Income Variability and Farm Size

By Charles V. Moore

THE VARIABILITY, as well as the level, of income affects size of farm and rate of expansion in size. Analysis of income variability may therefore be helpful in providing additional insight and understanding in studies of farm size.

This paper indicates that expansion in farm size may occur less rapidly in some types of farming than usually expected by researchers because of increased risks and limited capacity to pay debts.

The analysis shows the variability of both gross and net farm income for farms on two different soil types in Fresno County, Calif. Then, these variability measures are used in estimating a range within which total cost per dollar of gross income could be expected to fluctuate for observations on the short-run cost curves for farms of different sizes. Further, some conclusions are drawn about the effect of income variability on capital accumulation in farm size studies.

Procedure

A basic assumption in this study, following Tintner's (4)[1] variate difference method, is that a time series consists of two additive parts--an expected or predictable part and an unpredictable or random part. Some researchers (1) think that farmers recognize trends or expected fluctuations in prices and yields and take them into account in their planning. In other words, farmers are sufficiently aware of cyclical and secular trends in prices and changes in technology to include them in their planning formulations. However, farmers have only a subjective estimate of the random deviations away from the expected values. In this study, this random element of the time series after the predictable portion has been removed is of primary interest.

Tintner's variate difference method (4) was used to estimate the random component of these variables, and therefore the "risk," as defined by Knight.[2] This method separates the random from the expected component by a succession of finite differences of a time series. When this procedure has been carried out to the point where the difference between the present and the next preceding series is less than three times the standard error of the present series, we then assume that we have an adequate estimate of the variance of the random component (4, ch. 6).

The correlation between all possible pairs of crops under consideration was calculated to take into account the degree values for one-crop moves in relation to other crops. If the correlation between incomes of two crops is highly positive, adding the second crop to the plan will increase the total variance of the plan. Adding a second crop which is negatively correlated can reduce the total variance.

Variability measures, based on State and county data for prices and yields, were made for eight crops. A deflated cost series of budgeted production items was used in determining variability of net income. The use of State or county data underestimates the variance faced by an individual farmer. This is because individual random fluctuations are "averaged out" in State or county data. This effect is usually greater for yield data than for price data, especially if production is localized, as it is for alfalfa seed and certain other specialty crops (1, p. 179).

Total variance for a cropping plan, for both gross and net income, was determined as follows:

$$\sigma_T^2 = q^2 \sigma_A^2 + (1-q)^2 \sigma_B^2 + 2q(1-q)\, r_{AB}\sigma_A\sigma_B,$$

where q = proportion of land resources devoted to crop A and 1-q = proportion of land devoted to crop B, and r_{AB} = correlation between the incomes of enterprises A and B (2, p. 514).

[1] Underscored numbers in parentheses refer to items in Literature Cited, p. 113.

[2] A situation where the probability of given outcomes is known and can be insured against (3).

Several farm sizes on two soil types, and crops adapted to these soils, were analyzed to illustrate the above procedure. Gross income-total variance of the cropping plan for each observation on the short-run cost curves (figs. 1 and 2) was calculated as well as the standard deviation. The range within which the short-run cost curve could be expected to fluctuate two-thirds of the time was obtained by dividing total cost first by calculated gross income plus one standard deviation and again by calculated gross income minus one standard deviation.[3] To determine the slope and position of the short- and long-run cost curves, four "fixed plants" were defined in man-years for each of the soil types.[4] These four farm sizes were 1, 2, 4, and 8 man-years of permanent labor force.

Cotton is the major crop adapted to the two soils in this study. The farms in the light sandy soil area also grow alfalfa hay, dry beans, grain sorghum, and barley. Those in the heavy clay soil area grow, in addition to cotton, alfalfa seed, safflower, sugarbeets, beans, barley, and grain sorghum. Two technologies in the production of cotton were examined--solid plant and two-in-one-out "skip row."

The least-cost combination of land, labor, and machinery was determined for each farm size for at least five levels of gross farm income, using linear programming and expected prices. Up to nine combinations of machinery and technologies were analyzed for each level of gross income (level of output). The minimum-cost combination for each level of gross income was determined by dividing total cost (fixed plus variable) by gross income. These least-cost combinations, plotted and joined together, formed the short-run average cost curves for each farm size.

