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Effect of risk perspective on fertilizer choice by sharecroppers

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Abstract

Peanut and corn are two major crops in the tri-state area of the southeast USA, an area encompassing north Florida, southwest Georgia, and southeast Alabama. Sharecroppers in this region apply higher amount of input in crop production than the average farmers. We analyzed the behavior of sharecroppers in this region with regard to their fertilizer application decisions. Two hypotheses were formulated and tested based on sharecroppers' fertilizer application decisions: one assuming that sharecroppers are risk-averse farmers and the other assuming that sharecroppers are regret minimizers. Our results show that a sharecropper uses different fertilizer treatments when minimizing risk depending on risk perspective and desired income. Sharecroppers who apply more fertilizer to obtain a desired level of income are regret minimizers where as sharecroppers who apply relatively low fertilizer are risk minimizers. At the same desired level of income, a regret minimizer farmer would apply a higher amount of fertilizer than the risk-averse farmers. Our analysis revealed that sharecroppers in the southeast USA are regret minimizers as they apply a higher amount of fertilizer than an average farmer on the major crops grown in the region. The result of this study also confirms the result of a previous study in the region which reported that sharecroppers in the region are over capitalized and apply more fertilizer than average farmers.

Keywords: Southeast USA; Sharecroppers; Regret minimizer; Risk averse; Peanut–corn rotation

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1. Introduction

Sharecropping has been an accepted form of land tenancy in the southeastern USA since the antebellum period (Wells, 1987). It is still a common mode of land tenancy for producers in the region using a peanut–corn rotation (M. Lamb, personal communication). Lamb estimates that peanut–corn sharecropping accounts for 10% of the total cultivated acreage under this two-crop rotation system. In our study, sharecroppers are defined as those farmers who own capital and lease land by paying a share of the crop output to the landowners. The sharecroppers in the study area are characterized as traditional small, part-time farmers with small cash reserves, gross annual sales less than or equal to $40,000 and low rates of high school completion, compared with commercial farmers (Nelson et al., 1991).[1] In sharecropping, landlords and sharecroppers share inputs and outputs, the ratios of which depend on several factors such as productivity of the land and bargaining power of both landowner and sharecroppers (Paudel et al., 1998; Barry et al., 2000).

Nelson et al. (1991) determined in a survey of South Georgia farmers that low resource farmers (LRFs) including sharecroppers use fertilizer more extensively than commercial farmers, and tend to overuse fertilizer compared with efficient levels. LRFs in this region use fertilizer least efficiently of all variable inputs. At the same time, fertilizer is the primary limiting input for corn rotated with peanuts in the region. The Alabama Cooperative Extension Service (ACES) estimates the total expense of fertilizer to be $55 per acre per year, which represents about 35% of variable cost in corn production (Crews et al., 1994). Thus, improving efficiency in fertilizer use would enhance sustainability of sharecroppers.

Traditionally, efficiency of the risk-averse sharecropper has been considered for the case of nonvarying input levels, where only one treatment choice is selected by the sharecropper for an entire field. The input application decision in this situation is similar to that of an efficient landowner (Baron, 1982; Otsuka and Hayami, 1988; Allen and Lueck, 1993). If sharecroppers had the choice of negotiating varying input levels, such as fertilizer treatments, the outcomes should reflect their risk perspective and offer insight into the reasons LRFs overuse fertilizer.

We examine the case of peanut–corn sharecroppers in Alabama. The decision variables are acres on which different fertilizer combinations are applied, with five discrete combinations of nitrogen, phosphorus, and potash (NPK) representing the proportions of primary nutrients. We apply two risk objectives — minimization of negative income deviation and income regret minimization — to evaluate whether sharecroppers' fertilizer choices are influenced by their risk perspective. If so, contractual arrangements that account for risk perspective would be needed to improve the sustainability of these LRFs, as opposed to merely enlarging farm size as recommended by Jones (1991). The specific objectives of this study are:

1. to find the behavior of sharecroppers under two commonly used risk hypotheses;

[1] All monetary units are given in US dollars.

2. to explain the nature of different sharecroppers in each of these risk categories; and
3. to explain how these risk models are useful in identifying sharecropper input decision behavior.

