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PEST MANAGEMENT GROUPS

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by

S. Pridgen Rook and Gerald A. Carlson

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FARMER PARTICIPATION IN PEST MANAGEMENT GROUPS

Farmers are increasingly forming groups or cooperatives to provide collective pest control. Participation in a private pest control group is voluntary, unlike some publicly provided pest control, such as mosquito abatement or federal insect quarantine efforts. The possible benefits of group control are varied. Collective control may internalize production externalities due to mobile insect populations, pesticide drift, or pest management information externalities. Group economies of size or scale may lower the cost of pest control to the group members. Pest control groups may also facilitate the delivery or adoption of new advanced pest management techniques.

Pest control groups are active for several crops and in various regions of the country. There are grower pest management co-ops operating in Indiana and Kentucky for corn, alfalfa, and soybeans (Meister). The degree of cotton farmer dependency on cooperatives for pest management services varies throughout the cotton belt (Good, et al.). At the time of this study, there were approximately twelve cooperative or commercial cotton pest management organizations operating in the study area. Group services vary, but generally each group provides scouting, aerial application service, chemical supplies, insect trap monitoring and decisions on when to apply insecticides to the cotton. In essence, the farmer transfers pest control treatment rights to the spray group when he signs the group contract. The contract specifies the annual per acre cost and range of service responsibilities.

Many extension pest control programs now operating have the potential of developing into grower-owned programs (Meister). These state and
federal extension programs could benefit from research concerning the factors which encourage pest control group participation.

This effort was enhanced by the examination of other related works. Buchanan conceptualizes an optimal number of club or group members and an optimal quantity of club service for an individual. Regev, et al., indicate the importance of considering mobile pests as a common property resource, show how private and social control policies diverge, and indicate the development of an optimal pest control policy. Willey and Hall examine the adoption of pest management consultants by California growers. Carlson analyzes factors affecting use of pest management consultants. Grube examines the decision to use scouts to monitor cotton insect populations in the Delta states.

This research indicates the factors determining a farmer's decision to join a cotton pest control group using a dichotomous qualitative dependent variable. The estimation technique and the participation model are presented first. Then, the variables and parameter estimates are discussed. Conclusions follow.

GROUP PARTICIPATION MODEL

A farmer chooses one of two alternatives: join a group or not join a group. Each individual has an objective function composed of a non-stochastic portion, which is a function of observable alternative characteristics and observable socioeconomic characteristics, and a stochastic portion which is a function of unobservable alternative characteristics or unobservable individual characteristics (Domencich and McFadden). By assumption, the nonstochastic portion of the objective function equals $B'X$ where $B'$ is a row vector of parameters and $X$ is a column vector of
exogenous variables (observable alternative and socioeconomic characteristics). The stochastic nature of the objective function allows one to define an individual's probability of choosing each alternative as a specific cumulative distribution function evaluated at a given value (Domencich and McFadden). \( P_{\text{join}} = F(B'X) \) where \( P_{\text{join}} \) is the probability of joining and \( F \) is a specific cumulative distribution function. If the cumulative distribution function is a logistic function, then \( P_{\text{join}} = \frac{1}{1 + \exp(-B'X)} \), and maximum likelihood logit estimation is used to estimate the \( B \) vector.\(^1\) The parameter estimates indicate the relationship between the probability of joining a group and the observable variables in the objective function.

The Simple Economic Model

If the farmer is maximizing profit, then the participation decision is based on a comparison of profits. For the moment, ignore uncertainty, transaction costs, and the nonexcludable features of the service. Assuming the nonpest control inputs are independent of the group participation choice, the difference in the profits on a per acre basis is:

\[
P_y (Y - Y') - P_i (I - I') - P_g G
\]

where \( P_y \) is the price of the output (cotton), \( Y \) and \( Y' \) are the quantities produced per acre if the farmer joins or does not join, respectively, \( P_i \) is the price of an individually applied pest control input, \( I \) and \( I' \) are the quantities of an individually applied pest control input if the farmer joins or does not join, respectively, \( P_g \) is the price of the group services on a per acre basis, and \( G \) is the quantity of group applied pest control input.\(^2\) If the difference in profits is greater than zero, one expects the farmer to join the group.
It is assumed each group member receives the same amount of pest control per acre and each member of a particular group pays the same price per acre. The quantity of pest control an individual farmer desires will not necessarily coincide with the quantity of pest control the group provides. If any farmer joins the group, he must accept group decisions on the level of pest control received. If the group members have single-peaked preferences, then by simple majority voting the group will select the level of the median voter or member (Black). This uniform purchase constraint modifies usual marginal conditions for optimal input use and gives a different incentive structure for group versus individual input use.

