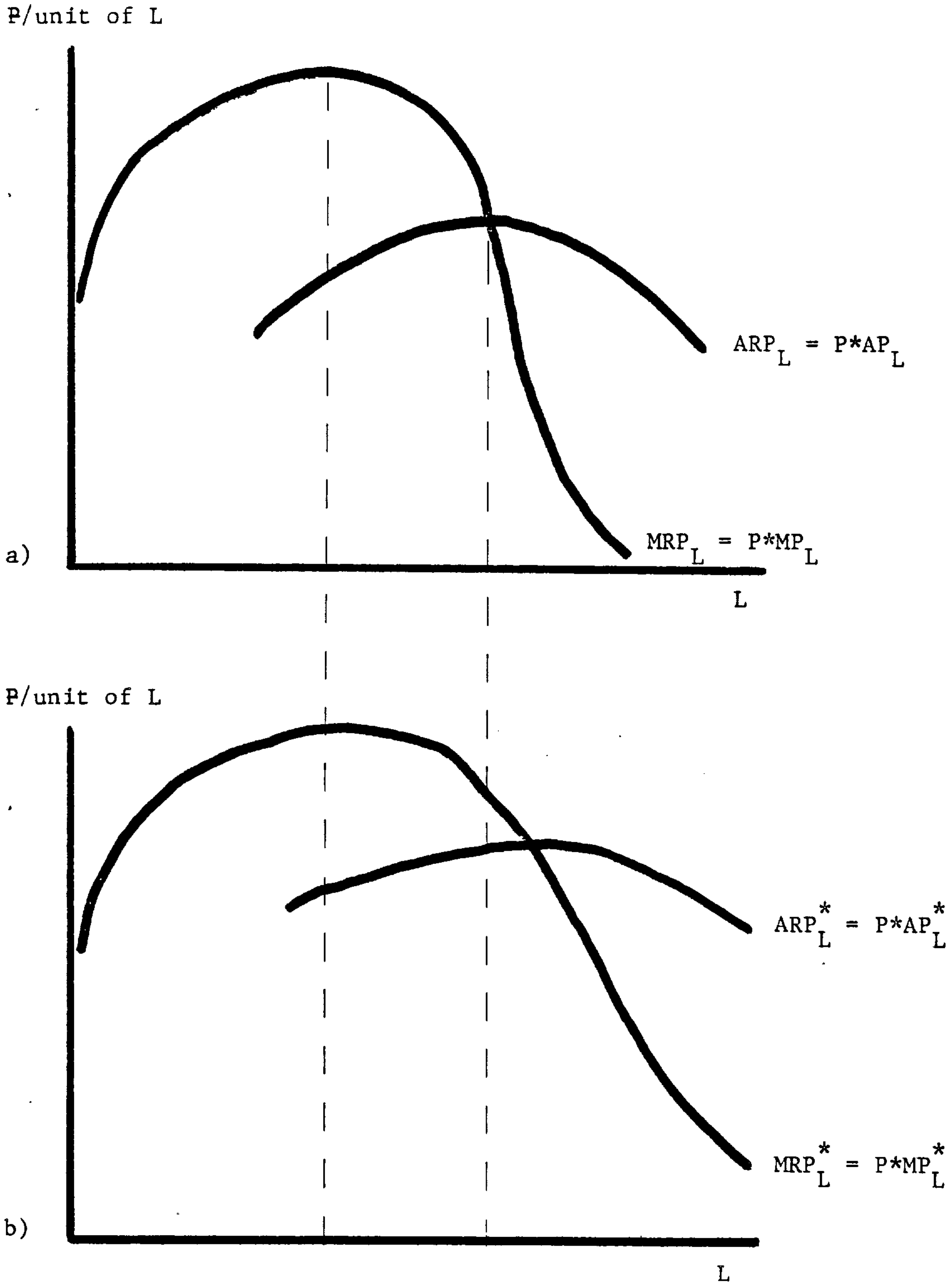
For a more detailed description of the statistical specifications and empirical results of the preceeding studies, see Appendix A.

Price Responsive Behavior: A Hypothesis

In the introduction to this text, it was stated that the second objective of this study was to compare the price elasticities estimated during the MV period with those estimated by Mangahas et al. in the pre MV period. Given the statement of the objective, a brief review of agricultural development in the Philippines and a review of the literature, a hypothesis concerning the price responsive behavior of palay farmers in the Philippines will now be developed.

It is hypothesized in this study that when comparing palay farmers in the pre MV and MV periods, farmers are as price responsive and in some cases more price responsive in the latter period than in the former. The argument for greater price responsive behavior in more recent years can be defended by noting that as yields increase per unit of land, the negative sloping portion of the marginal value product of land becomes more elastic, and hence flattens the input demand function for land (figure 2). Hence, one can claim that the price responsive behavior of palay farmers could have increased over the MV period in some regions of the Philippine, due to the induced innovation of modern fertilizer responsive rice varieties.

Figure 2. Demand Curves for Land in the Pre MV (a) and MV (b) Periods



Theoretical Model

In this section, a theoretical framework is derived for area response estimation under conditions of risk and uncertainty. An area response function is in fact an input demand function, and is derived by maximizing a stochastic utility of profit function with respect to land. The models presented herein were first described by Hazell and Scandizzo (6), and later modified by Ryan (16).

Following Hazell and Scandizzo's specification, one can describe the following stochastic profit function,

$$(1) \qquad \Pi = \hat{p}'Nx - c'x,$$

where $\hat{p}$ = an nx1 vector of expectied product prices,

c = an nx1 vector of production costs per hectare,

x = an nx1 vector of crop area,

N = an nxn diagonal matrix of stochastic yields with jth diagonal element ε_j.

Given this stochastic profit function, it becomes obvious that a decision criterion other than maximizing the expectation of (1) is required. Hence, the negative exponential utility function will be used to access the decision makers preferences between alternative risky choices, and it is assumed that the farmers subjective distribuiton is a normal distribution of net returns per acre.

Continuing on with Hazell and Scandizzo's model, one can express the farmers problem as ,

$$(2) \quad \underset{x}{\text{Max}}\ EU = E[p'Nx] - c'x - \phi V[p'Nx],$$

where ϕ is a measure of absolute risk aversion.

Assuming a set of behavioral assumptions[1], the first order necessary conditions for expected utility maximization are,

$$(3) \quad M\hat{\beta} - c - \phi\Omega x = 0,$$

where M is the expected value of the matrix N, and Ω is an nxn covariance matrix of hectarage revenues. Assuming Ω is non-singular, one can rearrange (3) to yield the following input demand function for land,

$$(4) \quad x^* = \frac{1}{\phi}\Omega^{-1}M\hat{\beta} - \frac{1}{\phi}\Omega^{-1}c.$$

Continuing on with Ryan's assumptions that variances and covariances of yields are zero and that there are only two competing crops, the following area response function can be derived,

$$(5) \quad x1_t^* = a + bNR1_t^* + cNR2_t^* + dR_t + eQ_t + u1_t,$$

where NRℓ is the expected area-inducing returns of crop ℓ, R is a vector of risk variables, and Q is a yield index reflecting weather and technology, and ul is a random error term.

It should be noted that the super script * in equation (5) denotes x to be at an optimal level. However, in any given time peri-

---

[1] see Appendix A.

od, a farmer may not be able to adjust the actual level of x to its optimal level. Hence, Nerloves partial adjustment model (10) is used and equation (5) can be modified as follows:

$$(6) \quad x1_t = (1 - \gamma)x1_{t-1} + \gamma a + \gamma bNR1^*_t + \gamma cNr2^*_t + \gamma dR_t + \gamma eQ_t + \gamma u1_t.$$

For more information on the assumptions and steps used in deriving the theoretical model, see Appendix B.

Methodology

The section on the literature reviewed the relevant empirical work done over the past twenty years on area response estimation in the Philippines. Specifications and data were discussed in detail. The previous section developed the theory for a dynamic input demand function, and provided the foundation for a statistical specification. In this section, the statistical model and the regions it is specified over are described.

The area resonse models were estimated over the same regions as those used in the Mangahas study. Figure 1 shows the nine regions utilized. The regional specification was used for the following reasons:

1. to capture the heterogeneous nature of specific geographic regions, in order to more precisely estimate price responsive behavior.

2. to facilitate the comparison ofthe Mangahas, Recto, and Ruttan study, which took place during a time of significant frontier expansion, with the results of this study, which would reflect a period of induced technical innovation.

Given these regions, it is the contention of this paper that regional area response functions will better reflect farmer' decision making processes. The major alternative crops that compete with rice for production resources are presented in table 3, by region.

Table 3. Major Crop Producing Regions

Region	#	Major Alternative Crops
Ilocos	(1)	Corn
Cagayan Valley	(2)	Corn
Central Luzon	(3)	Corn, Sugar Cane
Southern Tagalog	(4)	Corn, Sugar Cane, Coconuts
Bicol	(5)	Corn, Coconuts
Western Visayas	(6)	Corn, Sugar Cane
E&C Visayas	(78)	Corn, Sugar Cane, Coconuts
N&E Mindanao	(10)	Corn, Coconuts
S&W Mindanao	(911)	Corn, Cocounts

Statistical Model

The statistical specification follows directly from the theoretical section. Variables utilized as proxies for this specification include hectarage harvested, average farm prices, average farm yields, a lagged dependant variable, technology, and fertilizer prices. The regional statistical model is expressed as follows:

$$x1_{k,t} = (1-\gamma_k)\,x1_{k,t-1} + \gamma_k a_k + \gamma_k b_k EGR1_{k,t} + \gamma_k c_k EGR2_{k,t}$$

$$\gamma_k d_k TEC_{k,t} + \gamma_k e_k FER_{k,t} + \gamma_k f_k R_{k,t} + \gamma_k u1_{k,t},$$

where $x1_{k,t}$ = hectarage planted to palay in region k, year t,

$EGR1_{k,t}$ = expected gross returns per hectare for palay, region k, year t,

$EGR2_{k,t}$ = expected gross returns per hectare of a major alternative crop, region k, year t,

$TEC_{k,t}$ = technology index for region k, year t,

$FER_{k,t}$ = farm price of fertilizer per unit, region k, year t,

$R_{k,t}$ = risk variable, region k, year t,

$u1_{k,t}$ = random error term.

The Ordinary Least Squares (OLS) procedure will be used to estimate the parameters in the statistical model.

For more information on the description and derivation of the data and variables used in the analysis, see Appendicies C and D.

Empirical Estimates

Parameter Estimates

The equations were estimated via ordinary least squares for the time period 1958/59-1977/78 and are presented in table 4. Most of the estimated coefficients are large relative to their standard errors, as indicated by the "t ratio". Variables were maintained in the equations when their "t" value was greater than |1|. However, exceptions occur in some equations due to the presence of multicollinearity. Although the presence of multicollinearity renders some parameter estimates statistically insignificant, the variables were maintained since multicollinearity does not produce biased estimates.

In general, the results were very encouraging (table 4). The high R squares and "t" ratios in some regions confirms the statistical model and the accuracy of the data collected. The low R squares in other regions could be due to under-specification caused by the lack of regional fertilizer price and meteorological data, and the ommision of the risk variables. In terms of choosing a price between palay ordinario and palay fancy 2nd class, the latter was chosen because of its greater ability in explaining area planted to palay.