2. Rationale

Most studies in sharecropping have emphasized that sharecroppers apply less inputs than landowners (Bernat, 1987; Eswaran and Kotwal, 1985; Reid, 1979). However, this claim is only expected when sharecroppers are considered risk neutral. When risk is considered in sharecropping, the optimal input application behavior of a sharecropper changes drastically. The high input application behavior of sharecroppers is counterintuitive if analyses reflect risk neutrality. In the current farming system in both developed and developing countries, sharecropping is practiced when sharecroppers try to minimize risk in farming. Therefore, input and output risk perspective in sharecropping is necessary to analyze sharecroppers' behavior when uncertainty persist due to environmental and market phenomenon. The risk perspective used in this study could also be applied in developing countries to determine the behavior of sharecroppers based on the major input application in farming systems.

3. Reasons for sharecropping and two hypotheses on input applications

Reasons for sharecropping include limited technology, poor education, low wages, and imperfections in factor markets for owner's land and sharecropper's labor (Chew, 1993). The main reason for sharecropping in the southeastern peanut region is to obtain economy of size (M. Lamb, personal communication). LRFs tend to be overcapitalized, with machine sizes too large for the number of acres farmed (Nelson et al., 1991). A sharecropping contract may enable a LRF to improve the efficiency of mechanization by increasing the amount of land farmed.

According to Chew (1993), sharecropping is usually coincident with unsophisticated technology and relatively low land productivity, so that monitoring sharecropper efficiency is not required. The landowner may resist adoption of expensive technology by a sharecropper if the output share returned by the technology is less than the cost share or loan invested by the landlord. The choice of several different fertilizer treatments in corn has potential for increasing yield without a large cost share by the landlord, and may represent an alternative to capital investment for increasing landowner and sharecropper income above variable cost (IAVC). IAVC is the net difference between gross income and total variable cost.

The sharecropper's risk perspective depends on the landowner's goals as well as his or her own. Given that the contractual arrangement binds the landowner's and the sharecropper's financial well-being together, there is an incentive for each to convince the other to adopt the desired risk perspective. If the sharecropper dominates, we hypothesize that risk minimization is the goal, such that negative deviations from the average IAVC expected over a planning horizon is minimized. With limited off-farm employment, capital and land, southeastern sharecroppers who are LRFs want to avoid falling below a maintenance income level. This is critical in the region since the average annual net farm income of LRFs is at or below the poverty line (Jones, 1991).

If the landowner dominates, we hypothesize that regret minimization is the goal. Regret is the difference between IAVC that would result with perfect foresight about the profit-maximizing production choices and IAVC realized from the actual choices. The southeastern landowner's household income is likely to come from both farm and off-farm sources, so staying above a floor in the farm portion is less a concern than getting as close as possible to a ceiling. The landowner wants to minimize the cost of bad decisions on the part of the sharecropper by contracting for the best possible management to maximize yield without incurring costs that offset the yield gains.

We model the two risk perspectives — minimizing negative income deviation (hereafter referred to as "risk minimizing") and minimizing income regret (hereafter referred to as "regret minimizing") — using linear programming methods and compare the results to observed conditions in the region. For the risk minimizing sharecropper, we use the Minimization of Total Absolute Deviation (MOTAD) model developed by Hazell (1971). In our example, a sharecropper plans to maintain his or her IAVC above the average IAVC by choosing corn acreage allocated to each fertilizer level.

The MOTAD model punishes the selection of enterprises that increase the negative deviation of IAVC, a property not present in risk programs such as the mean-variance (E-V) model. We examine how fertilizer-acreage allocation and risk tolerance adjust to varying target income levels.

4. Model development

4.1. Profit maximization equation

The sharecropper–landowner relationship in the southeastern USA is characterized by output and variable input cost sharing. Profitability for the sharecropper is based on his or her IAVC. Total IAVC from corn and peanuts in a given year is:

$$\begin{aligned}\mathrm{IAVC} = {} & \alpha\left(\sum_{i=1}^{5} A_i Q_i P_\mathrm{c} + A_\mathrm{p} Q_\mathrm{p} P_\mathrm{p}\right) \\ & - \beta\left(\sum_{i=1}^{5} r_i A_i + \sum_{i=1}^{5}\sum_{j=1}^{5} r_j x_{ij} A_i + \sum_{k=1}^{6} r_k x_k A_\mathrm{p}\right) \qquad (1)\end{aligned}$$

where A_i is acres of corn on which the ith fertilizer treatment is used and A_p are acres of peanuts, Q_i and Q_p are yields of corn in bushels per acre per fertilizer treatment and peanuts in tons per acre, and P_c and P_p are output prices for corn in US dollars per bushel and for peanuts in dollars per ton. The first term in Eq. (1) represents revenue from the two enterprises with α being output share. The second term in Eq. (1) is variable cost for the enterprises, in which r_i is the cost of the ith fertilizer level, A_i is acreage by fertilizer treatment, r_j and x_{ij} are the per unit cost of the jth category of other corn inputs and the quantity used per acre per fertilizer treatment, r_k and x_k are the per unit cost of the kth category of peanut inputs and the quantity used per acre and β is the input cost share.

