Risk

Safety-First, Gambling, and the

Subsistence Farmer

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I. Introduction

Recent papers discussing the plight of the low income farmer have hypothesized that their small land holdings cause them to be risk averse in their crop planting decisions. For example, Falcon (1964), Mellor (1966), Boussard and Petit (1967), Behrman (1968) and Lipton (1968) contend that fluctuations in prices and yields lead small farmers to grow a larger proportion of their land with food crops which promise a lower expected return than the cash crop. Similarly, Porter (1969), Schultz (1964), Wharton (1968), and Roumasset (1971) hypothesize that a new innovation, such as new rice technology, will not be readily adopted by low-income farmers because of their inability to bear substantial risk.

In apparent contrast to these analyses, there is in fact empirical evidence that in many cases farmers with the smallest holdings of land will plant a larger percentage of their land in cash crops than those with somewhat larger farms, often a percentage comparable to that of the very largest enterprises. Table 1 presents illustrative data for three such cases: jute planting in Mymensingh (the largest jute growing district in Bangladesh), Nigerian cocoa farming, and cotton farming in the late 19th-century U.S. South.

It is easy to understand that high-income farmers would be in a position to grow a larger proportion of their land with the crop having

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Table 1

Proportion of Land Devoted to Cash and Food Crops

Bangladesh (Mymensingh District)			Nigeria (96 Farms)			U.S. South (1880)		
Acreage Class	Percent of Land Cash Crop (Jute)	Percent of Land Food Crop (Rice)	Acreage Class	Cash Crop (Cocoa)	Food Crops	Acreage Class	Percent of Land Cash Crop (Cotton)	Percent of Land Food Crop (Corn)
0- 0.49	39.1	60.9	0-1.99	52.8	47.2	0-49	50.41	49.59
0.5-0.99	28.8	71.2	2-3.99	42.5	57.5	50-99	46.46	53.54
1.0-2.49	24.5	75.5	4-6.99	39.2	60.8	100-199	45.13	54.87
2.5-4.99	23.8	76.2	7-9.99	57.8	42.2	200 & over	58.20	41.80
5.0-7.49	24.5	75.5	10-12.99	57.6	42.4			
7.5-12.49	24.8	75.2	13-15.99	64.4	35.6			
12.5 & over	26.3	73.8	16 & over	76.5	23.6			

Sources: Pakistan Census of Agriculture (1960) Vol. 1, East Pakistan
R. Gallelli, et al, Nigerian Cocoa Farmers (1956)
R. Ransom and R. Sutch (1973), private communication.

the highest expected return and variance, but why would the lowest income farmers want to gamble? One possible explanation would be that the farmer has a utility function which decreases sharply at some critical income level so that he prefers to gamble in order to avoid poverty.[1] Such behavior would be the obverse of that postulated by Friedman and Savage (1948) where the individual gambles in order to become wealthy. The principal difference is that the Friedman-Savage individual who loses the lottery can survive without taking drastic action while the farmer who does not have enough to feed his family will be forced to borrow or starve.

The approach taken in this paper explicitly postulates that the subsistence farmer focuses on short-run goals such as minimum income as a basis for determining his crop allocation. Such an approach, we believe, has an advantage over the expected utility model in that it more closely corresponds with the terminology of real farmers and hence may be more easily amenable to survey techniques at the micro level. The approach also implies that a behavioral kink exists at a critical income level; the kink may be due to either psychological or economic factors, rather than a generalized rate-of-preference for goods. Psychological factors, such as losing face by having to borrow, would encourage individuals to focus on a short-run income goal. Similar incentives would exist if there were imperfections in the capital market so that the cost of borrowing for low

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[1] Masson (1974) has hypothesized that the utility function might have a kink at a critical income level for reasons similar to those by which we rationalize the "target". He presents evidence for the hypothesis, using data by O'Mara (1971) on diffusion of technology in a Mexican farm project.

income farmers is considerably higher than the market rate. Masson (1972) has shown that such imperfections with or without transactions costs would lead risk-neutral individuals to behave as if they were risk-averse. He has not examined the case, considered in this paper, where an individual must borrow if his income falls below a critical level.

At the outset, the point deserves emphasis that the cash crop will in fact be the risky choice for a subsistence farmer in almost all cases. This assertion is not the result of a perverse quirk of nature, but is inherent in the process of exchange. A farmer who buys his food must consider the yield variance of the cash crop as well as the price variance for both crops; for the farmer who grows his own, only the yield variance is relevant. In the 19th century South, for example, the price and yield variances for cotton and corn were similar (the corn price variance in fact being slightly higher). But the standard deviation of corn obtained <u>in exchange for cotton</u> at market prices was four to five times as great as that of corn grown at home. In Bangladesh, the comparable ratios were between two and three (see Table 2, p.13). Hence, the model developed here may have quite general applicability, wherever the major cash crop is not also a food crop.