[3] This assumes that there is a normal distribution of incomes and that time is "fixed," that is, for a large number of independent observations of income, we could be 67 percent confident of obtaining an income within this range. Calculated gross income was used in lieu of expected gross income because prices used were ones projected to 1967. Prices were those projected by ERS, adjusted for local conditions and transfer costs. This modification gives the calculated gross income a slight downward bias.

[4] The detailed procedures for examining economies of farm size are described in "A Study Guide for a Cooperative Project in Economies of Farm Size," prepared by Farm Production Economics Division, ERS, Nov. 1963.

Empirical Results

The broken lines which form a band around the calculated cost curves are determined by dividing the total cost by calculated gross income plus and minus one standard deviation.[5] The width of this band is a function of the cropping program. On the light-soil farms, minimum-cost cropping programs consist of cotton up to the maximum allowed under the acreage allotments, and alfalfa hay. When resources are utilized to their short-run capacity, further expansion of output causes small grains to be substituted for alfalfa hay in the optimum plan. Barley, dry beans, and grain sorghum have high positive income correlations with each other and, when they are added to the cropping plan, they tend to increase the variability.

The heavy-soil farms had a greater variety of crops but were dominated by cotton, sugarbeets, and alfalfa seed. With increased output, small grains come into the program when labor and machinery are being used to capacity. However, the major crops have very low or negative income correlations and this keeps the total variance low.

In the absence of detailed farm data, direct comparisons of total variances among soils and farm sizes are not possible; but I calculated a coefficient of relative variability.[6] Relative variability of gross income is higher for the light soils than for the heavy soils, although both are fairly stable over the range of farm sizes.

COST ECONOMIES

An envelope curve was drawn tangent to the calculated short-run cost curves, to form the planning curve. Envelope curves were also drawn to the plus and minus one standard deviation curves (figs. 3 and 4) to indicate the magnitude of variability around the planning curve.

Costs per dollar of gross income decrease rapidly as initial output expands for farms on

[5] For both the short- and long-run cost curves, zero cost variability is assumed. These confidence bands therefore are the ratio of a constant over a variate and not the ratio of two variates.

[6] $\text{R.V.} = \frac{\text{Standard deviation}}{\text{Calculated income}} \times 100.$