For illustrative purposes, assume there are three discrete levels of pest control demanded: low, median, and high. (The level of demand may differ among growers because of differences in pest levels or differences in crop susceptibilities.) The possible benefits of group participation for farmers with different pest control demands are illustrated using equation (1), Figure 1, and Table 1. It is assumed that the price of the output is fixed, the quality of the output is not affected by pest control, and the nonpest control inputs are independent of the pest control inputs. Thus a value marginal product (VMP) curve represents the demand for the pest control input. A farmer may profit from group participation for two reasons: group control may be more productive than individual control (VMP _group_ is greater than VMP _individual_) and group control may be less expensive than individual control (P _g_ is less than P _i_).

Table 1 indicates the welfare gains and losses of participation according to equation (1) for individuals with different levels of pest
Figure 1. Group Participation for Three Levels of Pest Control Demand
Table 1. Summary of the Net Gain or Loss of Group Participation

<table>
<thead>
<tr>
<th>Pest Control Demand Level</th>
<th>Productivity Differences</th>
<th>Expenditure Differences</th>
<th>Loss</th>
<th>Net Benefit of Joining</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_y(Y-Y')$</td>
<td>$-P_1(I-I')$</td>
<td>$-P_g$</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>Median</td>
<td>$CLG_{1,ND}$</td>
<td>$P_{1,M1,0}$</td>
<td>$P_{LGO}$</td>
<td>$CLP_{P,ND} - 0$</td>
</tr>
<tr>
<td>High</td>
<td>$AHJB$</td>
<td>$P_1KGO$</td>
<td>$P_{LGO}$</td>
<td>$AHJB + P_1KLP g &gt; 0$</td>
</tr>
<tr>
<td>High Without Supplement</td>
<td>$AHJB -$</td>
<td>$P_{1,M1,0}$</td>
<td>$P_{LGO}$</td>
<td>$AHJB + P_1KLP g$</td>
</tr>
<tr>
<td>Low</td>
<td>$JM1_{h,G}$</td>
<td>$P_{1,Q1,0}$</td>
<td>$P_{LGO}$</td>
<td>$ESP_P,1QF$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$JMK &lt; 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$JGR &gt; 0$</td>
</tr>
</tbody>
</table>

*aColumn titles refer to elements of equation 1 and table entries refer to areas shown in Figure 1.*

control demand assuming group VMP is higher, and group control is less expensive. If there is a restriction against the use of private supplemental pest control inputs if one joins, then the case of "high without supplement" is needed. The last column in Table 1 shows the net benefit of joining a pest control group for different pest control demand levels. Each of the components of the model as delineated by the columns of Table 1 are discussed and hypotheses are developed for explaining farmer participation in pest management groups.

**Productivity Differences**

The difference in the value of individual and group productivity is indicated in Figure 1 by two value marginal product curves (VMP) for each level of demand. The gain due to higher group VMP (or productivity) is indicated for each different demand level in column 2 of Table 1. As the
net change in value of the output produced resulting from participation increases, the probability of participation increases. Groups may offer higher pest control productivity than an individual due to more accurate group scouting or timing of pesticide applications.

Groups may be able to coordinate the pest control activities of its members to internalize production externalities. The farmers within a pest or beneficial insect population's range "share" the pest or beneficial population (Regev, et al.). By coordinating their efforts or attacking pests with a united approach, the farmers avoid chasing the pests from one farm to the next or allowing a considerable buildup of the population in an untreated area. Cooperation may also encourage the establishment of a natural enemy or beneficial population to help control the pest throughout the host's range. The externalities that the group may influence are affected by the pest's mobility (which includes mobility among seasons as well as within one season), the beneficial population's mobility, pesticide drift, and the ease of copying a neighbor's pest control practices. The productivity gain of group control over individual control will depend on the production and information externalities or the degree that neighbors' control activities enhance or conflict with each other. Thus, a measure of a group's potential to internalize externalities is needed.