The next section develops a model of choice based on a lexicographic preference order which stresses the importance of short-run goals in determining the subsistence farmer's allocation. Moderate and high-income farmers are not as likely to be affected by these short-run goals, in which case their crop allocation will be based on maximizing some long-run objective function such as expected net return. Subsequent sections illustrate the applicability of the model in explaining patterns of choice between jute and rice in

Bangladesh and cotton and corn in the 19th-century South. The concluding section discusses policy implications of the model.

II. Framework for Analysis

Economists such as Georgescu-Roegen (1954), Chipman (1971), Encarnacion (1965) and Day (1970) have proposed models of choice based on hierarchical goals (i.e. a lexicographic order) to analyze decision making under uncertainty. Parallel developments in behavioral science and organization theory by Simon (1955) and Cyert and March (1963) have indicated that individuals and firms make decisions based primarily on satisfying short-run goals rather than long-run objective functions.[1] The model developed below integrates concepts from these two theories by utilizing the Arrow-Hirshleifer state preference approach. The approach also builds on Tobin-Markowitz portfolio analysis by stressing the importance of risk and return in farmers crop allocation decisions.

Consider a farmer with present wealth (W_o) which can be allocated to activities x and y next period. The value of W_o consists of a certain amount of land as well as labor and capital, and his decision governs the amount of land devoted to the subsistence crop such as rice or corn (x) and the cash crop such as jute or cotton (y). The future is represented by a point in time (time 1) in which, for simplicity, we will assume there are two alternative states of nature-- either a normal year (state a) or an extreme year (state b) with respective probabilities of occurrence p_a and p_b. The extreme year may be caused by some natural hazard such as a flood or drought. If W_o is invested solely in x, then the net return at time 1 is a random variable X which can take on one of two values, X_a or X_b. The random variable Y is defined in a similar manner.

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[1] Fishburn (1974) presents an excellent survey of the literature on the theory of lexicographic orders and its use in models of preference and choice.

Let m represent the proportion of W_o allocated to activity x with the residual 1-m allocated to y. Each value of m represents a distinctive adjustment by an individual to future states of nature. Following Arrow (1964) and Hirshleifer (1970) we will designate the outcome of a specific allocation decision after a particular state of nature has occurred as a state of the world. Since there are only two states of nature in this example, each value of m implies two possible states of the world, Z^a and Z^b, for wealth at the end of period (W_1). Thus if m=1 the two possible states of the world are $Z^a=X_a$ with probability p_a and $Z^b=X_b$ with probability p_b; when m=0, then Y_a and Y_b are the two possible states of the world. If an individual diversifies by allocation 2/3 of W_o to activity x (i.e. m=2/3) and the remainder to y, then with constant returns to scale, $Z^a= 2/3X + 1/3Y_a$ with probability p_a and $Z^b=2/3X_b + 1/3Y_b$ with probability p_b.

The individual is assumed to allocate his initial wealth in such a way as to maximize some objective function (e.g. expected return) but he has certain goals which may constrain his behavior. For example a farmer may want to maximize the expected return from his land but has certain minimum requirements which may be critical to his future survival as well as desired cash reserves which he would like to have on hand at the end of the season. The individual is assumed to be able to rank these goals in order of importance to him, with 1 being the most important goal and R the least. In this two goal example the subsistence requirement would normally be ranked number 1.

The possible outcomes of each goal, i, are given by a random variable Z_i with predetermined target value denoted by Z_i^*. For example Z_i may be the random variable "net return per unit of land" and Z_i^* may be the "minimum required return per unit of land". The value of Z_i^* may be determined by minimum food requirements over the course of the year. The probability distribution of Z_i will be determined by the proportion of W_o allocated to producing x and y respectively. For each goal, i, the decision maker is assumed to be willing to tolerate a maximum risk level, α_i^* that $Z_i < Z_i^*$. As will be shown in the next section the value of α_i^* may be determined by cost considerations, such as the differential between lending and borrowing costs for the small farmer, or by some personal preference function.

Given these assumptions, the appropriate model to describe an individual's behavior in allocating his land to two different crops might be

maximize

$$E\{W_1\} \qquad (1)$$

subject to

$$\text{Probability}\left[Z_i < Z_i^*\right] \leq \alpha_i^* \qquad i=1,\ldots,R \qquad (2)$$

This model is of the chance-constrained programming variety which has been treated extensively in the management science literature.[1] If there is at least one feasible solution to this problem, then the farmer chooses the portfolio yielding the highest $E(W_1)$. If, on the other hand, there is no feasible alternative which satisfies all the constraints, then the individual will be forced to relax one or more of his restrictions.