In the empirical results that follow, comparisons will be made between the elasticities estimated in this and the Mangahas et al. study, in order to test the 2nd hypothesis stated in the introduction to this text. The results are presented in table 5. However, it should be noted that not all of the elasticities reported in the Mangahas et al. study were kept for comparison. The criteria used for selecting elasticities estimated in the Mangahas et al. study are that:

1. the palay price coefficients have a positive sign,

2. the coefficient of lagged hectarage was utilized in the equation, was positive, and ranged between 0 and 1,

3. the results seem reasonable, especially when compared to other studies estimated over the same period of fit for the Philippines.

Table 4. Parameter Estimates

```
ILOCOS REGION                      SSE    1648414462       F RATIO        438.42
MODEL:    MODEL01                  DFE            14       PROB>F         0.0001
DEP VAR: PHARAL01                  MSE     117743890       R-SQUARE       0.9895
DURBIN-WATSON D STATISTIC    =   2.1955
FIRST ORDER AUTOCORRELATION =  -0.1260

                          PARAMETER     STANDARD
VARIABLE          DF      ESTIMATE        ERROR        T RATIO

INTERCEPT          1      69259.42      13517.23        5.1238
PHLAG01            1      0.108362      0.066817        1.6218
RRPFM01            1      13887.73      3480.346        3.9903
DUM01              1      187942.2      12791.64       14.6926
-------------------------------------------------------------------------------
ILOCOS REGION                      SSE    1275848539       F RATIO        395.44
MODEL:    MODEL02                  DFE            13       PROB>F         0.0001
DEP VAR: PHARAL01                  MSE      98142195       R-SQUARE       0.9918
DURBIN-WATSON D STATISTIC    =   1.8066
FIRST ORDER AUTOCORRELATION =   0.0709

                          PARAMETER     STANDARD
VARIABLE          DF      ESTIMATE        ERROR        T RATIO

INTERCEPT          1      102833.2      8218.712       12.5121
PHLAG01            1      0.102115      0.067568        1.5113
PPFYLD01           1      0.892737      0.188519        4.7355
PMWYLD01           1     -2.134595      0.491330       -4.3445
DUM01              1      176685.1      12163.74       14.5256
-------------------------------------------------------------------------------
CAGAYAN VALLEY                     SSE   29952757761       F RATIO          2.13
MODEL:    MODEL03                  DFE            13       PROB>F         0.1350
DEP VAR: PHARAL02                  MSE    2304058289       R-SQUARE       0.3959
DURBIN-WATSON D STATISTIC    =   1.6991
FIRST ORDER AUTOCORRELATION =   0.1348

                          PARAMETER     STANDARD
VARIABLE          DF      ESTIMATE        ERROR        T RATIO

INTERCEPT          1      247474.5      95236.99        2.5985
PHLAG02            1      0.325791      0.265400        1.2275
PPFYLD02           1      0.947906      1.209695        0.7836
PMWYLD02           1     -1.121868      2.471436       -0.4539
ASWPAVEM           1    -30.975848     40.811280       -0.7590
```

Table 4. (Continued)

```
CAGAYAN VALLEY                    SSE  23656801279      F RATIO           2.63
MODEL:    MODEL04                 DFE           12      PROB>F          0.0789
DEP VAR: PHARAL02                 MSE   1971400107      R-SQUARE        0.5229
DURBIN-WATSON D STATISTIC    =    2.2714
FIRST ORDER AUTOCORRELATION =   -0.1458

                             PARAMETER      STANDARD
VARIABLE              DF      ESTIMATE         ERROR      T RATIO

INTERCEPT              1      316886.1       96276.5       3.2914
PHLAG02                1      0.129145      0.269027       0.4800
PPFYLD02               1      2.133903      1.300968       1.6402
PMWYLD02               1     -0.878048      2.290140      -0.3834
ASWPAVEM               1      4.537514     42.661421       0.1064
TREND                  1      -13358.4      7474.992      -1.7871
------------------------------------------------------------------------------
CENTRAL LUZON                     SSE  26485385584      F RATIO           5.47
MODEL:    MODEL05                 DFE           12      PROB>F          0.0075
DEP VAR: PHARAL03                 MSE   2207115465      R-SQUARE        0.6949
DURBIN-WATSON D STATISTIC    =    2.4287
FIRST ORDER AUTOCORRELATION =   -0.3309

                             PARAMETER      STANDARD
VARIABLE              DF      ESTIMATE         ERROR      T RATIO

INTERCEPT              1      14539.02      149967.4       0.0969
PHLAG03                1      0.448840      0.145514       3.0845
PPFYLD03               1      0.806448      0.496764       1.6234
PMWYLD03               1     -0.615187      1.379147      -0.4461
TECR03                 1      213679.8      173366.9       1.2325
DUM03                  1      152915.1      47886.18       3.1933
------------------------------------------------------------------------------
CENTRAL LUZON                     SSE  26924541849      F RATIO           7.23
MODEL:    MODEL06                 DFE           13      PROB>F          0.0027
DEP VAR: PHARAL03                 MSE   2071118604      R-SQUARE        0.6898
DURBIN-WATSON D STATISTIC    =    2.4090
FIRST ORDER AUTOCORRELATION =   -0.3256

                             PARAMETER      STANDARD
VARIABLE              DF      ESTIMATE         ERROR      T RATIO

INTERCEPT              1      9056.524      144784.9       0.0626
PHLAG03                1      0.451920      0.140801       3.2096
PPFYLD03               1      0.637449      0.311242       2.0481
TECR03                 1      215463.6      167896.1       1.2833
DUM03                  1      157998.8       45054.5       3.5068
```

Table 4. (Continued)

```
SOUTHERN TAGALOG                 SSE  32565224642        F RATIO           1.17
MODEL:   MODEL07                 DFE           13        PROB>F          0.3675
DEP VAR: PHARAL04                MSE   2505017280        R-SQUARE        0.2652
DURBIN-WATSON D STATISTIC    =    1.5649
FIRST ORDER AUTOCORRELATION =    0.1862

                           PARAMETER      STANDARD
VARIABLE           DF       ESTIMATE         ERROR        T RATIO

INTERCEPT           1         295722      106227.7         2.7839
PHLAG04             1       0.201294      0.256836         0.7837
PPFYLD04            1       0.502586      0.717255         0.7007
MHARAL04            1      -0.409585      0.568540        -0.7204
TECR04              1         206517        154685         1.3351
-----------------------------------------------------------------------------
SOUTHERN TAGALOG                 SSE  32162080165        F RATIO           0.91
MODEL:   MODEL08                 DFE           12        PROB>F          0.5079
DEP VAR: PHARAL04                MSE   2680173347        R-SQUARE        0.2743
DURBIN-WATSON D STATISTIC    =    1.5315
FIRST ORDER AUTOCORRELATION =    0.2008

                           PARAMETER      STANDARD
VARIABLE           DF       ESTIMATE         ERROR        T RATIO

INTERCEPT           1       310176.9      116027.7         2.6733
PHLAG04             1       0.201152      0.265664         0.7572
PPFYLD04            1       0.265827      0.960776         0.2767
MHARAL04            1      -0.512700      0.645389        -0.7944
TECR04              1       141156.2      232382.7         0.6074
TREND               1       3945.316      10172.62         0.3878
-----------------------------------------------------------------------------
WESTERN VISAYAS                  SSE  14400668146        F RATIO           8.52
MODEL:   MODEL09                 DFE           14        PROB>F          0.0018
DEP VAR: PHARAL06                MSE   1028619153        R-SQUARE        0.6461
DURBIN-WATSON D STATISTIC    =    2.5883
FIRST ORDER AUTOCORRELATION =   -0.4274

                           PARAMETER      STANDARD
VARIABLE           DF       ESTIMATE         ERROR        T RATIO

INTERCEPT           1       53704.77      83614.09         0.6423
PHLAG06             1       0.612429      0.127819         4.7914
RRPFM06             1        53162.5      22138.49         2.4014
FRTLR06             1       -71703.5      37949.74        -1.8894
```

Table 4. (Continued)

```
WESTERN VISAYAS                  SSE   14962826073      F RATIO          8.03
MODEL:    MODEL10                DFE            14      PROB>F         0.0023
DEP VAR: PHARAL06                MSE    1068773291      R-SQUARE       0.6323
DURBIN-WATSON D STATISTIC    =    2.3318
FIRST ORDER AUTOCORRELATION =   -0.3082

                              PARAMETER      STANDARD
VARIABLE            DF        ESTIMATE        ERROR        T RATIO

INTERCEPT            1        -28444.1       104486.5      -0.2722
PHLAG06              1        0.673669       0.139451       4.8309
RRPFM06              1        43799.94       20518.21       2.1347
TREND                1        2813.108       1649.115       1.7058
_____________________________________________________________________________
N&E MINDANAO                     SSE   20497518851      F RATIO          2.31
MODEL:    MODEL11                DFE            13      PROB>F         0.1129
DEP VAR: PHARAL10                MSE    1576732219      R-SQUARE       0.4154
DURBIN-WATSON D STATISTIC    =    2.1722
FIRST ORDER AUTOCORRELATION =   -0.1386

                              PARAMETER      STANDARD
VARIABLE            DF        ESTIMATE        ERROR        T RATIO

INTERCEPT            1         56434.6       65033.57       0.8678
PHLAG10              1        0.585822       0.247460       2.3673
RRPFM10              1        27316.13       18803.52       1.4527
TECR10               1        30755.62       81520.85       0.3773
ASWPAVEM             1      -19.760321      30.845479      -0.6406
-----------------------------------------------------------------------------
N&E MINDANAO                     SSE   21929794944      F RATIO          1.95
MODEL:    MODEL12                DFE            13      PROB>F         0.1626
DEP VAR: PHARAL10                MSE    1686907303      R-SQUARE       0.3746
DURBIN-WATSON D STATISTIC    =    2.4314
FIRST ORDER AUTOCORRELATION =   -0.2960

                              PARAMETER      STANDARD
VARIABLE            DF        ESTIMATE        ERROR        T RATIO

INTERCEPT            1        121737.3       75783.44       1.6064
PHLAG10              1        0.506067       0.257847       1.9627
PPFYLD10             1        0.878517       0.953983       0.9209
PMWYLD10             1       -1.418614       2.335105      -0.6075
ASWPAVEM             1      -15.607498      36.636034      -0.4260
```