The degree to which group control can increase a farmer's production may depend on the particular farmer's situation (e.g., yield or pest problems). If the farmer has relatively low yields and severe pest problems due to a lack of pest control skills, then the group should be able to improve profits by providing better pest management. The expected improvement may not be dependent on the farmer's situation. If the group expects to improve everyone's production by a constant percentage, then the farmer with higher potential yield will benefit more than the low
yielder. Thus, group effectiveness may vary positively or negatively with the individual farmer's yield or pest severity.

**Expenditure Differences**

In most cases when a farmer joins a spray group, he no longer purchases or applies the pest control input individually. (The possible exception is the farmer with a high input demand.) This saving is shown in column 3 of Table 1. If the farmer joins, he purchases pest control inputs through the group and pays the group fee ($PLGO$—see column 4 of Table 1). Higher relative prices for individually provided pest control ($P_i/P_g$), increase the potential saving from group participation.

Individual relative prices vary due to differences in the scale of farm operations, the cost incurred in the acquisition of the pest control skills, and the operator's opportunity cost of time due to foregoen farm and nonfarm activities. Larger farms may experience economies of size and pay lower input prices. The higher the cost of obtaining pest management skills and the higher the operator's opportunity cost of time, the more likely he is to relinquish his pest control duties to a group.4

The cost of group services may be affected by subsidization of the group through direct monetary aid or the provision of pest control inputs or pest control personnel.

**Net Benefit of Joining**

When the group control is more effective than individual control and the group pays a lower price for the pest control input, the model predicts the median and high demanders will experience a net gain from joining. High demanders who are not allowed to supplement group control with individual inputs and the low demanders have the potential to lose by joining the group. The magnitude of the potential loss increases,
as the difference in the individual desired level and the group level increases. For example, as the low VMP curve moves further from the median VMP curve, the negative term (SLGR) in the net gain expression \( g' \) becomes larger. \( \text{(See Table 1 and Figure 1.)} \) Thus the probability of joining for the low demander and the high demander, if he is not allowed to supplement group inputs with his own pest control inputs, is affected by the magnitude of the absolute difference between the individual desired level of control and the level the group provides.

Extensions of the Simple Model

This simple model may be extended by considering risk, the public good features of the service, transactions costs of joining, and the existence of differences in the services provided by the various groups.

Pest control decisions are risky decisions. Arrow shows that the probability that makes an individual just indifferent between accepting and rejecting a gamble, defined as a portion of wealth, increases as the portion of wealth gambled increases and as wealth increases. Thus, as the proportion of farmland in cotton increases, the proportion being gambled increases, and one would expect the farmer to seek a higher probability of winning or producing a profitable crop. Group participation supplemented by the farmer's own field inspections may improve his profitability odds. The group reduces risk if its scouts check the fields more often or with greater accuracy, or if it provides more timely aerial application services. If the group provides a better (risk-reducing) service, then as the proportion of cropland in cotton increases one would expect the probability of joining the group to increase.

An additional consideration is the relationship between farm size and the tendency of potential members not to free-ride. Olson and
Zeckhauser explain the tendency of larger members of international alliances to bear a disproportionate share of the cost of defense for countries in the alliance. Larger cotton farmers, as larger nations, may value collective services more than smaller entities because the impact of their own participation on the quality of the collective service is larger. If larger cotton farmers value cooperative pest control more than the smaller farmers, then larger farmers will join more or free-ride less.

A farmer's previous participation decisions may influence his current group choice. Transactions costs associated with joining or leaving the group may affect the profitability. Previous participation would provide experience with the group service, and hence, information. If group pest control is a service difficult to evaluate, then experience may substitute for other information sources.

If the experimental data has participation information for more than one group, then group quality may affect the participation decision. The quality of pest control each group provides may influence the potential production differences and the relative prices.

To summarize, the probability of group participation is a function of higher relative group productivity, lower relative costs, risk reduction (+), the tendency not to free-ride (+), former membership experience (+), and group quality (+). (+, -, ?, refer to positive, negative and uncertain effect on participation.) Higher relative group productivity is measured by production externalities (+), yield (?), and pest density (?). The comparison of individual costs and group costs is measured by the scale of farm operation (-), the farmer's pest control skill level (-), the operator's opportunity cost of time for farm and
nonfarm activities (+), the group service price (-), and group subsidization (+). The net benefit of joining is influenced by the difference between the desired level of control and the level the group provides (-).