One solution to this latter problem would be to assign different penalty functions for deviating from each of the goals and trying to mini-

[1] For a recent set of references on chance-constrained programming see Eisner, Kaplan and Soden (1971).

mize the overall costs. This approach, labeled as goal programming, has recently received wide coverage in the literature.[1]

The main drawback of goal programming is that it forces the decision maker to specify simultaneously the costs of deviation from each of his goals. Not only may it be difficult to obtain these appropriate cost functions, but it is somewhat unrealistic to assume that in practice a decision maker will modify all his constraints simultaneously. Rather, as Cyert and March (1963) have argued, he is likely to change one constraint at a time to see if he can obtain a feasible solution.

Such a procedure implies a decision rule based on a lexicographic order. Specifically the farmer is assumed to modify his constraint set by using a system of priorities dictated by the relative importance of each of the goals, lowered-numbered goals being more important than higher-numbered ones. If he cannot satisfy all goals he will first accept a lower probability of achieving goal R than any of the others. His modified objective is thus

maximize

$$\text{Probability}\left[Z_R > Z_R^*\right]$$

subject to

$$\text{Probability}\left|Z_i > Z_i^*\right| \leq \alpha_i \qquad i=1,\ldots,R-1$$

[1] For a discussion of goal programming and list of references see Dyer, (1972) and

If there is still no feasible alternative, then goal R-1 will be relaxed and the first R-2 constraints will be maintained, and so on down to the last possible case where the objective function is minimize Probability ($Z_1 < Z_1^*$). In terms of the Arr Hirshleifer state-preference formulation, this approach implies that for each goal i, there is a critical state of the world Z_i^*, towards which the decision maker is aiming. Given uncertainty, he is assumed to tolerate some maximum risk level, α_i^*, that future wealth will fall below this state of the world. If the set of goals w estimated subsistence requirements during each of the next R periods, then a lexic graphic preference order would be a logical decision rule for the farmer to follow

III. Application to Crop Allocation Decisions in Bangladesh

The above model of choice can explain planting decisions by Bangladesh farmers who must decide how much of their land should be allocated to jute and the aus variety of rice. In Bangladesh jute and rice are both predominantly grown on relatively small owner-occupied farms.[1] Although the average size of jute growers' plots is somewhat greater than the average of all farmers' holdings, it rarely exceeds ten acres with 3 to 6 acres being the most common size.[2]

Aus rice is sown between the middle of February and the middle of April while jute is planted between early March and early May. Both crops are harveste between July 1 and early October. In general, land, labor and equipment are read interchangeable between the two. There is some land suitable only for rice or ju alone, but for most land a decision must be made between a subsistence crop (rice or cash crop (jute).

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[1] According to the 1960 Pakistan Census of Agriculture approximately 61 percent of all Bangladesh farms were owner-operated and another 37 percent were owner-cum tenant. The owner-operated farms contained 82 percent of total land area. For a more detailed discussion of the structure of agriculture in Bangladesh see Khan(1 pp.38-56.

[2] For a more detailed description of the economic characteristics of those farmers who grow jute and rice and the importance of the subsistence constraint, see Rabb (1965), Economy of Jute (1966) and Hussain (1969).

To illustrate the rationality of gambling behavior on the part of the subsistence farmers it is only necessary to introduce a single short-run goal-- a desired level of rice to feed one's family. Naturally such a model is oversimplified since there may be other short-run constraints such as cash requirements and available labor supply which play a role in crop allocation decisions. The lack of data on individual farms has prevented us from developing a more refined model for Bangladesh at this time. Individual farm data is available on the allocation of land between cotton and corn in the 19th-century South and these will be discussed in the next section.

For analysis purposes it is most convenient to express the crop returns and the minimum consumption requirement in terms of rice per acre since this is the critical constraint. Letting X and Y represent the net returns from rice and jute respectively, define

$X = r$

$Y = (j P_j - C)/P_r$

where

j = yield of jute per acre (in maunds)[1]

r = yield of aus rice per acre (in maunds)

P_j = price of jute per maund at the grower's level (in rupees)

P_r = current retail price of rice per maund (in rupees)

C = cost differential per acre of growing jute rather than rice (in rupees)

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[1] One maund equals 82.29 pounds.

Using (1) and (2) and assuming constant returns to scale the allocation model is

$$\max \quad E\{mX + (1-m)Y\} \tag{3}$$

subject to

$$\text{Probability}\{mX + (1-m)Y \leq Z^*\} \leq \alpha^* \tag{4}$$

where Z^* represents the minimum consumption level in rice per acre.