Table 4. (Continued)

```
E&C VISAYAS                    SSE  25659372075      F RATIO          4.92
MODEL:    MODEL13              DFE           14      PROB>F         0.0154
DEP VAR: PHARAL78              MSE   1832812291      R-SQUARE       0.5134
DURBIN-WATSON D STATISTIC   =   1.7340
FIRST ORDER AUTOCORRELATION =   0.1125

                         PARAMETER     STANDARD
VARIABLE         DF       ESTIMATE        ERROR        T RATIO

INTERCEPT         1       147733.8     92971.38         1.5890
PHLAG78           1       0.443876     0.211087         2.1028
RRPFM78           1       34167.55     17459.89         1.9569
ASWPAVEM          1     -50.514159    29.658418        -1.7032
------------------------------------------------------------------------
E&C VISAYAS                    SSE  26279103501      F RATIO          4.70
MODEL:    MODEL14              DFE           14      PROB>F         0.0180
DEP VAR: PHARAL78              MSE   1877078822      R-SQUARE       0.5016
DURBIN-WATSON D STATISTIC   =   1.4868
FIRST ORDER AUTOCORRELATION =   0.2008

                         PARAMETER     STANDARD
VARIABLE         DF       ESTIMATE        ERROR        T RATIO

INTERCEPT         1       189635.3     114891.5         1.6506
PHLAG78           1       0.352102     0.247984         1.4199
RRPFM78           1        19204.7     18085.21         1.0619
TREND             1       -4011.41     2535.867        -1.5819
________________________________________________________________________
S&W MINDANAO                   SSE  28384801960      F RATIO          6.31
MODEL:    MODEL15              DFE           12      PROB>F         0.0043
DEP VAR: PHRAL911              MSE   2365400163      R-SQUARE       0.7243
DURBIN-WATSON D STATISTIC   =   1.5595
FIRST ORDER AUTOCORRELATION =   0.1323

                         PARAMETER     STANDARD
VARIABLE         DF       ESTIMATE        ERROR        T RATIO

INTERCEPT         1       -27905.2     116950.2        -0.2386
PHLAG911          1       0.787972     0.163997         4.8048
PPFY0911          1       1.159979     0.785842         1.4761
TREND             1       -18006.7     8686.437        -2.0730
TECRO911          1         727859       228913         3.1796
ASWPAVEM          1     -10.973068    47.692613        -0.2301
```

Table 4. (Continued)

```
S&W MINDANAO                  SSE   26123140197      F RATIO         4.35
MODEL:   MODEL16              DFE            11      PROB>F        0.0197
DEP VAR: PHRAL911             MSE    2374830927      R-SQUARE      0.6643

                          PARAMETER     STANDARD
VARIABLE           DF      ESTIMATE        ERROR      T RATIO

INTERCEPT           1      181799.4     96031.91       1.8931
PHLAG911            1      0.677290     0.175923       3.8499
PPFY0911            1      0.331002     0.406034       0.8152
MHRAL911            1     -0.221300     0.130401      -1.6971
TECR0911            1      686865.8     232453.9       2.9548
ASWPAVEM            1    -87.698620    37.683541      -2.3272
-----------------------------------------------------------------------
```

Calculated Variables

FRTLR06 = ASWPAVEM/PFPFAV06

PMWYLD01 = MWPFAV01*MYLDAV01
PMWYLD02 = MWPFAV02*MYLDAV02
PMWYLD03 = MWPFAV03*MYLDAV03
PMWYLD06 = MWPFAV06*MYLDAV06
PMWYLD10 = MWPFAV10*MYLDAV10
PMWY0708 = MWPF0708*MYLDV708

PPFYLD01 = PFPFAV01*PYLDAV01
PPFYLD02 = PFPFAV02*PYLDAV02
PPFYLD03 = PFPFAV03*PYLDAV03
PPFYLD04 = PFPFAV04*PYLDAV04
PPFYLD06 = PFPFAV06*PYLDAV06
PPFYLD10 = PFPFAV10*PYLDAV10
PPFY0708 = PFPF0708*PYLDV708
PPFY0911 = PFPF0911*PYLDV911

RRPFM01 = PPFYLD01/PMWYLD01
RRPFM06 = PPFYLD06/PMWYLD06
RRPFM10 = PPFYLD10/PMWYLD10
RRPFM78 = PPFY0708/PMWY0708

TECR03 = PHARIR03/PHARAL03
TECR04 = PHARIR04/PHARAL04
TECR10 = PHARIR10/PHARAL10
TECR0911 = PHRIR911/PHRAL911

Table 4. (Continued)

Variable Description List

ASWPAVEM = wholesale prices of ammonium sulphate(21%), Manila, Jan - June average, per 10,000 lbs bag,

MWPFAV(#) = farm price of white shelled corn, Jan - June average, pesos/sack of 5,700 kgs, region #,

MYLDAV(#) = corn yield, 3 year moving average, cavan of 57 kgs per hectare, region #,

PFPFAV(#) = farm price of palay fancy 2nd class, Jan - June average, pesos/sack of 4,400 kgs, region #,

PHARAL(#) = palay hectarage harvested, all, region #,

PHARIR(#) = palay hectarage harvested, irrigated, region #,

POPFAV(#) = farm price of palay ordinario, Jan - June average, pesos/cavan of 4,400 kgs, region #,

PYLDAV(#) = palay(all) yield, 3 year moving average , sacks of 44 kgs per hectare, region #,

Table 5. Estimates of the Price Elasticities of
Palay Hectarage in the Philipppines

Region	Model #	This Study		Mangahas et al.	
		S.R.	L.R.	S.R.	L.R.
Ilocos	1	0.2292	0.2571	0.222	0.506
	2	0.3458	0.3851		
Cagayan Valley	3	0.1923	0.2852	-	-
	4	0.4328	0.4970		
Central Luzon	5	0.1483	0.2690	0.129-	0.616-
	6	0.1172	0.2138	0.274	2.150
Southern Tagalog	7	0.0777	0.0973	0.239-	0.419-
	8	0.0411	0.0515	0.899	2.062
Western Visayas	9	0.3365	0.8682	0.907	3.515
	10	0.2772	0.8496		
N&E Mindanao	11	0.2577	0.6222	-	-
	12	0.2145	0.4342		
E&C Visayas	13	0.2584	0.4646	0.133-	0.145-
	14	0.1452	0.2241	0.264	0.315
S&W Mindanao	15	0.1554	0.7331	0.002-	0.009-
	16	0.0443	0.1374	0.374	0.930

Ilocos -- model01, model02

The statistical results are the strongest in the Ilocos region, with around 99% of the variance in area planted explained by the variables presented. All coefficient signs meet _a priori_ expectations and the ratio of gross returns of palay to corn (RRPFM01) in model01 is statistically significant within .13% , and the gross returns variables for palay and corn (PPFYLD01 and PMWYLD01) for model02 are statistically significant within the .04 and .08% level, respectively. The elasticities (table 5) estimated for this region are 0.2292 and 0.3458 in the short run, and 0.2571 and 0.3851 in the long run. Comparing these results with those of Mangahas et al., it appears that Ilocos farmers in the MV period were more price responsive in the short run and less price responsive in the long run, when compared to farmers in the pre MV period. These results could be due to the larger coefficient of adjustment (smaller coefficient of lagged hectarage) in the MV period than in the pre MV period. Ilocos farmers were more responsive to hectarage inducing information in the MV period than they were in the pre MV period.

Cagayan Valley -- model03, model04

All coefficients have the correct _a priori_ signs with gross returns to palay (PPFYLD02) and TREND in model04 being statistically significant within the 12.7 and 9.9% level, respectively. The "t" ratio's are generally low with small R squares, indicating the presence of multicolinearity and under specification in models 03 and 04. The elasticities reported in this region are 0.1923 and 0.4328 in the short run, and 0.2852 and 0.4970 in the long run. Comparisons made to the pre MV period cannot be made since Mangahas et al. reported incorrect signs for price coefficients. Comparing the coefficients of adjustment between the two periods indicates that Cagayan Valley farmers were much more responsive to hectarage inducing information in the MV period, than in the earlier pre MV period.

Central Luzon -- model05, model06

The statistical results yielded fair results with gross returns for palay (PPFYLD03) and the technology variable (TECR03) reporting "t" ratio's greater than |1| in both models. The R squares indicate that almost 70% of the variance in hectarage planted is explained by the variables utilized in the equations. The price elasticities estimated are 0.1483 and 0.1172 for the short run, and 0.2690 and 0.2138 in the long run. Comparing these elasticities with those from the Mangahas et al. study, the short run elasticities reported in the MV period were at the bottom range of those reported in the pre MV period. The long run elasticities for the MV period were much less than those reported in the pre MV period, and this could be accounted for by the differences in the coefficients of adjustment over the two periods. The coefficients of adjustment are 0.5512 and

0.5481 in this study, and 0.4450 and 0.0594 in the Mangahas et al. study. Hence, farmers were quicker to adjust to acreage inducing information in the MV period than they were in the pre MV period, even though they were slightly less price responsive.

Southern Tagalog -- model07, model08

The performance of this model was particularly bad with all variables statistically insignificant within the 10% level, and R squares less than 30%. These poor results could be attributed to the presence of multicollinearity between the gross returns variables, and the lack of other hectarage inducing variables. The fertilizer price variable was statistically insignificant, the ratio's of gross returns for palay to corn gave an incorrect sign, and hence both were dropped from the analysis. The gross returns for palay (PPFYLD04) and a proxy for corn price, corn hectarage harvested (MHARAL04), were used in the analyisis instead. The short and long run elasticities are rather low, especially when compared to those reported in the Mangahas et al. study, therefore no comparisons were made since they were statistically insignificant anyway.

Western Visayas -- model09, model10

The results in this region are fairly good, with all variables reported statistically significant within the 11% level and explaining around 63% of the variance in area planted. The gross returns variable was calculated as the ratio of palay to corn (RRPFM06), and is significant within almost the 5% level in both models. The fertilizer price index (FRTLR06), calculated as the ratio of the fertilizer to regional palay price, was found statistically significant in this region only. The elasticities calculated are 0.3365 and 0.2272 in the short run, and 0.8682 and 0.8496 in the long run. Compared to the pre MV period, these elasticities are much lower, indicating farmers in this region were less price responsive than they were in the pre MV period. However, when one considers criteria 3 for accepting elasticities for comparison from the Mangahas et al. study, a short run elasticity of 0.907 seems a bit unreasonable for acceptance. Sison et al. (17) estimated a Nerlovian distributed lag area reponse function for the Philippines over the time period 1950-60, and found price elasticities with a range of 0.01 to 0.23, and a mean of 0.12. Hence, it is advised that strong conclusions not be made from this comparison alone. The coefficients of adjustment are almost the same in the two periods, with 0.3876 and 0.3263 reported in this study and 0.2581 reported in the Mangahas et al. study.

Northern & Eastern Mindanao -- model11, model12

The statistical results of model11 and model12 yielded correct *a priori* signs for all coefficients, and the ratio of gross revenues (RRPFM10) was statistically significant within the 17% level.

However, the low R squares in this region suggest a lack of sufficient variables to explain area planted. The price elasticities reported are 0.2577 and 0.2145 in the short run, and 0.6222 and 0.4342 in the long run. Comparisons cannot be made to the Mangahas et al. study since all of their equations yielded price coefficients with incorrect signs.

Eastern & Central Visayas -- model13, model14

The R squares for model13 and model14 reveal that over 50% of the variation in area planted can be explained by the variables used in the models. All coefficients have correct a priori signs, and the ratio of gross revenues (RRPFM78) in model13 is statistically significant within almost the 7% level. The trend variable in the second model suggests a general downward trend in area planted over the period of estimation. The fertilizer price variable (ASWPAVEM) is statistically significant in the first model suggesting that increasing variable costs of producition could result in substitution of production resources. The elasticities reported are 0.2584 and 0.1452 in the short run, and 0.4646 and 0.2241 in the long run. Comparing these results to those in the Mangahas et al. study, one could conclude that farmers were as price responsive in the MV period than they were during the pre MV period. Another interesting result is that the coefficient of adjustment in this study is consistently smaller than that in the Mangahas et al. study, suggesting that farmers in the MV period were less responsive to hectarage inducing information than they were in the pre MV period. Hence, one could conclude from this region that although farmers were as price responsive in the MV period than in the pre MV period, farmers of the former period adjusted hectarage planted to their optimal level slower than did their counterparts in the latter period.