789-683 O-65-2

SHORT-RUN AVERAGE COST CURVES
BY FARM SIZE, LIGHT SOILS, FRESNO COUNTY

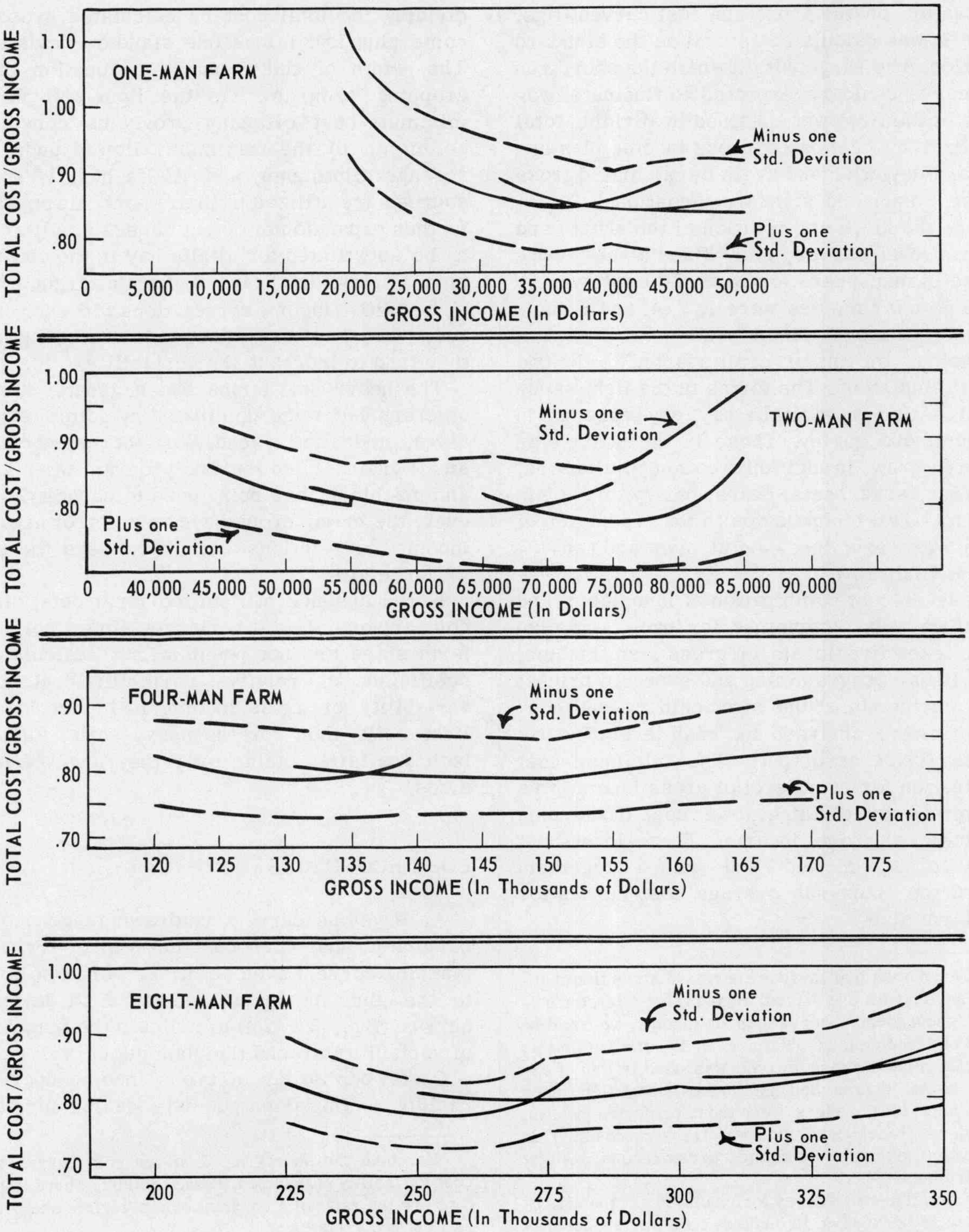

Figure 1

SHORT-RUN AVERAGE COST CURVES
BY FARM SIZE, HEAVY SOILS, FRESNO COUNTY

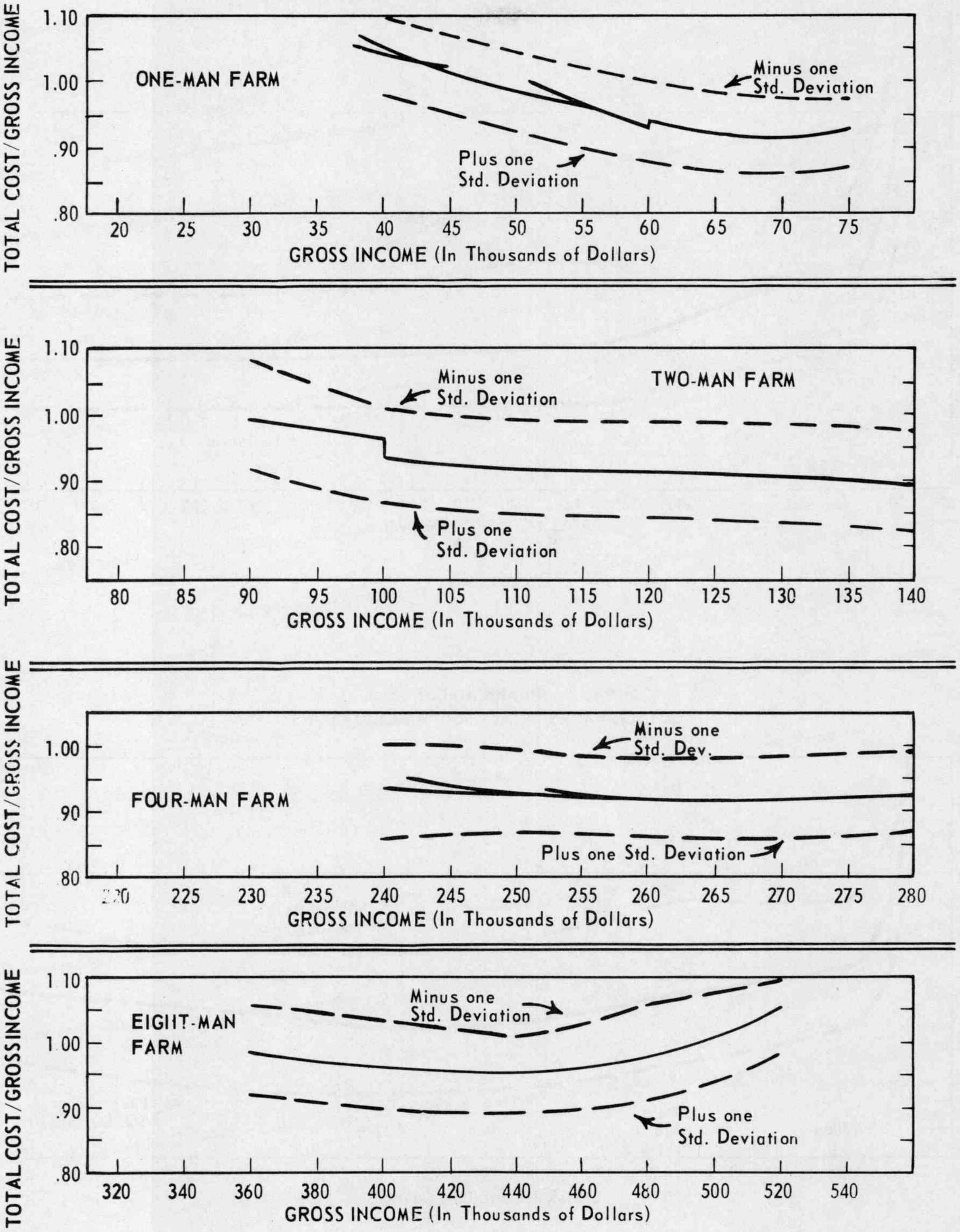

Figure 2

PLANNING CURVE
COTTON FARMS, LIGHT SOIL, FRESNO COUNTY

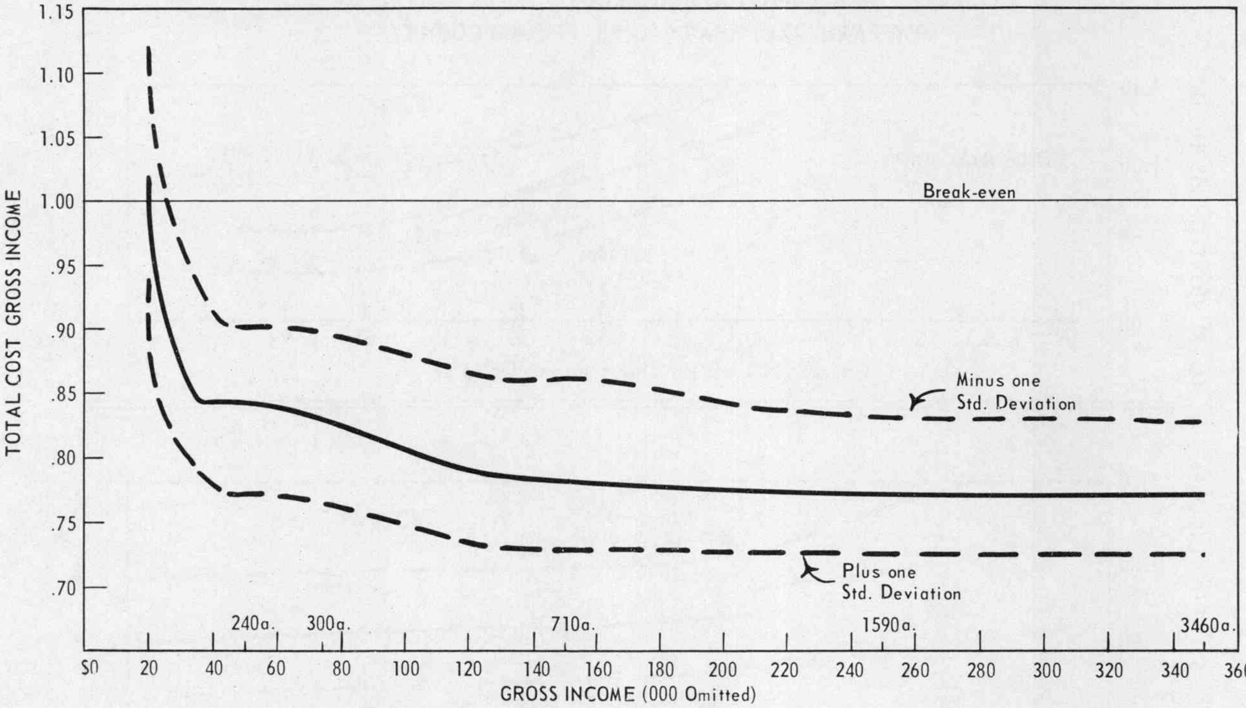

Figure 3