Acreage summed across all corn fertilizer treatments is equal to total corn acreage, with $A_i \geqslant 0$ for all i treatments. Other variable corn inputs include machinery, post-harvest activities, herbicides, pesticides and soil amendments. Variable peanut inputs are the same five categories as for corn, plus P-K fertilizer. A sharecropping system is defined for $0 < \alpha, \beta < 1$, with the landowner's shares equal to $(1-\alpha)$ and $(1-\beta)$. We assumed output and input cost shares equal 0.5. This avoids the necessity of accounting for welfare losses incurred under sharecropping (Chaudhuri, 1994). Also, this assumption is consistent with unrestricted bargaining between landowner and sharecropper, with reservation wage equal to zero, which reflects conditions in the southeastern USA (Arce, 1995). Eq. (1) may be used to calculate per acre IAVC of either of the two enterprises by setting the value of acreage for one crop to zero and the other to one. The detailed information about variables used and their units are presented in Table 1.

4.2. The MOTAD Model

We formulated the MOTAD model for the peanut–corn sharecropper as:

$$\underset{\lambda, A_i}{\text{Min.}} \sum_{t=1}^{T} Z_t^- \tag{2}$$

subject to:

$$(I_{pt} - \overline{I_p})A_p + \sum_{i=1}^{5}(I_{it} - \overline{I_i})A_i + Z_t^- \geqslant 0 \qquad \text{all } t \tag{3}$$

$$\overline{I_p}A_p + \sum_{i=1}^{5}\overline{I_i}A_i = \lambda \tag{4}$$

$$\sum_{m=1}^{6} L_{pm}A_p + \sum_{m=1}^{6}\sum_{i=1}^{5} L_{cmi}A_i \leqslant 5200 \tag{5}$$

$$A_p + \sum_{i=1}^{5} A_i \leqslant 400 \tag{6}$$

Table 1
Variable definitions used in the risk models

Variable	Definition (unit)
Profit Function	
IAVC	Income above variable cost ($)
α, β	Output and input share for a sharecropper
A_i	Corn acreage
A_{p}	Peanut acreage
Q_{p}	Per acre peanut yield (tons)
Q_i	Per acre corn yield with *i*th fertilizer treatment (bushel)
P_{p}	Peanut price ($/tons)
P_{c}	Corn price ($/bushel)
r_i	Cost of *j*th category of peanut input ($/treatment)
r_j	Cost of *j*th category of corn input ($/treatment)
r_k	Cost of *k*th category of corn fertilizer ($/treatment)
x_{ij}	Quantity of *j*th category of input used in *i*th type of corn
MOTAD Model	
Z_t^-	Negative deviation of IAVC from the mean ($)
$I_{\mathrm{p}t}$	IAVC obtained from peanuts in year *t* ($)
I_{p}	Average IAVC from 30 years of peanut rotation ($)
λ	Desired income ($)
$L_{\mathrm{p}m}$	Labor used in peanut in *m* bimonthly period (h)
$L_{\mathrm{c}mi}$	Labor used in *i*th corn management in *m*th bimonthly period (h)
Regret Model	
R_t	Regret in any given period *t* ($)
I_t^*	The largest possible IAVC in time period *t* ($)
x_k	Quantity of corn fertilizer used in treatment *k*

$$A_{\mathrm{p}} = \sum_{i=1}^{5} A_i \tag{7}$$

$$A_{\mathrm{p}}, A_i, Z_t^- \geqslant 0 \qquad \text{all } i, t \tag{8}$$

In Eq. (2) the objective is to choose acreage at each fertilizer level, A_i, and the target income, λ, to minimize, Z_t^-, the negative deviation of IAVC from its mean over the sharecropper's planning horizon $t=1$ to T. Eq. (3) requires that income deviations in all years, $(I_{\mathrm{p}t} - \bar{I}_{\mathrm{p}})A_{\mathrm{p}}$ for peanuts and $\sum(I_{it} - \bar{I}_i)A_i$ for corn, at least cover the negative income deviation. Income is per acre IAVC from Eq. (1), multiplied by appropriate acreage choices. Eq. (4) defines the target income as equivalent to the average from the corn and peanut enterprises over T.