Southern & Western Mindanao -- model15, model16

The statictical results for this region were fairly good with 66 and 72% of the variance in area planted explained by the variables used in model15 and model16, respectively. Due to multicollinearity between the gross returns for palay and corn, the variable for corn was dropped from model15 and gross returns for palay (PPFY0911) was found statistically significant at the 17% level. The technology variable (TECR0911) was found statistically significant at the 0.79 and 1.31% level in model15 and model16, respectively. The fertilizer price variable was found statistically significant in model16 only (at the 4.01% level). The trend variable (TREND) had a negative coefficient and it's significance confirmed the presence of a downward trend in area planted over the period of fit. The price elasticities reported for the MV period are 0.1554 and 0.0443 for the short run, and 0.7331 and 0.1374 for the long run. These elasticities fall into the range reported by Mangahas et al., and hence no change is found between the pre MV and MV periods. The coefficients of adjustment are virtually the same over the two periods with 0.2120 and 0.3227 being reported in model15 and model16, respectively , and 0.4019 and 0.2076 being reported in the Mangahas et al. study.

Bicol --

The statistical results for the Bicol region were generally poor with incorrect signs, low "t" ratios, and low R squares for all combinations of variables. The alternative crop measures tested were the value per hectare of coconuts, and the farm prices of copra and corn averaged over the six months prior to wet season planting (January thru June). The value per hectare of coconuts and the average farm price of copra entered into the specification directly, while the average farm price of corn was multiplied first by the expected yield of corn per hectare. Hence, given the poor statistical results, no empirical estimates were reported for this region.

Conclusions

In general, the statistical results in the preceeding section were very encouraging, with the gross returns for palay statistically significant in most regions. The gross returns to palay was calculated by multiplying the lagged three year average of yield, by the simple average of the January thru June monthly prices of palay fancy 2nd class. Gross returns to corn and copra were calculated in the same way, with gross returns to corn found statistically significant in half the regions. Copra and sugarcane data calculated as the value of production per hectare was found statistically insignificant in all regions.

The significance of the gross returns to palay and corn confirms a priore expectations that farmers form price expectations from market information directly preceeding planting (as opposed to say a 12 of 24 month average) and form yield expectations with relatively recent historical experiences (using a 3 year as opposed to a 5 year moving average to reflect yield expectations). Its significance also confirms the theoretical model, in which the gross returns variable was derived as an explanitory variable. Traditionally, supply and area response analysis have used commodity prices per unit only, and have not considered yield per harvested area as part of an explanitory variable of supply or area inducing behavior.

The technology variable was significant in the large rice producing regions of Central Luzon, Southern Tagalog, and Southern and Western Mindanao. Since the dependant variable reflects the sum total of area planted in both wet and dry season planting within a crop year, the significance of the technology variable confirms the expectation that irrigation investment has increased the practice of double cropping in those regions of the Philippines. The fertilizer price variable (Manila) was significant in only Eastern & Central Visayas and Southern & Western Mindanao. The fertilizer price index calculated as the ratio of fertilizer to regional palay price was found significant in the Western Visayas region only. These results reflect the need for better variables that measure the average price of fertilizer in all regions of the Philippines. The trend variable was important in Eastern & Central Visayas and Southern & Western Mindanao in capturing the downward trend of hectarage planted in recent years.

The elasticities estimated revealed that farmers in the MV period were at least as price responsive, and in some cases more price responsive, than farmers in pre MV the pre MV period. Exceptions occur in the Southern Tagalog and Western Visayas regions. Therefore, given the statistical results of this study and the comparisons that can be made to the Mangahas et al. study, the hypothesis that the price elasticities are as great or in some regions greater in the MV period than in the per MV period, fails to be rejected.

The coefficients of adjustment showed interesting trends when comparing this study to that of Mangahas et al. The coefficients reported in Ilocos and Cagayan Valley were greater than, and those in Western Visayas and Southern & Western Mindanao were the same as those reported in the pre MV period. These results confirm that farmers adjust their hectarage planted to optimal levels, in reaction to area inducing information, as fast or faster in the MV period than in the pre MV period. Exceptions to this statment occur in Eastern & Central Visayas, and comparisons could not be made in Southern Tagalog and Northern & Eastern Mindanao due to incorrect coefficient signs in the Mangahas et al. study.

Greater improvements can be made to the statistical results by testing regional farm prices for sugar cane, testing the response of palay farmers to price risk, and incorporating variable cost of production per hectare in the analysis. In addition, variables reflecting meteorlogical impacts on planting intentions and area harvested could greatly improve the statistical significance of the models.

Appendix A -- Literature Review

In 1965, Mangahas et al.(7,8) estimated national and regional area response functions for palay and corn in the Philippines. According to the authors[2], "There has been no previous attempt to estimate supply response functions for either subsistence or commercial crops in the Philippines." One could hardly disagree. The undertaking was a considerable task, since the least squares estimators were calculated on table calculators, and the estimation was made over eleven regions.

The area response functions were estimated for the pre and post WWII periods. Regional models were estimated for the post war period for two reasons. First, regional estimates would avoid aggregation problems inherent in estimating national models. Second, it was hoped that regional estimates would provide more precise price-response behavior from the heterogeneous regions of the older and more highly developed palay and maize producing areas (Ilocos, Central Luzon, Southern Tagalog, Bicol, and E&W Visayas), and the newer frontier regions of rapid farmland expansion (the Cagayan Valley and N&E and S&W Minanao). According to the authors[3], "It was initially hypothesized that rice and corn production in the frontier regions, where the area cultivated was expanding, would be more responsive to price

---

[2] from page 1 of Mangahas et al. (8).

[3] from page 690 of Mangahas et al. (9).

changes than in the older, more intensively cultivated areas." Major alternative crops considered were corn, sugar cane, and coconuts.

Two types of linear models were used, simple and partial adjustment models. The statistical models were then ran in two trials in which the price of the primary and substitute crops were kept separate and then used in ratios. In the first trial models, the season average farm prices of the primary and substitute crops were kept separate. The price and yield variables used in this trial represented a weighted measure of the major crops competing for rice production resources. Hectares planted were regressed onto these prices, lagged primary and substitute yield ratios, time trend, and lagged hectarage (depending on the type of model used). For the second trial models, the price and yield variables of the substitute crop reflected only one crop instead of a weighted average of all major substitute crops. Hectares planted were regressed onto the lagged primary to substitute price ratios, lagged primary to substitute yield ratios, time trend, and lagged hectarage (again, depending on the use of the partial adjustment model). For corn, third trial models were estimated, using the ratio of the lagged product price and the lagged index of the price of all substitute crops. National estimates were made for the pre and post war period, using first and second trial models. Regional estimates were made for post war periods, using first and second trial models.

The statistical results for palay suggested the estimates for the first-trial models were less acceptable than those from the second-trial. The poor results of the first-trial were reportedly due to multicollinearity between the lagged palay price and the lagged alternative crop price index. The partial adjustment models were not found significantly better than the simple models. The second trial models gave much better results, and in general the simple models performed better than the partial adjustment models.

For corn, the estimates of the second-trial models were not found to be generally superior to those of the first-trial. In fact, the authors found that the results of the third-trial produced price coefficients that tended to support the results of the first-trial models. In most cases, the partial adjustment model performed about as good as the simple models.

In terms of the regional analysis, palay prices were found to be significant in all but two regions. Transmigration and expansion of area cultivated were particularly rapid during the study period in the Cagayan Valley and N&E Mindanao, and the dependant variable for palay was found to be dominated by either the technology or the trend variable. Therefore, acceptable price coefficients were not obtained in these regions. Palay hectarage was also significantly related to,

1. factor prices, as measured by the lagged wage rate, in Eastern Visayas,

2. technology, as measured by the yield ratios, in Ilocos, Southern Tagalog, Bicol, E&W Visayas, S&W Mindanao,

3. and trend, in Ilocos, Southern Tagalog, Western Visayas, and S&W Mindanao.

The regional estimates for corn yielded acceptable price coefficients in all but two regions, Central Luzon and N&E Mindanao. Corn hectarage was also found responsive to,

1. factor prices, as measured by the lagged wage rate, in Ilocos, Bicol and Western Visayas,

2. technology, as measured by the lagged yield ratio, in Ilocos, Easter Visayas, and S&W Mindanao,

3. and trend in all nine regions.

The short run rice supply elasticities for the simple models generally ranged from .10 to .30, for the regions of Ilocos, and Southern Tagalog, Eastern Visayas, and S&W Mindano. The elasticities for the most irrigated regions of Central Luzon and Bicol, ranged from .40 to .60. The regions of Western Visayas and N&E Mindanao reported elasticities of .60 and .13 respectively. The supply elasticities for corn suggested farmers in the Philippines react positivly to increases in corn prices, and were relatively more responsive to prices in the post war then pre war period. The short run elasticities for corn ranged from .04 in Ilocos to .67 in Eastern Visayas. The authors grouped the magnitude of these elasticities into three groups,

1. low price elasticity- Ilocos and S&W Mindanao,

2. medium price elasticity- Cagayan Valley and Bicol, and

3. high price elasticity- Southern Tagalog and Eastern Visayas.

The authors concluded that the results did not confirm the preliminary hypothesis that palay and corn production had been more responsive to changes in regions where area cultivated expanded more rapidly than in the older, more intensively cultivated regions. They suggested that production changes in regions where cultivated area expanded rapidly, had apparently been dominated by autonomous forces associated with yield trends, and or time.

Sison et al.(17) estimated area response functions for palay in 1967. The paper attempted to empirically test for structural changes in rice supply relations that had occured because of the introduction of modern fertilizer responsive rice varieties. Having assumed that peasant farmers respond rationally to price incentives, the authors hypothesized that the growing difficulty in expanding area cultivated in the Philippines should reduce the price elasticity of area response for more recent years.

In order to test their hypothesis, parameters were estimated over the time periods 1950-74, 1950-60, and 1961-74, using national aggregate time series data. Both a simple model and a Koyck-Nerlove distributed lag model were employed in the analysis. The area response model was specified as a function of the price of palay, the price of an alternative crop, the condition of irrigation, rice and alternative crop technologies, and weather conditions.

The price variables used in the analysis were specified as the average unit value of a previous crop year, and the average prices received by farmers six months prior to wet season planting of palay ordinario and palay fancy. All three specifications were deflated by the wholesale price index, the price index of corn, and the price index of the nonrice crops. The Laspeyres formula was utilized in the calculation of the price index of nonrice crops, and reflected corn, coconut, sugar, tobacco, and abaca prices. The irrigation variable was calculated as the ratio of irrigated area to total cultivated area. The technology variable was expressed as the ratio of the average palay yield to corn yield per hectare, calculated over the past five years. Another specification for technology used the ratio of palay yield to the average yield of the five alternative crops. The weather variable was deleted from the analysis due to the lack of an appropriate weather index.