**EMPIRICAL RESULTS**

**Data and Variable Measurement**

The dependent variable is a dichotomous qualitative variable. GR76=1, if the farmer joined a spray group in 1976; GR76=0, if he did not join. Personal interviews of 193 cotton farmers provide information concerning farming practices (pesticide applications, yield, farm size, acreage distribution among crops, and group membership) and operator characteristics (age and education). Survey details, a copy of the survey, and summary statistics are available from the authors.

The production externality variable is measured by EXT76A which is an estimate of the number of cotton acres planted in the geographical operating area of the pest control group. Though the following information was not available, the density of cotton acres on each farm, the size of the cotton fields, the farmer's position relative to the group's operation, and his position relative to current members could influence production externalities and thus, participation.

Yield data and pesticide application data of the previous year are used to approximate anticipated yield and pest conditions. These variables are called YIELD and PSAPP, respectively.

Foregone off-farm work opportunities are estimated by an imputed wage, OFFWAGEA. The imputed wage is a function of the farmer's age, age-squared, and the years of education. A description of the wage model and data sources are available from the authors.
The on-farm opportunity cost is measured by the proportion of cropland planted in a crop which competes with cotton for the operator's time. PCPNUT76 is the proportion of cropland planted in peanuts.

The scale of farm operations is measured by the total acres of planted cropland, CROPAC. As farm size increases one expects (1) the farmer's opportunity cost of time to increase, (2) a smaller tendency to free-ride, and (3) to observe economies of scale. The first two factors would result in a positive relationship between participation and farm size; the last, a negative relationship. This is why the scale effect is uncertain (?)

PRICE76 is the estimate of the average price per acre for each group's service in 1976. The groups generally charge each farmer a fixed amount per acre for the season. Group information was obtained from interviews with spray group representatives and other sources (Carlson and Grube).

During the study period farmers and groups received various forms of extension aid including scouting report forms, insect trap information and the services of scout supervisors, scouts, and other program professionals (Worley, et al., Ganyard and Worley, Ganyard, et al., Good and Bonell). A detailed accounting of how project funds and extension personnel time were distributed among groups by years is frequently not available because extension assistance is available to all farmers regardless of group affiliation. If the Extension Service allocated time and funds to the groups according to the size of group membership, then the approximation used will give an indication of the amount of aid the various groups received. The project expenditures for the Edgecombe County group in 1974 are available (Ganyard, et al.). To estimate the subsidy variable (SF74) for the other groups, the 1974 project expenditure per farmer is multiplied by the number of farmers in each group.
The difference between the individual farmer desired level of control and the group level shown in Figure 1 is not observable except for nonmembers. DIFFABS is the absolute difference between the number of nonmember pesticide applications in 1975 and the average number of group applications in 1975. Using the absolute value of the difference assumes farmers are not allowed to supplement group pest control.

To complete the model, the proportions of cropland planted in cotton (PCCOT76), former group membership (GR74=1 if joined in 1974; GR74=0 if not) and a group quality variable are needed. The only quality measure available is the number of scouting inspections made by each group in 1976. It is assumed that the group made available to potential 1976 members at the beginning of the season the number of anticipated inspections.

Parameter Estimates

The dependent variable (GR76) may be considered an observation from a binomial distribution with n=1 and p=PJOIN=1/1+exp(-B'X). The Nerlove and Press program computes numerical approximations for the maximum likelihood estimates of B and the standard error vector. The estimates are consistent, asymptotically efficient, and asymptotically normally distributed (Mcfadden). In Table 2, the estimate of the coefficient is given with the estimate of the standard error of the coefficient in parentheses. The expected sign for each variable is included in brackets. The significance of each coefficient is indicated in Table 2.