Those farmers who have large parcels of land or other outside income will have a sufficiently low value of Z^* that they can satisfy the minimum consumption constraint given by (4) by maximizing (3). Let A_{max} represent the acreage size above which the farmer will not be constrained by (4). Farmers with land holdings below A_{max} will have a value of Z^* sufficiently high that they will be forced to sacrifice some expected return in order to reduce the variance. These farmers will determine their crop allocation pattern by the minimum return constraint. We will designate these as safety-first farmers to indicate that their decision is based first on satisfying a predetermined safety level (α^*).[1]

The poorest farmers may find that no crop allocation pattern will yield a feasible solution as specified by (4). If Z^* remains fixed, as will be assumed here, then such a farmer will be forced to raise his acceptable risk level above α^* and will thus grow more of the high return high-variance crop. These farmers will be appropriately designated as gamblers. Let A_{min} represent the acreage size below which the farmer will be forced to gamble. For any given value of α^* a sufficient increase in Z^* (e.g. a decrease in available land) will cause the minimum return constraint to be operative. Similar behavior will be observed if Z^* remains constant and α^* decreases. Relatively high required returns (Z^*) combined with relatively low acceptable risk levels (α^*) will lead to gambling behavior.

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[1]Note that this definition of safety-first differs from the one used by Roy (1952).

To determine what region the farmer is in if his acreage is below A_{max} simply allocate land so as to satisfy the following objective function:

$$\min \left\{ \text{Probability} \left[mX + (1-m)Y < Z^* \right] \right\} \quad (5)$$

Designate the resulting risk level as α'. If $\alpha' < \alpha^*$ then there is some portfolio of activities which will satisfy both Z^* and α^*, and the farmer will be a safety-first man. By definition his acreage will be between A_{min} and A_{max}. If $\alpha' > \alpha^*$ the farmer will gamble by setting $\alpha^* = \alpha'$ and utilize the crop allocation pattern specified by (5).

For the case of farms in Bangladesh published data on agricultural yields and prices from 1947-70 were utilized to estimate sample statistical moments for Jute and rice.[1] For the eight largest jute growing district in Bangladesh see Table 2 using a value of P_r=37.5.[2] Based on a 1969-70 survey of 142 farms in the Mymensingh district (see Khan (1970)) the cost differential, C, between growing rice and jute was found to range between 28 and 110 rupees depending on surplus manpower on farms and quality of the land. Setting an upper limit of 100, the value of C for each district was chosen so that the expected return of jute was only slightly higher than for rice. Given the considerably higher variance for jute than rice there would then be little incentive

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1 A more detailed discussion of statistical data for analyses of the jute-rice planting decision appears in Kunreuther (1972). Data for the Faridpur district indicate that the normal distribution is a good approximation for X and Y and this assumption will be maintained here for convenience.

2 A 1970 survey of rice prices in Bangladesh (see Efferson (1970)) indicates that farmers in villages were paying anywhere from 35 to 40 rupees per maund for rice. For purposes of this analysis we will utilize a value of P_r= 37.5. Since rice prices have followed an upward trend since 1957 we have assumed that only the current price of rice affects the farmer's crop growing decision. For further discussion on this point see Kunreuther (1972) p. 15.

Table 2

Sample Statistics for Jute and Rice in Eight Districts of Bangladesh

Region	C	Rice (X)		Jute (Y)		Coefficient of Correlation between X and Y
		μ_x	σ_x	μ_y	σ_y	
Dacca	76	9.69	1.56	9.72	3.32	.53
Faridpur	100	8.06	1.24	8.51	3.31	.27
Mymensingh	88	9.29	1.50	9.31	3.54	.49
Comilla	89	9.40	1.38	9.45	3.27	.22
Rangpur	59	9.60	.35	9.63	3.53	.50
Bogra	64	9.05	.69	9.08	3.37	.61
Pabna	100	8.55	1.68	8.72	4.31	.50
Jessore	55	9.98	1.46	10.00	3.14	.47

Data Source : Bureau of Agricultural Statistics in East Pakistan (1947-70)

for risk-averse farmers to grow jute on homogeneous land unless their utility curve had some kinks in it.

Estimates of Z* were obtained from data assembled by Islam (1966) in his analysis of rural family budgets for seven income groups in Bangladesh based on the 1960 National Sample Survey. Total expenditures for the lowest income group indicate that they required an equivalent of 16.15 maunds of rice per year for survival.[1] This value will be utilized as an estimate of Z* in determining the pr portion of farmers who will be forced to gamble. Safety-first farmers, on the otl hand, are likely to have levels of Z* which increase as a function of acreage size

[1] The per capita monthly total expenditure for the lowest income group was 15.42 rupees (see Islam 1966). Since average family size was 5.3 and P_r=37.5 rupees this is equivalent to household expenditure of 26.15 maunds of rice per year.