Labor use in peanuts, $L_{\mathrm{p}m}A_{\mathrm{p}}$, and corn, $\sum L_{\mathrm{c}mi}A_i$ for all i fertilizer levels, is summed across six two-month increments to match the activities on the farm. According to Eq. (5), total labor use must be no more than 5200 hours available from the sharecropper and his or her spouse working half the year at 40 hours per week and half at 60 hours per week. In practice, this constraint is rarely binding, so extra labor is not typically purchased by the sharecropper. The variables and parameters used in this model, their definitions, and their unit of measurement are presented in Table 1.

The peanut–corn farm is constrained to be no larger than 400 acres in Eq. (6). This is the average size of a commercial peanut farm in Georgia and southeast Alabama, which is a reasonable upper limit for sharecroppers to aspire to operate in order to gain economy of size (Nelson et al., 1991). Eq. (7) requires that corn and peanut acreage be equal, consistent with a crop rotation system in which the two crops alternate on the same field in subsequent years so that half of the acreage on the farm is in each crop in any year. Thus, choice of all A_i determines A_{p}. Eq. (8) gives the nonnegativity constraints.

We assume that as long as the sharecropper can pay back the total portion of the cost share after harvest, he or she obtains capital for variable cost for the next season from the landowner. Since production credit from landlord to tenant is common in sharecropping, we do not include a production capital constraint in this study (Braverman and Stiglitz, 1986).

The maximum possible target income is obtained by optimizing the model subject to the resource constraints in the absence of risk. We parametrically reduced λ and analyzed the effect on the sharecropper's corn acreage decisions, A_i, and risk tolerance, Z_t^-. IAVC varies with yield even though input choices are the same each year. We set T equal to 30 years, the average duration of a peanut farmer's career.

4.3. The regret minimizing model

To model the regret minimizing sharecropper, we adopted the linear programming model suggested by Hazell (1970). As with risk minimization, the idea is to avoid loss, but the loss is defined as a missed opportunity to receive the highest (perfect foresight) income, not a drop in income below a threshold. Thus, regret minimization is a more optimistic view of risk, where the fear is that the realized outcome is below the maximum possible income, which may be substantially higher than the target income that guarantees household survival.

When more than two choices exist, any choice may influence the regret experienced with all others. Even a choice not selected may influence which of the alternative actions is taken (Sugden, 1995). Thus, given several fertilizer treatment choices, even if one choice produces a high probability that target income will be attained, that choice may result in low yield, guaranteeing that the maximum possible income level is not attainable. To avoid losing the chance to attain the maximum income, the regret minimizing sharecropper selects the most intensive, highest yielding fertilizer treatment of those that meet the target income.

The sharecropper minimizes the difference between the greatest possible IAVC, I_t^*, and the realized IAVC, I_t, for the planning horizon, T. The difference between I_t^* and I_t is the regret. With perfect foresight, the combination that generates I_t^* would always be chosen and regret would equal zero. Since the decision cannot always be perfect, regret is nonnegative.

We model the decision of a regret minimizing sharecropper as:

$$\underset{\lambda, A_i}{\text{Min.}} \sum_{t=1}^{T} R_t \tag{9}$$

subject to:

$$\overline{I}_{\text{p}} A_{\text{p}} + \sum_{i=1}^{5} \overline{I}_i A_i = \lambda \tag{10}$$

$$I_t^* - I_{\text{p}t} A_{\text{p}} - \sum_{i=1}^{5} I_{it} A_i \leqslant R_t \qquad \text{all } t \tag{11}$$

$$\sum_{m=1}^{6} L_{\text{p}m} A_{\text{p}} + \sum_{m=1}^{6} \sum_{i=1}^{5} L_{\text{c}mi} A_i \leqslant 5200 \tag{12}$$

$$A_{\text{p}} + \sum_{i=1}^{5} A_i \leqslant 400 \tag{13}$$

$$A_{\text{p}} = \sum_{i=1}^{5} A_i \tag{14}$$

$$A_i,\ R_t \geqslant 0, \qquad \text{all } i, t \tag{15}$$

where R_t is the regret for year t. I_t^* is determined by optimizing the risk-free decision for each time period, specified as the upper limit on realized income in Eq. (11).