The results of the estimates of the price elasticities were not even significant at the 20% level. Although it was concluded that the results seemed to support the hypothesis, it was noted that the estimated elasticities were statistically insignificant and therefore weak evidence. The estimates for the irrigation parameter proved to be significant, and the authors concluded that there was no evidence for a change in the elasticity of irrigation. The technology specification for the ratio of palay and corn proved to b significant. However, the palay and alternative crop index proved to be inadequate, with incorrect signs and statistically insignificant parameter estimates. The conclusion with the technology variable (palay-corn ratio) was that although the statistical evidence was weak, the elasticity of palay area with respect to technology increased over time.

Ryan (15) critiqued Sison et al.'s paper and reestimated their model over the whole time period 1959-1974. The author contended that although the physical land frontier in the Philippines was being approached, the data in Sison et al.'s paper indicated that it had not yet impinged on the areas sown to rice. Ryan also critisized the use of two separate time periods since,

1. the frontier presumably was approched in a continuos asymptotic fashion, and

2. theory is not clear on how gross area sown should respond to a less elastic net land area.

Ryan then supplemented Sison et al.'s data and estimated some alternative formulations using a Nerlove distributed lag model. A technological dummy variable was created, taking the value zero in the years prior to 1966-67 and the value one in years thereafter. The technological dummy variable was used to test for a structural change brought on by the use of modern rice varieties. The equations were then constrained to test for changes in the intercept and parameter eatimates over the two time peroids. The statistical results failed to reject the hypothesis that the advent of the modern rice varieties in the Philippines has had no effect on the area supply intercept or on the area supply responses to changes in relative prices and irrigated area. Furthermore, the author also failed to reject the hypothesis that there is no difference in the whole area supply relationship (intecepts and slopes) after the advent of the modern rice varieties.

Appendix B -- Theoretical Model

A theoretical model for area response is derived under conditions of risk and uncertainty. The deterministic and stochastic models presented below were first described by Hazell and Scandizzo (6), and later modified by Ryan (15).

The Deterministic Model

In a deterministic framework, farmers behave as profit maximizers and operate in a perfectly competitive world. Input and output prices are determined in the market, are known to all, and are non-responsive to individual behavior.

Hence, following Hazell and Scandizzo's specification, the objective of the individual farmer is to,

$$(1) \quad \underset{x}{\text{Max}}\ \Pi = \hat{p}'Mx - c'x$$

where $\hat{p}$ = an nx1 vector of expected product prices,

c = an nx1 vector of production costs per unit area,

x = an nx1 vector of crop area,

M = an nxn diagonal matrix of crop yields with jth diagonal entry m_j.

The model above assumes all variables are known with certainty. Although crop producers know input prices with certainty at the beginning of a production period, output prices and yields are not. Therefore, assuming yield to be a source of risk, a production vector for a representative farmer now becomes $y = Nx$, where N is an nxn diagonal matrix of stochastic yields with jth diagonal element ε_j. Stochastic yields imply stochastic supply functions, and give rise to stochastic market prices p.

Hence, one can describe the following stochastic profit function,

(2) $\Pi = p'Nx - c'x.$

Given this stochastic profit function, it becomes obvious that a decision criterion other than maximizing the expectation of (2) is required. This is because risky choices cannot be appraised by maximizing expectations. Assuming our representative producer to be risk averse, he may be faced with several risky prospects that yield the same expected profit, but reflect varying degrees of risk. These levels of risk need to be appraised, and according to Dillon (2), the difficulty arises in that risk assessment is of a personal nature. Hence, the decision criterion to be used is Bernoulli's Principle, or the Expected Utility Theorem. This principle is outlined briefly by Anderson et al. (1).

Choice of a Utility Function

In order to describe a utility function, the representative producers subjective distribution must first be described. Assume that the farmers subjective distribution is a normal distribution of net returns per unit area, and as such is completely described by its mean and variance. Hence, the negative exponential utility function will be used to represent the producers preferences,

(3) $U(\Pi) = 1 - \exp(-\phi\Pi),$

where Π is profit as specified in (2), and ϕ is a measure of absolute risk aversion. Given that $\Pi \sim N(E[\Pi], V[\Pi])$, the negative exponential displays a constant coefficient of absolute risk aversion, which implies that the absolute risk premium is independent of the level of wealth. Thus, a constant ϕ enables the analysis to consider a utility of net revenue function, rather than a utility of wealth function. This function is used to reflect preferences of risk averse individuals, and under certain conditions, results in a mean-variance expected utility.

Hence, given the second property of Bernoulli's Principle and the assumption that $\Pi \sim N(E[\Pi], V[\Pi])$, one can express expected utility of profits as,

$$(4) \quad EU(\Pi) = \int \{1-\exp(-\phi\Pi)\}\exp\{-(\Pi-E[\Pi])^2/2\ V[\Pi]\}d\Pi.$$

Freund (5) shows easily that this is equivalent to maximizing the following function,

$$(5) \quad EU(\Pi) = E[\Pi] - 1/2\phi V[\Pi].$$

The expected utility function in equation (5) has the property that an increase in the mean value of Π for a given level of the variance of Π increases expected utility, and an increase in the variance of Π for a given mean value of Π lowers expected utility.

Area Response Under Risk

Continuing with Hazell and Scandizzo's model, one can expand (5) and express the farmers problem as,

$$(6) \quad \underset{x}{\mathrm{Max}}\ EU = E[p'Nx] - c'x - \phi V[p'Nx].$$

A set of behavioral assumptions consistent with equation (6) are as follows:

A1 $E[\varepsilon_j] = m_j$,

A2 $V[\varepsilon_j] = \sigma^2_{\varepsilon j}$,

A3 $E[p_j] = \hat{p}_j$,

A4 $V[p_j] = \sigma^2_{pj}$,

A5 $\mathrm{Cov}[p_i p_j] = \sigma_{pij}$; $\mathrm{Cov}[\varepsilon_i \varepsilon_j] = \sigma_{\varepsilon ij}$, all $i \neq j$,

A6 $\mathrm{Cov}[p_j y_i] = x_i$, $\mathrm{Cov}[p_i \varepsilon_j] = 0$, all i.

Given the behavioral assumptions A1-A6, the components of equation (6) can be expanded as,

$E[p'Nx] = \hat{p}'Mx$, where $M = E[N]$,

$V[p'Nx] = x'\Omega x$, where Ω is an nxn covariance matrix of unit area revenues with diagonal elements

$$w_{jj} = \sigma^2_{pj} E[\varepsilon^2_j] + \hat{p}^2_j \sigma^2_{\varepsilon j}$$

and off diagonal elements

$$w_{ij} = [\sigma_{pij} + \hat{p}_i \hat{p}_j]\sigma_{\varepsilon ij} + m_i m_j \sigma_{pij}.$$

Hence, the problem of the representative farmer can be expressed as follows:

$$\underset{x}{\text{Max}}\ EU = \hat{p}'Mx - c'x - 1/2\phi x'\Omega x. \tag{7}$$

The first order necessary conditions for maximization of expected utility yield,

$$(8)\quad M\hat{p} - c - \phi\Omega x = 0.$$

Assuming Ω is non-singular, the input demand functions for area response can be derived as follows,

$$(9)\quad x^{*} = \frac{1}{\phi}\Omega^{-1}M\hat{p} - \frac{1}{\phi}\Omega^{-1}c.$$

Following Hazell and Scandizzo's model, Ryan derived a supply response function with risk components by making the simplifying assumptions that yield variability was zero, and that there were only two crops under consideration. This thesis departs from Ryan's in that an area response function is derived from (9), instead of a supply function.

As in conjunction with Ryan, it is assumed that yield variability is negligible, and so variances and covariances of yields are zero and $E[\epsilon^2] = m_j^2$. This assumption is especially palatable in this analysis, given the separation of supply response into area and yield response. Hence, the diagonal and off diagonal elements of Ω reduces to,

$w_{jj} = \sigma_{pj}^2 m_j^2$, and

$w_{ij} = \sigma_{pij} m_i m_j$, respectively.

Therefore, assuming the case of two competing crops, (9) can be reduced to the following matrix form,

$$(10)\quad x^{*} = \frac{1}{\phi}\begin{bmatrix} \sigma_{p1}^2 m_1^2 & \sigma_{p12} m_1 m_2 \\ \sigma_{p12} m_1 m_2 & \sigma_{p2}^2 m_2^2 \end{bmatrix}^{-1} \begin{bmatrix} m_1\hat{p}_1 \\ m_2\hat{p}_2 \end{bmatrix} - \frac{1}{\phi}\begin{bmatrix} \sigma_{p1}^2 m_1^2 & \sigma_{p12} m_1 m_2 \\ \sigma_{p12} m_1 m_2 & \sigma_{p2}^2 m_2^2 \end{bmatrix}^{-1} \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}.$$

It will be noted that $m_j\hat{p}_j$ is gross revenues per unit area of crop j_i, and c_j is total cost per unit area of crop j.

Calculating the inverse of Ω, denoting the primary crop area x1, and gathering terms yields,

$$(11)\quad x1^* = \frac{1}{\phi\Delta}[\sigma^2_{p2}m^2_2 NR1^* - \sigma_{p12}m_1m_2NR2^*]$$

where $x\ell^*$ = optimal area of crop ℓ,

$NR\ell^* = m_\ell p_\ell - c_\ell$,

and $\Delta = m^2_1m^2_2(\sigma^2_{p2}\sigma^2_{p1} - \sigma_{p12})$.

Dividing the determinant of Ω, Δ, thru equation (11),

$$(12)\quad x1^* = \frac{\sigma^2_{p2}NR1^*}{\phi m^2_1(\sigma^2_{p2}\sigma^2_{p1} - \sigma_{p12})} - \frac{\sigma_{p12}NR2^*}{\phi m_1m_2(\sigma^2_{p2}\sigma^2_{p1} - \sigma_{p12})}.$$

Dividing the numerators of each term into the denominators, cancelling and seperating gives,

$$(13)\quad x1^* = \frac{1}{\phi m^2_1}\left[\frac{\sigma^2_{p1}}{NR1^*} - \frac{\sigma_{p12}}{\sigma^2_{p2}NR1^*}\right]^{-1} - \frac{1}{\phi m_1m_2}\left[\frac{\sigma^2_{p2}\sigma^2_{p1}}{\sigma_{p12}NR2^*} - \frac{\sigma_{p12}}{NR2^*}\right]^{-1}.$$

Hence, an area response function derived from utility maximization can be expressed as a function of yields, net returns, and variances and covariances of prices as follows,

$$(14)\quad x1^{*} = f\left[\frac{\sigma_{p1}}{NR1^{*}}, \frac{\sigma_{p12}}{\sigma_{p2}^{2}NR1^{*}}, \frac{\sigma_{p2}^{2}\sigma_{p1}^{2}}{\sigma_{p12}NR2^{*}}, \frac{\sigma_{p12}}{NR2^{*}}, \frac{1}{m_{1}^{2}}, \frac{1}{m_{1}m_{2}}\right]$$

The results are very similar to those of Ryan. In fact, the first four terms of equation (14) are almost exactly the same as those in equation (11) of Ryan's paper. However, given our goal of deriving an area response function, and Ryan's of deriving a supply response function, slight differences exist between the two functions. The last two terms in equation (14) reflect yields of the primary and secondary crops and do not exist in Ryan's model, and NR_j reflects net returns per unit area as compared with Ryans's net returns per bushel.