For these farmers we have permitted Z^* to increase up to 61.2 maunds of rice (the equivalent expenditure for the median income group in Islam's analysis) so as to obtain a crop allocation of jute and rice which matches the actual distribution based on 1960 agricultural data.

The acceptable risk level α^* depends upon the farmer's options should his returns fall below Z^*. One possibility would be for the tenant to borrow rice from his landlord at a relatively high interest rate (payable in maunds of rice next year). The one period newsboy model utilized in inventory theory may provide a good approximation for α^* in this case.[1] If the farmer had a good year so that his return exceeded Z^*, then he would incur a per unit holding charge (h) representing the opportunity cost associated with growing more rice than required. Similarly if a poor year forced him to borrow rice he would incur a per unit shortage cost (s). In the optimal solution to the newsboy model there is a simple correspondence between the acceptable risk level and the ratio of s/h. Specifically

$$\alpha^* = \frac{1}{(1+s/h)}$$

The minimal differentials in expected return between jute and rice specified in Table 1 and the high costs of borrowing by subsistence farmers imply a large s/h ratio. The subjective "shortage cost" may in fact be very much higher than in this illustration, if the ability to borrow at all is uncertain, or if a shortfall may involve the loss of property or tenure

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[1] For a description of the newsboy model see any basic operations research text, such as Hillier and Lieberman (1967), pp. 370-77, or Wagner (1969), pp. 792-98.

status, or social embarrassment. For this example α^* has been arbitrarily assumed to be .025.

Based on the estimates of Z^* and α^* and the means and variances in Table 1, we can determine critical acreage sizes for classifying farmers in Bangladesh. Households whose farm size is less than A_{min} acres would be gamblers while those whose plots ranged from A_{min} to A_{max} would be safety-first farmers. Table 3 presents the values of A_{min} and A_{max} and the corresponding percentage of land in these two categories for each of the eight jute-growing districts in Bangladesh. Based on the one-goal model over 80 percent of the acreage in all districts except Jessore would be in either the gambling or safety-first regions.

As stated above, the simple one-goal model is illustrative rather than realistic. Considerably more data on the characteristics of individual farms are needed to utilize such a model of choice to predict actual crop allocation decisions. For example, on farms where families have outside sources of income the minimum required return per acre would be lower than if they relied solely on their land for survival. Households with large families would have surplus labor which would tend to reduce the value of C but would increase Z^* given that they have more mouths to feed.

IV. Application to Nineteenth Century Southern Agriculture

In this section the lexicographic model presented above is used to explain patterns of choice between cotton and corn in the 19th century U.S. South, and to propose an explanation for one of the enduring puzzles of Southern economic history.[1] It may at first glance seem strange to apply a

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[1] The analysis of this section is developed and documented more fully in Wright and Kunreuther (1974).

Table 3

Proportion of Farms in Gambling and Safety First Regions for Eight Principal Jute Growing Districts in Bangladesh

District	A_{min}	A_{max}	Percentage of Land In Gambling Region	Percentage of Land In Safety-first Region
Dacca	3.9	9.8	44.7	37.9
Faridpur	4.6	11.3	46.4	37.9
Mymensingh	4.1	10.4	41.3	41.1
Comilla	3.9	9.3	60.0	29.0
Rangpur	3.8	9.2	32.4	39.7
Bogra	4.6	11.1	46.6	39.0
Pabna	5.0	11.1	43.0	37.2
Jessore	3.7	8.7	21.3	47.0

subsistence-farming model to an agricultural area and period in which labor was relatively scarce and farm sizes were far larger then those of Bangladesh. But in certain fundamental respects the cotton-corn decision was similar to the choice between jute and rice. Cotton was sold for cash, corn was predominantly consumed on the farm - both directly by humans and indirectly in the form of feed for hogs. (We assume corn prices and allocation reflected both types of demand.) Most cotton farms grew a mixture of cotton and food crops, of which corn was by far the most important.

The choice between cotton and corn was primarily a question of land allocation. The labor requirements of the two crops dovetailed nicely over the growing season (Davis 1939, p. 66; Gallman 1970; Moore 1958, p. 58;

Phillips 1918, pp. 207-08; Parker 1972, pp. 181-189.) In terms of land, however, the two crops were clearly competitive. To be sure, land was relatively cheap in the 19th century, but even in 1860 improved acreage was not a free good, and land in the most fertile parts of the South brought very high prices. Post-Civil War Agriculture Department and experiment-station studies of the cost of cotton were generally couched in terms of returns per acre (Texas AES 1893; USDA 1899). Since temporary off-farm employment was typically unavailable in most parts of the South, the question of diversification may be viewed as balancing a "portfolio" of acreage in the face of uncertainties about prices and yields.