Eq. (10) defines the target income as equal to the average from the corn and peanut enterprises over T. When λ is parametrically varied, the regret-target income frontier may be traced. Each acreage choice in this set generates the minimum regret (risk tolerance) that a farmer experiences for the target income. Eqs. (12)–(15) are resource and nonnegativity constraints identical to those in the MOTAD model. The detail on variables used in this model, their definitions, and their measurement units are shown in Table 1.

5. Model simulation

The five fertilizer treatments available to the sharecropper were based on recommended and applied corn fertilizer levels for the southeastern USA. In pounds NPK per acre, the five treatments were 120–25–40 (Corn1), 130–30–40 (Corn2), 140–35–40 (Corn3), 150–40–40 (Corn4), and 160–45–40 (Corn5). ACES recommends 150–40–40 (Corn4) for corn grown in rotation with peanuts in Alabama (Crews et al., 1994). The discrete nature of the treatment choices is consistent with the fixed relationships among macronutrients in crop production.

Peanut and corn yields for recommended practices with these five fertilizer treatments were simulated for a 30-year time horizon using the EPIC software developed by the US Department of Agriculture (USDA, 1990a, 1990b). The expected corn yields in bushels per acre associated with the five fertilizer levels were 67.19 (Corn1), 69.97 (Corn2), 72.58 (Corn3), 75.12 (Corn4), and 77.51 (Corn5). Peanut and corn input requirements and prices were obtained from enterprise budgets developed by ACES (Crews et al., 1994). We used the same data for the MOTAD and regret models.

The upper limit on λ was \$25,238, obtained by optimizing the models under risk neutrality. The risk tolerance (negative deviation or regret) — mean IAVC frontier was traced by parametrically reducing λ. For the risk minimizing sharecropper, we set \$5000 as the lower limit on λ to simulate fertilizer allocation according to the actual IAVC for LRFs in the southeastern USA, calculated at \$5100 (Jones, 1991).

6. Results

6.1. Risk minimizing situation

Table 2 shows the results of the MOTAD simulation for the risk minimizing sharecropper. At the maximum desired income of \$25,238, total absolute deviation was \$5521, which quantifies the sharecropper's risk aversion. Of 200 acres planted to corn, this sharecropper would allocate nine acres at fertilizer level Corn2 and 191 acres at fertilizer level Corn3.

The sensitivity analysis showed that allocation of acreage by fertilizer level changes as income goals and risk decline. At desired IAVC of \$25,200, with mean absolute deviation of \$5352, the sharecropper applies the lower fertilizer level, Corn2, on 142

Table 2
Behavior of a risk minimizing sharecropper

Desired IAVC (US\$)	Mean absolute income deviation (US\$)	Acreage allocation by fertilizer level[a]		
		Corn1	Corn2	Corn3
25,238	5521		9	191
25,200	5352		142	58
25,100	5305	199		
25,000	5278	198		
20,000	4198	158		
15,000	3149	119		
10,000	2099	79		
5000	1050	39		

[a] Corn1, Corn2 and Corn3 correspond to corn fertilizer levels 120–25–40, 130–30–40 and 140–35–40 in pounds NPK per acre, respectively. Peanut acreage is equal to the sum of corn acreage.

acres and applies Corn3 to only 58 acres. At these expected income-risk combinations, the sharecropper cultivates all available acreage.

As desired IAVC and risk decline, total acreage cultivated decreases, and the fertilizer level is reduced and collapsed into only one treatment. At expected IAVC \$25,100, and total absolute deviation \$5305, the sharecropper plants 199 acres of corn (and 199 acres of peanuts) with the lowest fertilizer treatment, Corn1. With further risk reduction associated with successively lower income requirements, the sharecropper continues to reduce crop acreage. At \$5000 desired IAVC, mean absolute deviation is \$1050 and only 39 acres of corn are planted using Corn1, along with 39 acres of peanuts. Under no circumstances does the risk minimizing sharecropper apply more intensive fertilizer than Corn3.