Dynamic Model

In deriving our statistical model, equation (14) can be expressed in general form as,

$$(15)\quad x1_t^{*} = a + bNR1_t^{*} + cNR2_t^{*} + dR_t + eQ_t + u1_t,$$

where $x1_t^{*}$ is area planted to crop 1, $NR1_t^{*}$ is the area-inducing returns of the primary crop, $NR2_t^{*}$ is the area-inducing returns of the secondary crop, R_t is a vector of risk variables, Q_t is a yield index reflecting weather and technology, and $u1_t$ is a random error term where $E[u1_t] = 0$, and $V[u1_t] = \sigma_{u1_t}^{2}$.

In equation (15), the optimal input demand function $x1^{*}$ is expressed as a function of net returns per unit area, risk, and a yield index. However, in any given period, the actual value of x1 may not adjust to its optimal level. Fixity of resources, technological constraints, lack of knowledge, and other variables may be responsible for this partial adjustment. According to Nerlove (11), "one plausible relation between x and x^*, is that in each period actual output is adjusted in proportion to the difference between the output desired in long run equilibrium and actual output." Therefore, we can specify the following relation:

$$(16) \quad x1_t - x1_{t-1} = \gamma[x1_t^* - x1_{t-1}], \gamma \quad (0,1), \text{ or}$$

$$x1_t - (1 - \gamma)x1_{t-1} = \gamma x_t^*.$$

Substituting (15) into (16) yields,

$$(17) \quad x1_t = (1 - \gamma)x1_{t-1} + \gamma a + \gamma bNR1_t^* + \gamma cNR2_t^* + \gamma dR_t + \gamma eQ_t + \gamma u1_t.$$

Hence, if $E[u1_t] = 0$ and $V[u1_t] = \sigma_{u1}^2$, then according to Dhrymes (4), $\gamma u1_t$ is uncorrelated with $x1_{t-1}$ and an application of OLS to (17) will yield consistent parameter estimates.

Appendix C -- Description of the Data and Variables

Data Used in the Analysis

The source of the data used in this analysis is the Philippine Council for Agriculture and Resources Research (12-14). Data for rice, corn, and coconuts was available, but sugar cane statistics was not. Therefore, sugar cane variables are not present in this analysis and it will therefore need to be updated sometime in the future. The time period utilized in this study is the crop years 1958/59- 1977/78. A brief description of the data used and the manipulations needed are presented below.

For the time period 1958/59-1977/78, data for area planted was not available and hence area harvested was used as a proxy. The hectarage data was reported by region for irrigated, non-irrigated, and all hectarage harvested. Starting in 1972/73, for palay area harvested, Pangasinan hectarage was combined with Ilocos hectarage, which was formerly a part of Central Luzon. Therefore, a dummy variable was used in the estimation of area planted in the regions of Ilocos and Central Luzon, to reflect this change in hectarage reported. Another change noted was that starting in 1971/72 for palay and corn hectarage harvested, Central Visayas and Western Mindanao were reported as seperate regions from Eastern Visayas and Southern Mindanao,respectively. Therefore, Central Visayas had to be added back to Eastern Visayas,and Western Mindanao had to be added back to Southern Mindanao, for this analysis.

Yields per hectare harvested were reported in sacks of 44 kilograms for palay, and cavans of 57 kilograms for corn. However, beginning in 1975/76 for palay and 1976/77 for corn, yields were reported in sacks and cavans of 50 kilograms, respectively. Therefore, the reported yields for palay and corn were converted to 44 kilograms per sack after 1975/76, and 57 kilograms per cavan after 1976/77,respectively. Again, the yields reported in the regions of Central Visayas and Western Mindanao were seperated from those reported in Eastern Visayas and Southern Mindanao after 1971/72 for palay, and 1970/71 for corn. These regions were combined by weighing the reported yields by hectarage harvested.

Monthly average farm price data was available by region for palay ordinario, palay fancy 2nd class, yellow shelled corn, and white shelled corn. The monthly prices were averaged simply over the six months prior to wet season planting, January thru June, in order to calculate the expected prices. Palay ordinario and palay fancy 2nd class were both tested in the model with the intention of choosing the price series that yielded the best overall statistical fit. The white shelled corn price series was chosen over the yellow shelled corn price series since most corn planted over the period of fit was planted to white corn. The prices of palay ordinario and palay fancy 2nd class were reported in pesos per 44 kilogram, and prices for white shelled corn were reported in pesos per 57 kilograms. However, starting in 1974/75, all prices of palay and corn were reported in pesos per 50 kilograms. The price data after 1973/74 was converted into pesos per 44 kilograms for palay, and pesos per 57 kilograms for corn. Beginning in 1973, palay and corn prices in the regions of Central Visayas and Western Mindanao were reported separately from those of Eastern Visayas and Southern Mindanao. These regions were combined by weighing palay and corn prices by production of the respected crops.

As for coconuts, it was tested as a major alternative crop in the Bicol region only. Two measures were used to reflect gross returns per hectare. One was a measure of value added for copra, using farm gate prices, and the other was a simple average of the monthly farm gate prices for copra resecada (January thru June).

Variable cost of produciton data was not available, but wage rates and wholesale fertilizer prices were. It was decided that area planted would be more responsive to fertilizer prices since the wage rate was often a fixed percentage of the harvest, and therefore considered a fixed cost of production from the point of view of the farmer. Monthly average wholesale prices of ammonium sulphate (Manila) were used and averaged simply over the months of January thru June.

Variables Used in the Analysis

In the previous section it becomes apparent that a great deal of processing of the raw data was required before they could be combined to form the variables used in the statitical model. The expected gross returns variables EGRl were constructed as follows:

$$EGR\ell_t = EPF\ell_t * EYLD\ell_t, \ell = 1,2,$$

where $EPF\ell_t = \sum_{j=1}^{6} PF\ell_j$,

$$EYLD\ell_t = \sum_{i=1}^{3} YLD\ell_{t-i},$$

$EPF\ell_t$ = expected farm price of commodity ℓ, year t,

$PF\ell_j$ = average farm price of commodity ℓ for month j,

$EYLD\ell_t$ = expected yield of commodity ℓ, year t,

$YLD\ell_{t-i}$ = season average farm yield for commodity ℓ, year t-i.

Prices were averaged six months prior to wet season planting in order to form farmer price expectations for both wet and dry season planting. Yield expectations were calculated by constructing a three year moving average of farm yields. It was hypothesized that farmers formed expectations on more immediate information than say a 12 month average farm price and a 5 year moving average of yield. Gross returns for palay and the major alternative crop were specified in the statistical model as seperate, and in the form of a ratio. The *a priori* expectation for the signs of the coefficients of gross returns would be positive for palay, negative for the major substitute, and positive for the ratio.

The technology variable TEC is calculated as the ratio of palay area harvested from irrigated land, to palay area harvested from irrigated plus non-irrigated land. The technology variable is constructed to measure the returns from irrigation investment in the form of increased hectarage planted per year from double cropping. Therefore, one would expect *a priori* a positive coefficient for this variable. The fertilizer price variable is used as it is constructed in the previous section, and again the risk variable was dropped from the model since an inadequate number of observations were available at the time of estimation.

Appendix D -- Data Used in the Analysis

OBS	TIME	ASWPAVEM	MWPFAV01	MWPFAV02	MWPFAV03	MWPFAV04	MWPFAV05
1	1958	.	1283.33	971.17	1116.80	931.00	1058.33
2	1959	840.00	1015.00	640.17	845.67	826.67	691.17
3	1960	825.00	1049.33	740.33	887.00	895.67	918.50
4	1961	925.00	1380.60	1039.00	1246.50	1282.00	1152.50
5	1962	942.50	1266.83	968.67	1100.83	1044.17	999.50
6	1963	1030.00	1453.00	1061.67	1389.00	1420.67	1202.17
7	1964	1152.17	1678.67	1255.50	1659.00	1695.33	1255.33
8	1965	1215.00	1887.00	1509.50	1725.00	1197.50	1458.00
9	1966	1230.00	1915.67	1615.33	1763.17	1616.17	1439.67
10	1967	1350.00	1924.00	1196.33	1524.33	1053.33	1557.67
11	1968	1325.00	1509.80	1252.83	1697.50	1377.33	1605.00
12	1969	1325.00	1887.50	1651.00	1806.00	1561.50	1423.00
13	1970	1580.00	2000.00	1448.67	1818.50	1484.83	1478.17
14	1971	1835.00	2938.00	2996.00	2775.00	2630.50	2457.00
15	1972	1889.17	3591.75	3034.67	2861.60	3320.75	2920.50
16	1973	2247.50	2150.00	2466.00	2475.00	2579.67	2558.67
17	1974	794.97	6523.93	4640.94	7381.50	4580.06	5390.30
18	1975	1217.91	5500.88	6181.46	6626.25	6130.73	6017.87
19	1976	.	5766.69	5681.38	6127.50	4933.16	5834.52
20	1977	1145.33	6582.59	5950.99	5700.00	6336.50	6433.97

OBS	TIME	MWPFAV06	MWPFAV10	MWPF0708	MWPF0911	MYLDAV01	MYLDAV02
1	1958	1081.00	987.50	1035.00	877.83	10.6167	14.4767
2	1959	704.50	596.00	747.67	442.00	10.4733	13.0867
3	1960	844.00	931.00	992.50	783.33	10.2267	12.0200
4	1961	1190.33	1192.67	1185.83	1105.17	8.9267	13.1367
5	1962	986.17	972.83	1108.83	914.67	7.5867	13.7267
6	1963	1340.00	1462.50	1443.83	1390.00	6.5400	15.3000
7	1964	1477.17	1272.33	1525.17	1239.17	6.1733	15.5200
8	1965	1550.50	1610.00	1656.50	1433.50	6.7100	16.6733
9	1966	1696.17	1637.33	1688.17	1405.67	7.7800	14.8767
10	1967	1348.00	1727.20	1602.33	975.17	8.5667	12.9500
11	1968	1365.17	1206.40	1582.00	1079.50	9.5500	12.4900
12	1969	1508.00	1298.00	1661.00	1219.00	9.4467	13.2133
13	1970	1730.50	1590.33	1456.67	1387.33	9.1233	15.4233
14	1971	2503.00	2475.50	2490.00	2593.83	8.6900	15.7900
15	1972	3259.50	3145.17	2700.17	2882.50	9.1933	16.8500
16	1973	2587.67	2618.50	2639.21	2564.81	9.1100	15.5333
17	1974	4736.13	4999.28	5856.81	4982.49	9.4500	14.7200
18	1975	5926.48	5571.94	5926.63	5399.87	8.9300	13.8900
19	1976	6004.57	5252.93	5945.52	5106.76	9.4833	14.9100
20	1977	5979.87	5246.85	6569.34	5344.12	9.5036	15.0136