PLANNING CURVE
COTTON FARMS, HEAVY SOIL, FRESNO COUNTY

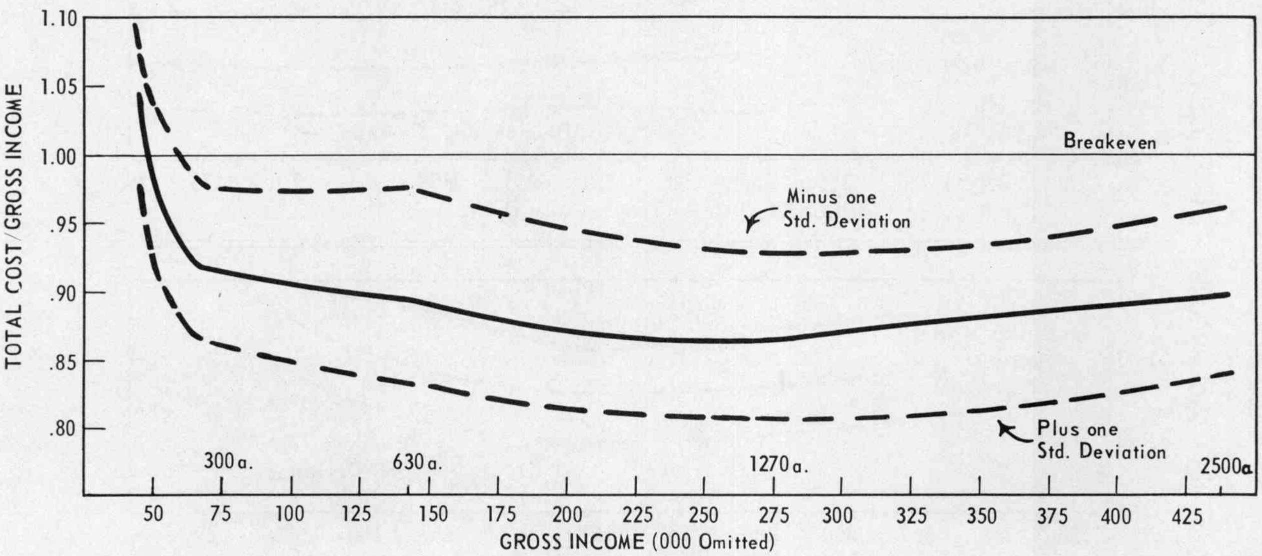

Figure 4

both soils. On the heavy-soil farms, costs reach a minimum of about $0.87 per dollar at $260,000 gross income (1,200 acres). However, plus and minus one standard deviation of gross income about this minimum gives a range from $0.93 to $0.81 per dollar of gross income. An institutional constraint, that causes the cotton allotment as a percentage of cropland to decrease as farm size increases, forces the heavy-soil planning curve to turn upward. At a gross income of $440,000 (about 2,500 acres of land), the calculated cost per dollar of gross income is $0.90, and the range of plus and minus one standard deviation is from $0.84 to $0.96.