Prior to the Civil War, many small farmers of the South were largely or entirely outside the market economy. We do not have acreage and yield data for the antebellum period, but there is every reason to believe that the expected value of cotton acreage was above that of corn. Yet 96.5% of farms in the Cotton South did grow corn; still more strikingly, 27.6% of the farm grew no cotton at all, and many more grew only small amounts. Gallman (1970) has explained plantation self-sufficiency in terms of the cheapness of land and the non-competitiveness between labor requirements for the two crops. Certainly some diversification can be explained on these efficiency grounds; but these considerations cannot explain why cotton was apparently such a "marginal" crop for so many farmers.

We believe that this behavior is well-explained by the "safety-first" model, without the "gambling region" at the lower tail of the distribution ; even the "small" farmer of 1860 could ensure, with reasonable confidence, that his family would not fall below intolerable levels of subsistence. There is now considerable evidence that almost all farms in the antebellum South attempted to achieve self-sufficiency in foods at the farm level.[1] The simplest way of viewing the matter is to postulate "self-sufficiency" as a target in its own right. In terms of a lexicographic order, such a goal implies planting enough acres in corn to achieve a confidence level $1-\alpha^*$ that the yield of corn will be sufficient to meet consumption requirements. This "self-sufficiency-constraint" requires small farmers to plant a larger share of their acreage in corn. As farm size expands, however, planters with the same goal will nonetheless be much less pressed by the constraint. Unfortunately, data on acreage by crop are lacking for 1860, but the figures on relative outputs by farm size do seem to fit this pattern, as shown in Table 4.

Table 4

Corn/Cotton Ratios (bushels/bales)
by Improved Acreage Size Class
Cotton South, 1860

Improved Acreage	0-49	50-90	100-199	200-299	300-499	500-999	over 1000
Corn/Cotton Ratio	76.71	62.82	45.81	34.16	28.46	24.41	18.74

Source: U.S. Census sample (1860)

1 See especially Gallman 1970)

A slightly different way of interpreting the same data is to view self-sufficiency not as an independently-postulated goal but as a target derived from the "subsistence" constraint that real income (i.e., in corn-bushel equivalents) not fall below Z^* per acre. We assume that typical small farms of 1860 could expect to achieve Z^* with reasonable confidence by specializing in corn. Shifting into cotton would increase expected earnings, but only at the price of greater risk (α') of falling below Z^*. For small farms the point where $\alpha' = \alpha^*$ is reached early, with little or no cotton. Even if standards of "tolerable" food consumption are higher on large farms, Z^* will be lower as farm size increases as long as the "elasticity of minimum standards with respect to farm size" is less than unity,[1] and in any case, because there are generally more household members per acre on small farms.

This minimum-income target is clearly not the same as a "subsistence constraint" in any biological sense, but the interpretation is not altogether different from the case of Bangladesh. As in Masson (1972), the "kink" in the function arises not from biology or from discontinuities in the utility of consumption, but because behavior must change below some income level -- specifically, the individual must borrow or sell assets, either of which may pose a threat to the security of the farmholding. A large farm, on the other hand, may share the self-sufficiency target, but - referring back to the newsboy model - the consequences of a shortage are less serious, and hence

[1] For evidence that the elasticity of the "poverty line" with respect to income is about 0.6, see Kilpatrick (1973).

α^* will be higher. The newsboy model implies (if s/h exceeds unity) that in a normal year farmers will grow more than their minimum tolerable level of corn, perhaps even more than they want to consume in any case. Most of the self-sufficiency studies have found that such surpluses were in fact common in 1860. But these surpluses will be viewed as a source of relief and not distress, in much the way that a good hostess is not dismayed to see food left over after a party-- at least she did not suffer the embarrassment of running short.

Regression analysis using farm data from the 1860 U.S. Census sample[1] confirms that the share of acreage devoted to cotton is inversely correlated with family members per acre, and positively correlated with improved acreage. An illustrative regression, for the alluvial region, is the following[2]

$$CT = .418 + \underset{(3.91)}{.0049^{**}SQ} - \underset{(2.08)}{.156^{**}P/IA} + \underset{(2.41)}{.00017^{**}IA} \qquad (6)$$

$$R^2 = .226$$

where CT= share of acreage in cotton,[3] SQ= an index of soil quality, P= on-farm population, IA= improved acreage and ** indicates significance at the .1% level. The model would also predict the positive correlation between CT and SQ, since better land will increase the probability of

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1 For description and discussion of the sample, see Parker (1970).