Unlike ordinary least squares, the maximum likelihood logit coefficient estimates are not partial derivatives of the dependent variable with respect to the exogenous variables. The derivative of the probability of joining with respect to an exogenous variable is dP/dX = b h P(1-P)
Table 2: Logit Estimates For Pest Control Group Participation\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Expected Sign</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>CONSTANT</td>
<td>-5.254*</td>
<td>-3.419</td>
<td>-4.901</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.884)</td>
<td>(3.206)</td>
<td>(3.648)</td>
</tr>
<tr>
<td>Externality</td>
<td>[+</td>
<td>-1.16E-3</td>
<td>-1.7E-3</td>
<td>-1.13E-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.25E-3)</td>
<td>(.28E-3)</td>
<td>(.33E-3)</td>
</tr>
<tr>
<td>Pest Density</td>
<td>[?]</td>
<td>.0440</td>
<td>.1172</td>
<td>.0893</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.1073)</td>
<td>(.1217)</td>
<td>(.1161)</td>
</tr>
<tr>
<td>Yield</td>
<td>[?]</td>
<td>.0028</td>
<td>.0052*</td>
<td>.0044</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.0028)</td>
<td>(.0031)</td>
<td>(.0034)</td>
</tr>
<tr>
<td>Scale</td>
<td>[?]</td>
<td>.0032**</td>
<td>.0026*</td>
<td>.0019</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.0014)</td>
<td>(.0015)</td>
<td>(.0018)</td>
</tr>
<tr>
<td>Opportunity Costs</td>
<td>[+</td>
<td>.0064</td>
<td>.0130</td>
<td>.2692</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.3638)</td>
<td>(.3983)</td>
<td>(.5285)</td>
</tr>
<tr>
<td>PCNPUNT76</td>
<td>[+</td>
<td>14.173***</td>
<td>12.334**</td>
<td>10.617*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.167)</td>
<td>(5.633)</td>
<td>(7.010)</td>
</tr>
<tr>
<td>Price</td>
<td>[-</td>
<td>-.0827*</td>
<td>-.1365**</td>
<td>-.1721**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.0604)</td>
<td>(.0712)</td>
<td>(.0826)</td>
</tr>
<tr>
<td>Group Quality</td>
<td>[+</td>
<td>.0888</td>
<td>.1174</td>
<td>.0888</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.0809)</td>
<td>(.0925)</td>
<td>(.1043)</td>
</tr>
<tr>
<td>Subsidy</td>
<td>[+</td>
<td>.33E-3***</td>
<td>.39E-3***</td>
<td>.35E-3**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.11E-3)</td>
<td>(.16E-3)</td>
<td>(.15E-3)</td>
</tr>
<tr>
<td>Proportion of Cotton</td>
<td>[+</td>
<td>8.227**</td>
<td>5.281</td>
<td>7.465*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.568)</td>
<td>(3.957)</td>
<td>(4.471)</td>
</tr>
<tr>
<td>Differences in No. Appliance</td>
<td>[-</td>
<td>-.6456***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(.2173)</td>
<td></td>
</tr>
<tr>
<td>Former Member</td>
<td>[+</td>
<td></td>
<td></td>
<td>4.026***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(.979)</td>
</tr>
</tbody>
</table>

Log Likelihood         | -35.674       | -30.142  | -22.054  |
Chi-Squared Test Statistic | 37.758       | 48.822   | 64.998   |

\textsuperscript{a}A one-tail test, \( H_0: b=0 \) and \( H_a: b<0 \) or \( H_0: b=0 \) and \( H_a: b>0 \), is used when the expected sign is negative or positive. A two-tailed test is used otherwise. *, **, and *** indicate significance at the 10, 5 and 1 percent levels, respectively.

\textsuperscript{b}Models A, B, and C are described in the text.
where $b_h$ is the maximum likelihood coefficient for the $n^{th}$ variable.

The derivatives reported in Table 3 are calculated using the probability evaluated at the mean value of each explanatory variable. This probability is reported in Table 3. The marginal effect of a discrete independent variable may be measured by the difference of the probabilities calculated when the specific variable assumes its different values, while the other variables assume their mean values (Flath and Leonard).

Three models are presented in Tables 2 and 3. Model A is appropriate when groups are initially forming and there is no prior group experience. Model B shows the impact on participation of a divergence in the individual's desired level of pest control and the level the group provides. Model C includes a prior group membership variable. These two variables are added and estimated in separate models because of correlation problems caused by the construction of DIFFABS and the nature of the sample available. For each model there are 98 complete observations. Of these 98 farmers, 74 joined a group in 1976.

Several methods are available to measure the performance of each model. Since this is a maximum likelihood estimate, one can calculate the likelihood using each of the predicted probabilities. The larger the likelihood of a model, the higher the maximum probability associated with the $B$ that maximized the probability of observing that sample. The log of the likelihood approaches zero as the likelihood approaches one. The log likelihood for each model is recorded in Table 2. When comparing models, one may compare log likelihoods as an approximate indicator of goodness of fit. Model C has the best likelihood (-22.054).