Appendix D (Continued)

```
OBS TIME MYLDAV03 MYLDAV04 MYLDAV05 MYLDAV06 MYLDAV10 MYLDV708

  1 1958   9.0233   7.8167   8.8500   7.0800   9.9467   6.3500
  2 1959   9.0800   7.9800   8.9700   6.6833  10.4900   5.8200
  3 1960   9.8900   9.3467   9.7267   7.3567  11.5800   6.8400
  4 1961   9.9200   9.6733   9.2400   8.3733  11.2433   7.8267
  5 1962   9.4267  10.2067   9.2400   9.3967  11.4500   8.7333
  6 1963   8.4333  10.5933   8.9900   9.6833  11.2033   8.1300
  7 1964   8.6633  12.9600   9.7700   9.6967  11.7933   7.5867
  8 1965   9.0667  14.0167  10.6400   9.7100  12.0800   7.3067
  9 1966   9.3100  12.8900  11.1967   9.3433  12.3567   7.5233
 10 1967   9.4933  11.4733  11.6033   9.4067  12.1767   7.8067
 11 1968  10.1333  10.1033  12.2933   9.4267  12.1900   8.3800
 12 1969   9.7267  11.2800  12.2500  10.1467  11.9100   8.8700
 13 1970   9.5433  13.3767  12.1800  10.6100  11.7433   9.3067
 14 1971   9.3533  15.5467  11.9800  11.3067  11.1967   9.5800
 15 1972  10.8767  15.9500  11.4800  11.0867  11.3367   9.7429
 16 1973  11.6367  16.2367  11.0500  10.6767  11.0733   9.7783
 17 1974  11.5667  15.2900  10.8300  10.1733  11.0167   9.9162
 18 1975  11.0733  15.3600  11.0367  10.5867  10.6100   9.8022
 19 1976  11.4800  15.4267  11.7400  11.2833  10.5233  10.3612
 20 1977  12.2282  16.4003  11.3614  11.4806  10.0822  10.3286
```

```
OBS TIME MYLDV911 PFPFAV01 PFPFAV02 PFPFAV03 PFPFAV04 PFPFAV05

  1 1958  13.6700        .        .        .        .        .
  2 1959  12.8400   960.33   774.17   957.83   875.67   903.67
  3 1960  13.1733   934.83   709.33   978.00   925.67   866.33
  4 1961  11.5667  1232.33  1081.83  1270.50  1160.33  1058.00
  5 1962  12.7833  1058.33   928.33  1155.33  1038.83   997.67
  6 1963  12.9200  1082.00  1047.83  1322.33  1333.67  1167.00
  7 1964  14.0100  1225.00  1261.33  1724.83  1523.33  1368.67
  8 1965  14.2767  1624.50  1379.00  1648.50  1539.50  1307.00
  9 1966  14.4333  1535.33  1428.50  1867.67  1594.67  1455.33
 10 1967  14.6367  2120.00  1504.00  1854.67  1577.00  1710.33
 11 1968  14.8767  1823.00  1520.50  1884.50  1843.50  1466.60
 12 1969  15.7900  1819.00  1635.60  1763.00  1953.00  1642.00
 13 1970  16.8167  1669.50  1916.67  2057.17  2141.67  1858.33
 14 1971  17.9067  2575.00  2840.00  2559.20  2656.50  2606.50
 15 1972  18.3746  2905.25  3233.33  3172.33  3583.33  2958.33
 16 1973  18.3983  2622.40  2644.83  2798.67  2647.50  2489.83
 17 1974  19.1220  4766.43  3917.47  4968.33  4239.69  3857.77
 18 1975  19.8705  4836.77  4338.55  4769.16  4427.28  4039.64
 19 1976  21.2056  4440.77  4300.12  4826.65  4414.23  4200.53
 20 1977  20.9049  4865.96  4415.99  5511.88  4221.36  4364.51
```

Appendix D (Continued)

OBS	TIME	PFPFAV06	PFPFAV10	PFPF0708	PFPF0911	PHARAL01	PHARAL02
1	1958	.	.	.	.	115420	260880
2	1959	831.33	799.00	945.67	688.00	104760	344380
3	1960	830.50	798.33	877.67	830.67	110630	453890
4	1961	1127.67	1083.33	1019.17	1034.17	104620	370620
5	1962	1061.33	873.00	952.83	918.50	119920	313250
6	1963	1226.00	1150.33	1125.17	1145.33	120080	289710
7	1964	1515.83	1314.50	1327.67	1303.50	139220	344180
8	1965	1477.50	1451.00	1259.00	1250.50	144710	354390
9	1966	1449.83	1642.33	1409.00	1326.20	132290	265520
10	1967	1513.00	1398.00	1503.67	1435.67	140950	296760
11	1968	1521.50	1440.00	1492.17	1452.00	129190	271980
12	1969	1634.00	1511.40	1688.80	1379.00	144820	314040
13	1970	1702.83	1900.00	1851.67	1767.17	127410	361170
14	1971	2449.50	2805.00	2748.17	2348.40	158920	383910
15	1972	2840.33	3183.33	2991.67	2531.17	322140	359340
16	1973	2528.83	3322.83	2514.51	2615.62	351370	392570
17	1974	4257.73	4570.72	3836.71	3854.80	338500	414810
18	1975	4046.53	4656.52	4170.86	4355.40	342590	418700
19	1976	3945.04	4115.17	4116.42	3799.45	310860	432600
20	1977	4037.15	4511.58	4519.71	4248.65	317690	413790

OBS	TIME	PHARAL03	PHARAL04	PHARAL05	PHARAL06	PHARAL10	PHARAL78
1	1958	769630	480030	302990	569840	198100	323080
2	1959	682520	377080	239650	569080	252070	428980
3	1960	545730	363850	317800	414310	172380	377940
4	1961	513550	406860	290540	400960	253490	283770
5	1962	520760	398410	310530	415950	243350	289760
6	1963	495700	414080	305370	396310	226100	274600
7	1964	510240	433280	299260	383680	218600	299470
8	1965	519310	467290	366910	377870	145090	323480
9	1966	602060	466990	300980	333200	180850	346850
10	1967	628010	529740	314560	376210	207630	349780
11	1968	608840	538080	300320	384900	248650	382940
12	1969	634750	345370	357960	397810	194330	256580
13	1970	641490	387080	298480	420570	212960	252950
14	1971	657760	410700	273560	417930	229860	275830
15	1972	451310	432440	305980	370560	251200	232330
16	1973	506550	446250	340530	419560	272790	241650
17	1974	500640	447040	347780	438910	294050	266860
18	1975	464720	461080	338590	448730	316170	270800
19	1976	412210	456120	334410	474170	157810	268530
20	1977	513540	439330	301280	447840	161220	252180

Appendix D (Continued)

OBS	TIME	PHRAL911	PHARIRO1	PHARIRO2	PHARIRO3	PHARIRO4	PHARIRO5
1	1958	309440	45870	75030	373690	103290	65980
2	1959	307950	48222	101477	256510	81968	77717
3	1960	441200	35650	91780	245250	87690	142920
4	1961	553780	47110	121600	215690	98260	129810
5	1962	549390	43340	127990	249550	145100	136850
6	1963	565500	38690	58580	222720	99790	137320
7	1964	571740	44550	68840	229600	103990	134670
8	1965	410130	65480	135270	230420	142380	134950
9	1966	467380	47110	145530	372610	228310	166560
10	1967	460020	75790	130880	360290	238520	134600
11	1968	467250	57720	128220	371560	276440	174040
12	1969	467780	76540	211860	327320	153490	164020
13	1970	410570	82400	212570	354330	180890	154790
14	1971	437910	95890	198610	272250	176850	137410
15	1972	386500	138040	192750	243150	166920	150670
16	1973	465530	136590	224390	305920	168560	170040
17	1974	490250	126630	220540	290810	177030	143780
18	1975	517940	152590	246720	300600	193470	140260
19	1976	308310	135920	246830	280940	198800	133910
20	1977	305760	155060	235530	293490	184790	127500

OBS	TIME	PHARIRO6	PHARIR10	PHARIR78	PHRIR911	POPFAVO1	POPFAVO2
1	1958	37430	12230	33580	6070	929.67	1051.33
2	1959	57857	37451	48644	54295	934.17	726.33
3	1960	61480	21300	116820	156900	875.83	666.33
4	1961	56090	62520	60530	194760	1140.67	1007.67
5	1962	85940	20860	71860	132080	942.17	852.33
6	1963	58810	27960	84880	201090	1016.67	961.00
7	1964	57550	26230	92840	205830	1241.67	1161.50
8	1965	65300	21230	58060	107370	1483.33	1259.67
9	1966	94900	48360	46790	202520	1454.33	1352.33
10	1967	80690	41140	101780	145330	2000.67	1391.67
11	1968	105180	86530	105290	177840	1758.67	1377.33
12	1969	72390	56080	63960	220070	1763.33	1435.33
13	1970	135110	101830	74580	174010	1020.83	1418.83
14	1971	23940	95620	78120	179460	2212.50	2231.25
15	1972	79860	43110	67940	158540	2645.17	2720.67
16	1973	92710	95130	63690	236710	2465.33	2410.67
17	1974	89910	96540	65240	201230	4289.82	3682.65
18	1975	91370	124390	65340	179850	4560.45	4148.17
19	1976	113090	80470	82690	134100	4333.27	4520.85
20	1977	100390	88150	75100	128070	4748.77	4454.41

Appendix D (Continued)

OBS	TIME	POPFAV03	POPFAV04	POPFAV05	POPFAV06	POPFAV10	POPF0708
1	1958	1144.33	1088.33	1030.50	1098.33	1072.33	1071.00
2	1959	874.83	764.50	764.00	831.50	807.17	910.83
3	1960	865.83	815.17	780.67	764.50	776.83	843.00
4	1961	1151.83	1099.17	973.67	1079.67	1016.33	999.00
5	1962	1036.83	1011.83	896.67	987.00	910.00	932.50
6	1963	1220.83	1191.00	1065.00	1155.83	1148.50	1158.67
7	1964	1553.50	1459.33	1223.83	1470.50	1298.50	1308.83
8	1965	1371.00	1450.50	1193.17	1368.50	1268.67	1237.50
9	1966	1665.00	1473.50	1369.17	1401.00	1461.83	1401.00
10	1967	1683.83	1285.33	1367.33	1255.83	1247.50	1607.33
11	1968	1697.33	1548.33	1287.50	1411.00	1304.83	1535.83
12	1969	1561.67	1712.17	1469.17	1576.83	1421.83	1622.33
13	1970	1817.83	1773.17	1518.83	1510.17	1444.17	1455.67
14	1971	2456.40	2188.00	2105.20	2145.60	2110.67	2134.50
15	1972	2896.00	2796.17	2440.20	2711.83	2709.83	2463.33
16	1973	2555.67	2421.83	2281.33	2402.00	2645.67	2573.64
17	1974	4652.71	3919.81	3741.17	3955.45	4043.45	3650.93
18	1975	4348.81	4129.69	3973.79	3791.92	4369.93	3877.96
19	1976	4567.49	4251.72	4016.03	4002.39	4136.29	4009.32
20	1977	5174.55	4518.21	4666.79	4213.88	4862.44	4443.95