The risk minimizing sharecropper with low income aspiration and relatively low risk tolerance chooses the least intensive fertilizer treatment. Greater income requirements are associated with higher risk acceptability and with more intensive corn fertilizer applications on more acreage. The sharecropper may bring more land into cultivation to meet a higher income desired, at the same time increasing risk undertaken.

6.2. *Regret minimizing situation*

Table 3 gives the results for the regret minimizing sharecropper. At the highest desired IAVC of \$25,238, the sharecropper's income regret is \$10,700, and all 200 acres are treated with Corn3, the intermediate fertilizer combination. Income regret declines with desired income and acreage is allocated between fertilizer treatments Corn4 and Corn5. At desired income equal to \$25,200, regret is \$10,430, 72 acres of corn are treated with Corn4 and 128 acres are treated with Corn5. All acreage is planted, so the sharecropper also cultivates 200 acres of peanuts. Greater reliance on Corn5 is associated with reduced income regret, as the higher fertilizer intensity permits the sharecropper to reduce the gap between I_t^* and realized IAVC by increasing yield.

Table 3
Behavior of a regret minimizing sharecropper

Desired IAVC (US\$)	Regret income (US\$)	Acreage allocation by fertilizer level[a]		
		Corn3	Corn4	Corn5
25,238	10,700	200		
25,200	10,430		72	128
25,190	10,393		27	173
25,180	10,373			200
25,100	10,412			199
25,000	10,462			198
20,000	13,428			158
15,000	16,500			119

[a] Corn3, Corn4 and Corn5 correspond to corn fertilizer levels 140–35–40, 150–40–40 and 160–45–40 in pounds NPK per acre, respectively. Peanut acreage is equal to the sum of corn acreage.

At desired IAVC equal to $25,180, regret is minimized over the range of all desired incomes for this sharecropper. Regret is $10,373 and all 200 acres of corn are fertilized at treatment Corn5, the most intensive nutrient level. These values are an inflection point in the regret-IAVC frontier. As desired IAVC decreases to $25,100, regret increases to $10,412 and though all acreage receives fertilizer treatment Corn5, cultivated area declines to 199 acres. At even lower desired incomes, regret increases and acreage planted decreases, with Corn5 remaining the preferred fertilizer level. Finally, income regret of $16,500 for the planning horizon exceeds desired IAVC of $15,000, and corn acreage is reduced to 119 acres.

As desired income declines, it is more probable that realized IAVC will meet the target. The desired income can be attained with various combinations of fertilizer treatments, but greater fertilizer intensity reduces the difference between I_t^* and realized IAVC by giving higher per acre yields. As desired income declines, so does regret, as long as it is possible to realize IAVC closer to I_t^* by using more intensive fertilizer applications. Acreage reduction at Corn5 forces regret higher because I_t^* remains the same at Corn5 while realized IAVC is pulled down by declining desired income.

6.3. *Risk minimizing versus regret minimizing situations*

Tables 2 and 3 show that at the highest possible IAVC, $25,238, the risk minimizing sharecropper and the regret minimizing sharecropper both allocate all 200 acres, with most treated at the intermediate fertilizer level, Corn3. As desired income declines, the risk minimizing sharecropper responds by first reducing intensity of fertilizer application, then reducing acreage once constrained at the lowest fertilizer level, Corn1. The regret minimizing sharecropper responds by first increasing the intensity of fertilizer application, then reducing acreage once constrained at the highest fertilizer level, Corn5.

The same amount of acreage is cultivated under either risk perspective for given desired income levels, so that at $\lambda = \$25,000$, 198 acres are planted, at $\lambda = \$20,000$, 158 acres are planted and at $\lambda = \$15,000$, 119 acres are planted. This is due to the identical form of the desired income constraints, Eq. (4) in the MOTAD model and Eq. (11) in the regret model. In adjusting to declining income expectations, the per unit cost of fertilizer at each treatment is traded off with the yield improvement from using more fertilizer, resulting in the acreage changes.

Risk minimizing sharecroppers manage downside income risk by reducing intensity of fertilizer, using progressively lower intensity on the same number of acres. In this way, they reduce the risk that the more costly fertilizer will fail to produce enough income to meet their target. At desired income below $25,100, the sharecropper cannot reduce costs by reducing fertilizer, so instead he or she reduces acreage. Corn1 is the lower limit on fertilizer intensity, so acreage must decline in response to the tightened risk tolerance associated with declining desired income. The total fertilizer cost for Corn1, r_1A_1 in Eq. (1), and by extension, cost in $\sum(I_{it} - \bar{I}_i)$ in Eq. (3), is reduced and risk (negative deviation) is minimized for the desired income.