2 For details of variable definitions and alternative regression procedures, see Wright and Kunreuther (1974).

3 Obtained from output data on assumption that land yields are constant for both cotton and corn.

achieving a given Z* from a given acreage.[1]

By 1880 the South was no longer self-sufficient in food, per capita production of corn and hogs falling to only half of what they were in 1860 (Ransom and Sutch 1972). Regional concentration on cotton production had markedly increased, despite the fact that relative cotton prices for the period 1876-1880 were not at all unusual compared to the 1850s. True, cotton prices had been high during the immediate post-war years 1866-76, but the region never again returned to self-sufficiency, even though relative cotton prices show no subsequent trend of any significance up to 1900 (DeCanio 1973, p. 616). Nor do relative yield trends appear to provide an explanation.

Not only had the regional crop-mix shifted, but the cross-section pattern had changed as well. Ransom and Sutch (1972) have documented the considerable extent to which small tenant farmers devoted a large share of their acreage to cotton, often more than farm owners with far greater holdings of land. An explanation for the concentration on cotton in terms of the institutional arrangements of Southern agriculture is a common theme among Southern historians. Typically it is argued that landlords and merchants-through crop-liens and informal pressures, imposed excessive cotton-growing

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[1] Results like these have considerable relevance for the measurement of total factor productivity and economies of scale in agriculture. For example, Fogel and Engerman (1974) find evidence of major economies of scale under slavery in 1860. But these results are obtained by aggregating outputs at market prices. The higher "efficiency" of plantations can be largely explained by this crop-mix effect, rather than the organizational economies stressed by Fogel and Engerman.

requirements on the tenants, who otherwise would have chosen more diversification.

The difficulty with the claim that the shift to cotton was economically perverse at the micro-level is that the price-yield-cost evidence strongly suggests that an acre of cotton land had a significantly higher expected yield in value terms than an acre of corn.[1] These differences are generally larger than the jute-rice differentials of Table 2. However, the differences in variance also are greater: σ_x (corn) average 1.6, while σ_y (cotton in corn-bushel equivalents) averages 7.4 . Assuming that a roughly similar relationship held sway before the Civil War as well, the explanation for the shift must somehow come to grips with the apparent change in behavior toward risk. The change may of course have been externally imposed on the tenants (though direct evidence of this is scanty), but our analysis suggests that it may have resulted from the quasi-voluntary decisions of the tenants (and owners of small farms) themselves, in the changed circumstances of the post-bellum South.

Why should the Southerners of 1880 have been more willing to bear risk than those of 1860? Our analysis focuses on the following three historical developments: (1) the drastic fall in average farm size, and specifically the emergence of large numbers of extremely small farms by 1860

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1 This statement is based on an extensive analysis of USDA state-level price and yield figures, and the cost-of-production figures in USDA (1899). Even when all of the costs of fertilizer, ginning and pressing, bagging and ties, marketing, implement repair and "other" expenses are assigned to cotton and not to corn, cotton retains an expected yield advantage. See Wright and Kunreuther (1974).

standards; (2) the rise of tenancy and associated systems of credit; (3) the rapid fall in the price of cotton during 1866-1875 from its historic highs after the Civil War. Our hypothesis is that these developments combined to create a class of small farmers in the "gambling" region.

The effect of the fall in farm size is to raise the minimum yield Z^* required for any given target; by itself, such a change could shift the crop mix in either direction. The former slaves, however, lacked tangible assets at the time of emancipation and hence were enmeshed willy-nilly in the market economy. Under either cash tenancy or sharecropping, a variety of changes militated against safety-first behavior: first, the system of advances during the year lessened the actual threat of falling below subsistence; second, the contraction of debts raised the amount of cash income which a tenant had to target in order to break even; third, the fact that the tenant had few assets and did not own his own farm reduced the incentive to "play it safe"; fourth, if a basic desire of the tenant farmer was to be an independent farm-owner (essentially the same desire as the safety-firsters of 1860), he now would have to target a much higher Z^* in order to achieve this goal, as opposed to maintaining it. Small farms and high targets necessitate gambling. These structural characteristics were reinforced by the course of cotton prices. The very high prices of the immediate post-war period coaxed many farmers into cotton, and the rapid fall made it difficult to get out.