OBS	TIME	POPF0911	PYLDAV01	PYLDAV02	PYLDAV03	PYLDAV04	PYLDAV05
1	1958	973.00	25.0167	27.0633	35.0500	24.1100	19.7267
2	1959	675.33	24.0133	27.2767	34.3300	23.3500	20.3333
3	1960	818.83	22.5333	28.2800	32.6867	23.0567	22.0933
4	1961	992.00	24.8367	28.3700	33.8967	23.6400	23.5367
5	1962	930.67	27.3333	27.8667	36.0567	25.0133	24.4700
6	1963	1126.83	29.2900	27.1333	39.3433	25.5533	25.4033
7	1964	1279.67	28.7900	27.4800	41.5300	25.9933	26.6533
8	1965	1146.00	27.5833	27.4533	41.6967	25.2967	27.6033
9	1966	1352.67	29.0633	29.2200	42.9167	25.6833	29.6467
10	1967	1387.50	31.5300	31.3033	41.8900	27.0667	30.6800
11	1968	1326.33	36.1467	34.4400	42.1100	28.3300	31.8667
12	1969	1232.17	40.0000	35.5267	41.1300	28.0900	31.8367
13	1970	1371.50	40.3600	37.2433	44.9000	31.8100	33.5400
14	1971	2112.50	38.8033	39.6567	48.2033	34.7733	32.6800
15	1972	2258.50	36.5733	40.4633	46.2300	36.8233	36.4333
16	1973	2399.66	34.6833	40.2167	42.5667	34.1967	35.5200
17	1974	3864.37	34.3700	38.4300	41.6867	33.6967	38.1100
18	1975	4046.67	31.2067	38.0600	44.7900	35.1933	35.7367
19	1976	3914.90	33.8589	39.3291	47.8609	36.9820	38.6462
20	1977	4335.88	34.2123	40.4641	50.4674	36.4623	40.5420

Appendix D (Continued)

```
OBS TIME PYLDAV06 PYLDAV10 PYLDV708 PYLDV911

  1 1958 19.8600  27.1067  21.4700  28.5733
  2 1959 19.6467  24.9400  20.0033  26.0433
  3 1960 20.8333  21.3633  18.6033  23.5467
  4 1961 24.1900  21.4500  19.9133  24.2267
  5 1962 27.1133  19.7667  20.3467  24.9467
  6 1963 27.7767  18.9933  20.2667  26.6867
  7 1964 27.2167  19.3500  19.9733  27.6733
  8 1965 27.4833  19.9600  19.5867  28.3233
  9 1966 26.9767  20.1300  18.0933  26.7633
 10 1967 29.5833  20.3000  17.7867  25.6300
 11 1968 30.9833  20.1033  17.8367  25.0933
 12 1969 32.6567  21.2533  19.1500  26.0533
 13 1970 32.4833  25.2100  21.2633  29.7800
 14 1971 33.3200  30.5467  24.8367  32.5033
 15 1972 34.1267  34.0800  27.1833  32.4840
 16 1973 33.3233  30.3600  27.6935  30.7185
 17 1974 33.3533  27.3200  27.8287  31.3894
 18 1975 34.5367  25.9333  28.3050  35.6020
 19 1976 35.3815  27.9745  30.3682  40.4385
 20 1977 37.5394  27.7615  31.6245  45.0142
```

Variable Description List

ASWPAVEM = wholesale prices of ammonium sulphate(21%), Manila, Jan - June average, per 10,000 lbs bag,

MWPFAV(#) = farm price of white shelled corn, Jan - June average, pesos/sack of 5,700 kgs, region #,

MYLDAV(#) = corn yield, 3 year moving average, cavan of 57 kgs per hectare, region #,

PFPFAV(#) = farm price of palay fancy 2nd class, Jan - June average, pesos/sack of 4,400 kgs, region #,

PHARAL(#) = palay hectarage harvested, all, region #,

PHARIR(#) = palay hectarage harvested, irrigated, region #,

POPFAV(#) = farm price of palay ordinario, Jan - June average, pesos/cavan of 4,400 kgs, region #,

PYLDAV(#) = palay(all) yield, 3 year moving average , sacks of 44 kgs per hectare, region #,

Appendix E -- Means and Sums

VARIABLE	MEAN	SUM
ASWPAVEM	1270.530023	22869.5404
FRTLR06	0.753295	13.55931
MWPFAV01	2665.228817	53304.5763
MWPFAV02	2315.080167	46301.6033
MWPFAV03	2626.307500	52526.1500
MWPFAV04	2344.876867	46897.5373
MWPFAV05	2392.591333	47851.8267
MWPFAV06	2390.935833	47818.7167
MWPFAV10	2289.713333	45794.2667
MWPF0708	2490.659279	49813.1856
MWPF0911	2156.335427	43126.7085
MYLDAV01	8.804012	176.0802
MYLDAV02	14.480015	289.6003
MYLDAV03	9.996246	199.9249
MYLDAV04	12.596348	251.9270
MYLDAV05	10.721404	214.4281
MYLDAV06	9.675365	193.5073
MYLDAV10	11.300111	226.0022
MYLDV708	8.499468	169.9894
MYLDV911	15.878789	317.5758
PFPFAV01	2320.881860	44096.7553
PFPFAV02	2151.441404	40877.3867
PFPFAV03	2478.450526	47090.5600
PFPFAV04	2299.827719	43696.7267
PFPFAV05	2122.002807	40318.0533
PFPFAV06	2105.076491	39996.4533
PFPFAV10	2238.231439	42526.3973
PFPF0708	2123.711041	40350.5098
PFPF0911	2014.957059	38284.1841
PHARAL01	188804.500000	3776090.0000
PHARAL02	352824.500000	7056490.0000
PHARAL03	558966.000000	11179320.0000
PHARAL04	435055.000000	8701100.0000
PHARAL05	312374.000000	6247480.0000
PHARAL06	422919.500000	8458390.0000
PHARAL10	221835.000000	4436700.0000
PHARAL78	299918.000000	5998360.0000
PHRAL911	444716.500000	8894330.0000
PHARIR01	82459.600000	1649192.0000
PHARIR02	158749.850000	3174997.0000
PHARIR03	289835.000000	5796700.0000
PHARIR04	160326.900000	3206538.0000
PHARIR05	137889.850000	2757797.0000
PHARIR06	77999.850000	1559997.0000
PHARIR10	59356.550000	1187131.0000

Appendix E (Continued)

VARIABLE	MEAN	SUM
PHARIR78	72886.700000	1457734.0000
PHRIR911	159806.250000	3196125.0000
PMWYLD01	23874.415931	477488.31862
PMWYLD02	34174.239652	683484.79303
PMWYLD03	27934.257817	558685.15633
PMWYLD06	24730.575052	494611.50104
FMWYLD10	25354.380244	507087.60488
PMWY0708	23022.050126	460441.00252
POPFAV01	2090.865867	41817.3173
POPFAV02	1941.517167	38830.3433
POPFAV03	2214.814667	44296.2933
POPFAV04	2044.888667	40897.7733
POPFAV05	1908.200333	38164.0067
POPFAV06	1956.687000	39133.7400
POPFAV10	2002.839333	40056.7867
POPF0708	1961.856748	39237.1350
POPF0911	1877.248609	37544.9722
PPFYLD01	76929.220969	1461655.19842
PPFYLD02	78035.308288	1482670.85747
PPFYLD03	108584.206101	2063099.91591
PPFYLD04	73546.353726	1397380.72080
PPFYLD06	67421.468554	1281007.90253
PPFYLD10	58167.582386	1105184.06533
PPFY0708	53234.576295	1011456.94961
PPFY0911	65507.127226	1244635.41729
PYLDAV01	31.510227	630.2045
PYLDAV02	33.263826	665.2765
PYLDAV03	41.467083	829.3417
PYLDAV04	29.256045	585.1209
PYLDAV05	30.252909	605.0582
PYLDAV06	29.419212	588.3842
PYLDAV10	24.195136	483.9027
PYLDV708	22.606661	452.1332
PYLDV911	29.574497	591.4899
RRPFM01	3.274293	62.21157
RRPFM06	2.869449	54.51953
RRPFM10	2.133526	40.53699
RRPFM78	2.374869	45.12251
TECR03	0.523061	10.46122
TECR04	0.364800	7.29600
TECR10	0.267563	5.35126
TECR0911	0.354258	7.08517

Citations

1. Anderson, J.R., et al. (1980). Agricultural Decision Analysis, 2nd Ed., Iowa State University Press, Ames, Iowa, pp. 66-69.
2. Dillon, J.L. (1977). The Analysis of Response in Crop and Livestock Production. Pergamon Press, Inc., N.Y., pg. 102.
3. Dhrynes, P.J. (1971). Distibuted Lags. Holden-Day, Inc., San Francisco, pg. 58.
4. Freund, R.J. "The Introduciton of Risk into a Programming Model," Econometrica, s. 24 (1956):253-63.
5. Hayami, Yujiro, and Vernon W. Ruttan, (1985). Agricultural Development: An International Perspective, 2nd Ed.,The Johns Hopkins Press, Baltimore, Maryland, Ch. 10.
6. Hazell, P.B.R. and P.L. Scandizzo. "Competitive Demand Structures Under Risk in Agricultural Linear Programming Models," American Journal of Agricultural Economics. 56 (1974):235-244.
7. Mangahas, M, A.E. Recto, V.W. Ruttan, Production and Market Relationships for Rice and Corn in the Philippines. IRRE, tech. bull. 9. Los Banos, Philippines, 1965.
8. Mangahas, M, A.E. Recto, V.W. Ruttan, "Price and Market Relationships for Rice and Corn in the Philippines." Journal of Farm Economics, 48 (August 1966):685-703.
9. Myint, Hla. "The 'Classical Theory' of International Trade and the Underdeveloped Countries," Economic Journal, 68 (June 1958):317-37.

10. Nerlove, M. (1958). The Dynamics of Supply, The Johns Hopkins Press, Baltimore, Maryland, pg. 62.

11. Philippine Council for Agriculture and Resources Research. Data Series on Coconut Statistics in the Philippines, Los Banos, Laguna, Philippines, 1980.

12. ________. Data Series on Corn and Sorghum Statistics in the Philippines, Los Banos, Laguna, Philippines, 1981.

13. ________. Data Series on Rice Statistics in the Philippines, Los Banos, Laguna, Philippines, 1981.

14. ________. Data Series on Sugar Cane Statistics in the Philippines, Los Banos, Laguna, Philippines, 1980.

15. Ryan, J.G."Comments on Structural Changes in Rice Supply Relations: Philippines and Thailand." IRRI, Economic Consequences of the New Rice Technology. Los Banos, Philippines, 1978.

16. Ryan, Timothy. "Supply Response to Risk: The Case of U.S. Pinto Beans," Western Journal of Agricultural Economics. 2 (1977):35-43.

17. Sison, J.F. et al. "Structural Changes in Rice Supply Relations: Philippines and Thailand." IRRI, Economic Consequences of the New Rice Technology. Los Banos, Philippines, 1978.

18. von Neumann, J. and O. Morgenstern (1947). Theory of Games and Economic Behavior, 2nd Ed., Princeton University Press, Princeton, N.J., Ch. 3.