To test a hypothesis concerning the significance of several or all of the coefficients of a given model, one may perform a likelihood ratio test. When the null hypothesis that all coefficients except the
Table 3. Partial Derivatives of the Probability of Pest Control Group Participation

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Externality</td>
<td>EXT76A</td>
<td>- .17E-4</td>
<td>- .14E-4</td>
</tr>
<tr>
<td>Pest Density</td>
<td>PSAPP</td>
<td>.0047</td>
<td>.0095</td>
</tr>
<tr>
<td>Yield</td>
<td>YIELD</td>
<td>.30E-3</td>
<td>.43E-3</td>
</tr>
<tr>
<td>Scale</td>
<td>CROPAC</td>
<td>.34E-3</td>
<td>.21E-3</td>
</tr>
<tr>
<td>Opportunity Costs</td>
<td>OFFWAGEA</td>
<td>.69E-3</td>
<td>- .0011</td>
</tr>
<tr>
<td></td>
<td>PCPNU76</td>
<td>1.524</td>
<td>1.003</td>
</tr>
<tr>
<td>Price</td>
<td>PRICE76</td>
<td>- .0089</td>
<td>- .0106</td>
</tr>
<tr>
<td>Group Quality</td>
<td>GQINS76</td>
<td>.0096</td>
<td>.0095</td>
</tr>
<tr>
<td>Subsidy</td>
<td>SF74</td>
<td>.36E-4</td>
<td>.32E-4</td>
</tr>
<tr>
<td>Proportion of Cotton</td>
<td>PCCOT76</td>
<td>.8846</td>
<td>.4293</td>
</tr>
<tr>
<td>Differences in No. Applications</td>
<td>DIFFABS</td>
<td>- .0525</td>
<td></td>
</tr>
<tr>
<td>Former Member</td>
<td>GR74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P(join) at Means of Exogenous Variables

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.8775</td>
<td>.9107</td>
<td>.9223</td>
</tr>
</tbody>
</table>

No. Farmers and (%) where Probability of Correct Assignment is

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 0.6</td>
<td>73(74.5)</td>
<td>79(80.6)</td>
<td>90(91.8)</td>
</tr>
<tr>
<td>&lt; 0.4</td>
<td>13(13.3)</td>
<td>12(12.2)</td>
<td>8(8.2)</td>
</tr>
</tbody>
</table>

constant are equal to zero is tested for each model, each of the chi-squared test statistics leads to the rejection of the null hypothesis at a significance level equal of 0.01. The chi-squared test statistics are recorded in Table 2.

Logically, if the model predicts a high (low) probability that an event will occur and it does (does not), then the model has predicted correctly. The selection of $P \geq 0.6$ as a "high" probability and $P \leq 0.4$ as
a "low" probability is arbitrary. The number of observations where the
model predicts correctly, or the probability of correct assignment is
greater than or equal to 0.6, is the sum of the number of observations where
the predicted probability of joining is greater than or equal to 0.6 and
the farmer joined plus the number of observations where the predicted
probability of joining is less than or equal to 0.4 and the farmer did
not join. Conversely, if the model predicts a high (≥ 0.6) probability
that an event will occur and it does not or if the model predicts a low
probability (≤ 0.4) that an event will occur and it does, then the model
has predicted incorrectly. The number and percentages of correct and
incorrect predictions are recorded in Table 3. Model C has the best pre-
dictive power (91.8 percent correct).

Model A

Looking at Model A, the significant variables are acres of cropland
(CROPAC), the proportion of cropland in peanuts (PCPNUT76), the group
price (PRICE76), the subsidy proxy (SF74), and the proportion of cropland
in cotton (PCCOT76). The other variables in the model generally have
acceptable signs, but they are not significantly different from zero.

Refer to Table 3 to determine the predicted impact of changes in
these exogenous variables. The predicted probability of joining when each
exogenous variable assumes its mean value is 0.8775. If a farmer increases
total cropland by 100 acres above the mean, then the probability of group
participation increases by (100)(.34E-3) or 0.034. Thus the new predicted
probability is 0.9115, ceteris paribus.

Similar interpretations can be given for the other significant vari-
ables. If the proportion of cropland devoted to peanuts increases by
0.1 (e.g., from .2 to .3), then Model A predicts the probability of group
participation will increase by 0.1524. If the spray group raises the price per acre for the service by $10.00, then this would decrease the probability of joining by 0.089. Model A predicts a 0.036 change in the probability of joining, if the project funds are increased by $1,000 to one group. If the proportion of cropland planted in cotton increases by 0.1, then the model predicts the probability of joining will increase by .0885.