Empirical verification of these hypotheses is difficult because we have no direct measure of Z^*, nor even a measure of the extent of indebtedness as a proxy. Nonetheless, we would predict a correlation between cotton-growing and the presence of tenancy and very small farms. Table 5 uses county averages for 1880 to test these predictions. Regression (7) shows that a positive overall correlation still exists between farm size and the share of acreage in cotton; however, regressions (8) through (13) show that the pattern is actually U-shaped since the coefficient associated with small farms is positive. The strong association between tenancy and cotton comes through clearly, but the U-shaped pattern is present whether tenancy is included or not. Regression (13) might be interpreted as showing that the threshold between gambling and safety-first behavior was around 50 acres for "owned" farms, whereas for tenants it was at least 100 acres.[1]

V. Policy Implications of the Model

If the lexicographic model of choice is a correct description of behavior, then a conflict is likely to arise between the economic status of the individual and optimal resource allocation from the standpoint of economic development. The group of farmers who follow the safety-first strategy may be said to have misallocated their resources by planting a substantial portion of their land with a food crop having a lower expected return than the cash crop, and this misallocation arises from the institutional arrangements of the agricultural sector rather than from ignorance or technical inefficiency. To achieve a more efficient allocation of resources two

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[1] The argument of this section could of course be translated in terms of a discontinuous utility-of-income schedule, as in Masson (1974). However, to explain the change from 1860 to 1880, one would have to postulate a shift in the utility schedule, whereas our explanation involves stable preferences during the two periods - fundamentally, the desire to be an independent family farm owner.

Table 5

Regression Coefficients: Cotton South, 1880
Dependent Variable: Cotton Acreage/Total Acreage
(County Data)

Variable \ Regression Number	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Constant	.249	.109	.162	.310	.297	.132	.279
Cotton Yield/ Corn Yield	3.34** (5.64)	3.38** (6.24)	3.25** (6.20)	2.65** (4.48)	2.59 (4.63)	3.08 ** (5.85)	2.60 ** (4.64)
POP/IA	.068 (1.09)	-.041 (0.70)	-.041 (0.73)	-.075 (1.22)	-.072 (1.23)	-.038 (0.67)	-.008 (0.13)
IA/# Farms	0.0019** (7.75)	0.0022** (9.65)	0.0016** (6.88)	.0019** (8.11)	0.0013** (5.63)	0.0019* (8.36)	0.0014** (6.21)
Tenants/ # Farms			0.328** (5.44)		0.390** (6.76)		
Farms <50/ # Farms		0.00038** (8.60)	0.00020** (3.74)	0.00011** (7.36)	0.00005** (2.70)	0.00027** (5.86)	0.00007** (4.45)
Farms 50-100/ # Farms				-.00026** (5.95)	-.00016** (6.76)		-.00019** (4.54)
Ten. Farms <50/ # Farms <50						0.190** (5.48)	0.067 (1.27)
Ten. Farms 50-100/ # Farms 50/100							.259** (3.60)
R^2	.229	.354	.401	.329	.401	.401	.405

N= 386 counties
t-ratios in parenthesis
** indicates significance at 1% level

choices are open: (1) reduce the safety-first farmers to gamblers, or (2) give them enough security so that they will focus more on the relative expected returns from their crops and less on their variance.

Ironically, the post-bellum South did manage to develop institutions which achieved a combination of (1) and (2), creating a class of very small farmers with little to protect by exercising caution. The irony is compounded in that these institutions almost certainly hurt the region as a whole. The South was in the unusual position of possessing substantial unexploited monopoly power in world cotton markets; hence the shift depressed the cotton price while having no effect on world corn and hog prices.[1]

Even for the more usual case in which a country actively desires to expand its foreign-exchange earnings by increasing cash-crop production, strategy (1) seems to us indefensible from the standpoint of equity. Turning to strategy (2), one obvious device would be for the government to provide a minimum guarantee of enough food to feed the family in case of a bad harvest. Through surveys of individual farmers it should be possible to determine these minimum requirements (i.e. Z^*) as a function of family size and age distribution. Another way of reducing the importance of variance in the crop allocation decision would be for the government to provide easy

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[1] For documentation of this assertion, see Wright (1974)

credit to farmers at market rates of interest during poor harvests.[1] Other things being equal, such an arrangement would raise the farmer's acceptable risk level by reducing his s/h ratio. The extent that such individual risk reduction is desirable will of course be tempered by whatever social preference exists for reducing the dependence of foreign exchange earnings on a small number of commodities, as discussed by Brainard and Cooper (1968).

The lexicographic model also makes a case for land reform, but only of generous proportions; mild land reform directed toward the very poorest class may have some resource allocation costs by shifting them from gamblers to safety-first farmers.

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1 Before the 1971 Pakistan war, low interest loans called "toccavi " loans were available to farmers in East Pakistan if there was a bad crop. Procuring them involved considerable red tape, and most small farmers felt they could not be obtained when needed.

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