Costs decrease throughout the range of output studied for the light-soil farms. Nearly all of the cost savings have been achieved by the time output has reached $140,000 gross income (about 640 acres of land). The calculated cost per dollar of gross income at this point is $0.79, with a range of plus and minus one standard deviation from $0.73 to $0.85.

The same cotton allotments were assumed for the light-soil farms as for the heavy-soil farms. Cotton allotments run from 30 percent of cropland on the one-man farms to 15 percent on the eight-man farms. As farm size increases with the associated percentage decrease in allotments, cotton is replaced by low-value crops such as barley and safflower on the heavy-soil farms; but on light-soil farms, relatively profitable alfalfa hay replaces cotton.[7] This explains why the planning curve turns up on the heavy-soil farms while remaining constant on the light-soil farms.

The bands of plus and minus one standard deviation around the planning curve are narrower for the heavy-soil farms (although the expected incomes are lower) than for the light-soil farms, reflecting the lower relative variability of the heavy-soil cropping plans.

VARIABILITY OF NET INCOME

Since most expansions in farm size are financed in part from earnings retained from income of previous years, an analysis of income variability is germane. Further, since all debt repayment must come from net income, both the absolute and relative magnitudes of the fluctuations must be taken into account.

Variability of net income is the result of the interaction of price, yield, and cost variability. Thus, the relative variability of net income is greater than that for gross income.

Figures 5 and 6 trace out a smoothed estimate of net income for the light- and heavy-soil farms, respectively. These income curves, based on the short-run cost curves, indicate the absolute and relative magnitudes of possible net income fluctuations. Because of the critical nature of minimum net income levels and possible penalties involved in defaulting on loan payments, I have drawn the area encompassed by plus and minus two standard deviations about the calculated net income. Assuming a normal distribution, it would be expected that the net income received in any one year would fall within this range about 95 percent of the time.

For the light-soil farms, only a very small portion of this 95 percent probability area overlaps the negative income portion of the chart. This indicates that a large proportion of retained income could be reinvested in expansion of farm size each year. The debt-carrying capacity of these farms would be relatively high. Only a small reserve would be necessary to meet fixed debt payments in adverse years.

A large part of the area bounded by plus and minus two standard deviations from net income for the heavy-soil farms falls into the negative income area. Although the net farm income would be expected to average out to the calculated farm income over time, the debt-carrying capacity (ability to meet fixed principal and interest payments) of the heavy-soil farms is much less than that of the light-soil farms. Hence, farm expansion from internally generated funds and equity would probably be slower for the heavy-soil areas.

The amount of money available for reinvestment in any one year is further reduced by an allowance for family living expenses. Subtracting a living allowance from net income would cause a large reduction in the funds which could be used to expand farm size.

[7] Including cotton allotments as a restraint causes these curves to be planning curves, rather than true long-run cost curves where all factors are completely variable.

Literature Cited

(1) Carter, H. O., and G. W. Dean. Income, price, and yield variability for principal