Model B

Model B illustrates the effect of a divergence in the desired level of an individual's pest control and the level of pest control provided by the group (DIFFABS). DIFFABS has a statistically significant inverse relationship with participation. Joining a group imposes a uniform pest control input level on all members, even when there are various levels of pest control desired. By joining, some farmers will buy "too much" pest control (low demanders) or "too little" pest control (high demanders who may not supplement group control). This indicates that group participation is less likely when there is large variation in the level of pest control demanded by individuals.

Model C

Looking at Model C, one can see the importance of former membership on the participation decision. Observing the sample available, 78 percent of the farmers made the same participation decision for three consecutive years (1974-1976). (Sixty joined three consecutive years; 16 did not join three consecutive years.) Previous group experience may provide information or affect the transactions cost of the decision. It
is also possible that the factors determining earlier participation decisions are not changing substantially from year to year. For this sample, Model C is the best model to predict behavior.

CONCLUSIONS AND SUMMARY

When a farmer decides to join a group, the group is then responsible for some part of the pest control. The probability that a given farmer will delegate pest control responsibility to a group is found to be positively related to the operator's on-farm opportunity cost and negatively related to the purchase price of the service. The group participation analysis provides support for the hypothesis that small cotton farmers tend to free-ride more. The analysis also indicates a positive relationship between group participation and the similarity of the farmer's desired level of control and the level the group provides. As expected, subsidization of a group lowers group fees or provides more extension contact and encourages participation.

The logit participation models were also able to lend some support to the importance of transaction cost and risk. The probability of joining is directly related to the proportion of cropland in cotton (risk proxy). Also, former group membership provides information and lowers contracting costs.

The other variables in the participation model are theoretically important, though empirically insignificant. For example, the variable created from the available data to measure the group's ability to internalize production or information externalities is empirically insignificant. The group's ability to internalize externalities could be a major
advantage of group participation. As suggested in the text, other externality proxies may be more useful demonstrating this group advantage when more detailed group and farmer information becomes available.

The predictive power of the model could be useful to group operators in the area, chemical suppliers, or aerial applicators, who are interested in estimating the demand for their services. Furthermore, this information may aid in the design of subsidy programs, the development of groups for other crops or other locations, or the modification of group policies to attract more members. These results indicate that pest control groups may be very successful for a target crop in areas where the majority of farmers have relatively (a) large planted cropland acreages, (b) large proportions of cropland in the target crop, and (c) high opportunity costs of time.
FOOTNOTES

1If the cumulative distribution function is linear, then \( P_{\text{join}} = B'X \) and OLS is used to estimate the \( B \) vector. Each farmer is observed to join \( (y = 1) \) or not join \( (y = 0) \). The OLS model is \( y_i = B'X + e_i \) with \( E(y_i) = P_i \) being the probability of an individual, \( i \), joining. This implies \( E(e_i) = 0 \) and \( \text{Var}(e_i) = E(e_i^2) = P_i(1 - P_i) \). The problems with OLS estimation include: the error term is heteroscedastic, the predicted dependent value may be a numerical value that is unacceptable as a probability, the errors are not normally distributed and the usual test for significance of the coefficients do not apply (Domencich and McFadden, Nerlove and Press). The statistical problems of OLS are increased as the probability differs from 0.5.

2This equation is easily modified to include several types of pest control inputs, but the model is presented using one input or an aggregate of pest control inputs to facilitate graphical analysis.

3This model has similarities to the benefit of participation in public mosquito abatement as given by Tullock.

4The farmer's pest control skill level is omitted from this presentation due to data difficulties.

5The Edgecombe County expenditures were subtracted from the total project expenditures to estimate SF74 for the other groups.

6When each of the models estimated below are estimated using OLS, Model A has 15 percent of the predicted probabilities greater than 1, Model B has 4 percent less than 0 and 27 percent greater than 1, and Model C has 8 percent less than 0 and 38 percent greater than 1. Thus, OLS is not an appropriate estimation technique for this sample. See footnote 1.
REFERENCES


Good, Joseph M. and Norman P. Bongi111. *Cotton Insect Pest Management*