Regret minimizing sharecroppers react to lower desired incomes by increasing fertilizer intensity in order to realize income as close as possible to the maximum possible income level. Allocation of acreage shifts from all 200 acres in Corn3 to a split between Corn4 and Corn5, with Corn5 dominating. At desired income below \$25,100, less than 200 acres are planted at the highest fertilizer treatment, Corn5. As desired income declines, the divergence of realized IAVC from I_t^* in Eq. (10) increases so income regret increases, indicating lower tolerance for risk of making the wrong production decision. The sharecropper applies less of the highest intensity treatment when constrained from choosing intensity higher than Corn5 because additional acres at Corn5 add more to the optimal income, I_t^*, than to realized income, $\sum I_{it}A_i$, making regret larger as desired income declines. Desired income can be met at least cost with less acreage in Corn5, but lower desired incomes cause greater divergence between realized and maximum income.

Under both risk perspectives, at desired income below \$25,180, acreage is not fully utilized even when it is available if fertilizer rate is not permitted to change. The risk minimizing sharecropper would prefer to plant all 200 acres of corn only if at intensity less than Corn1 and the regret minimizing sharecropper would prefer to plant all 200 acres of corn only if at intensity greater than Corn5. In both cases, the risk tolerance decreases as desired income decreases. Both choices are bounded, so that acreage must be reduced when desired income falls in order to minimize risk.

The different risk measures cause the intensity level chosen to move in opposite directions. For the risk minimizer, only the effect on realized income matters, so the lowest intensity that can meet desired income is chosen. For the regret minimizer, the difference between realized and maximum possible income matters, so to have a chance to realize the optimum, the highest intensity is chosen.

7. Conclusions

Our analysis shows that a sharecropper uses different fertilizer treatments when minimizing risk depending on risk perspective and desired income. If a sharecropper practicing a peanut–corn rotation is constrained to select only one level of corn fertilizer, less or more than the optimal amount of fertilizer for the risk perspective may be applied. Variations in fertilizer use due to risk behavior are obscured if the acreage allocation decision is modeled with only one fertilizer choice.

Regardless of risk perspective adopted, the sharecropper does not use all available acreage as desired income declines. Our model constrains cultivation to an upper limit of 400 acres, but not all of this is farmed under certain risk-income scenarios described in Tables 2 and 3. At decreasing tolerance for risk a sharecropper can obtain the desired level of income with less acreage than the total available land.

The same desired income is attainable with either Corn1 or Corn5, but the risk perspective determines which fertilizer intensity is selected. The observed intensity of fertilizer use may suggest the risk attitude of the sharecropper. Consistent with the application of Sugden (1995), higher input application would be expected for a regret minimizer. Higher inputs application costs more per unit to use but generates more yield per unit of input, making it more likely the sharecropper can realize the desired income.

The typical Southern LRF has a mean operation size of 72 acres, generating approximately $5100 IAVC (Jones, 1991; Nelson et al., 1991). Our models suggest that at desired income equal to $5000, the sharecropper would farm 78 acres (39 each in corn and peanuts) under either risk perspective, with fertilizer intensity Corn1 if a risk minimizer, and intensity Corn5, if a regret minimizer.

Nelson et al. (1991) showed with allocative efficiencies that southern LRFs overuse fertilizer, but underuse land. Consistent with this study, our analysis suggest that the regret minimizing risk perspective is relevant to describe southern sharecroppers. This would mean that the landowner's interests dominate the cropping decisions. The landowner's ability to dominate the risk perspective would depend on labor supply for sharecropping and other wage earning opportunities.

Jones (1991) noted that larger farm sizes are needed to raise income for LRFs, but attention must be paid to the sharecropper's risk perspective since income desired and risk tolerance affect input intensity and extent of acreage. Nonfarm wage earning options not only raise income for LRFs as suggested by Jones (1991), but also enable sharecroppers to make input choices according to their own risk perspectives.

The results obtained in this southeast USA peanut–corn based study are anticipated for other enterprise and regions. However, this could be shown only by applying the method used in this study to the data and problem situations in other regions to identify the behavior of sharecroppers with regard to their input application decision.

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