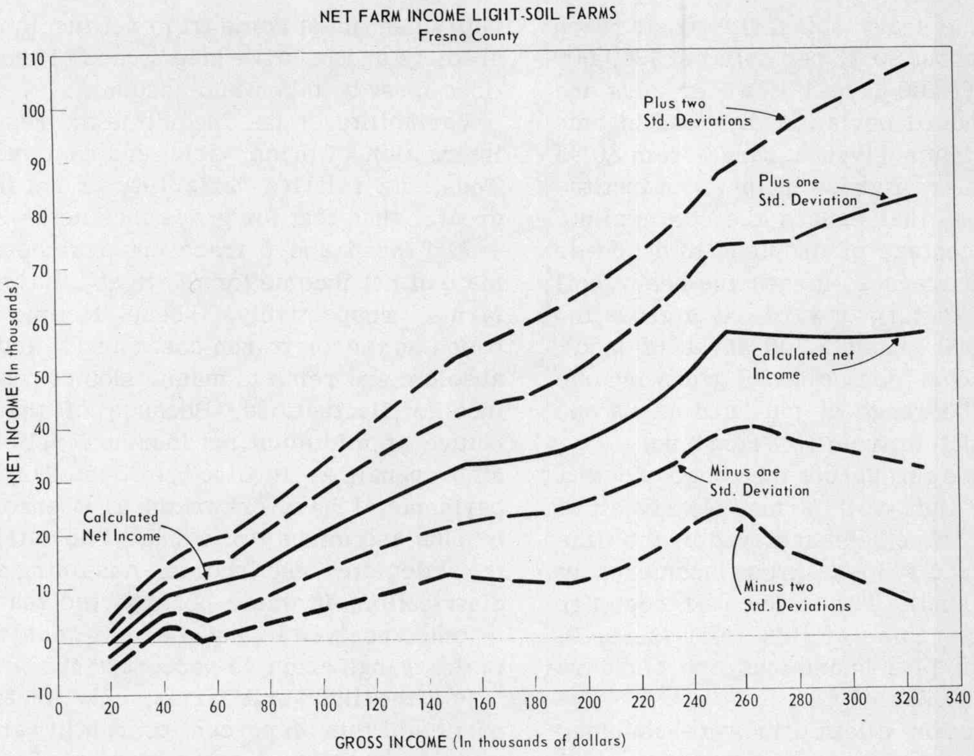

Figure 5

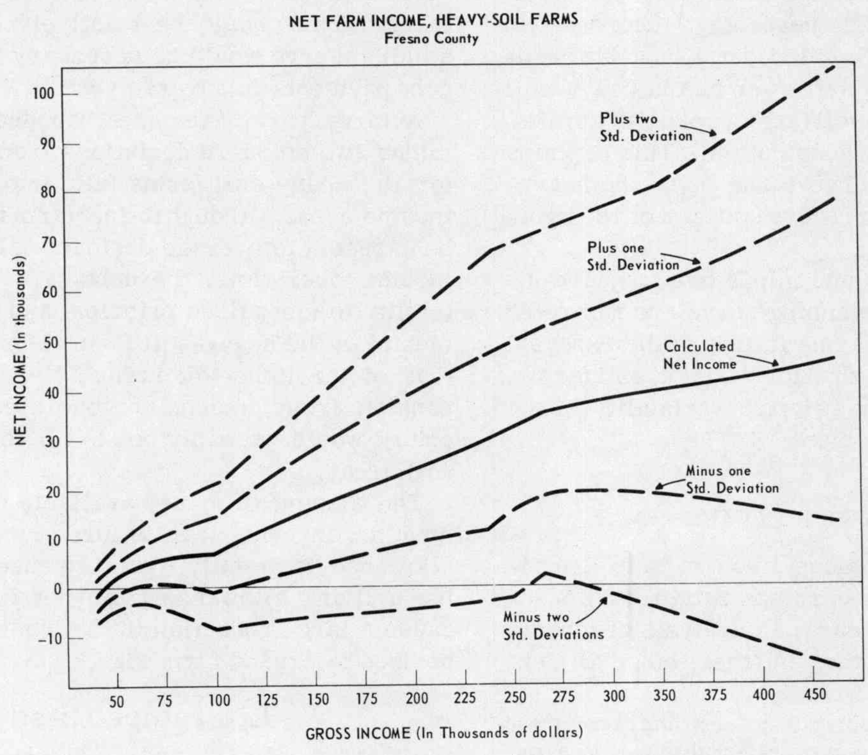

Figure 6

California crops and cropping systems. Calif. Agr. Expt. Sta., Hilgardia 30:175-218, October 1960.

(2) Heady, Earl O. Economics of agricultural production and resource use. Prentice-Hall, New York, 850 pp., illus., 1952.

(3) Knight, F. H. Risk, uncertainty, and profit. Houghton Mifflin, Boston, 381 pp., illus., 1921.

(4) Tintner, Gerhard. The variate difference method. Cowles Comm. Monog. 5, Principia Press, Bloomington, 175 pp., illus., 1940.