PRICE, YIELD, AND GROSS REVENUE VARIABILITY FOR SELECTED GEORGIA CROPS*

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A topic of considerable recent discussion is the use of high return per acre crops such as vegetables as a possible means of improving income levels on small, limited-resource farms. Though production economic analyses (those using conventional techniques such as budgeting and linear programming) indicate that farmers with small acreage might increase their income substantially by selecting vegetable enterprises, very few farmers are selecting vegetables over field crops. One possible explanation for their failure to do so is that the income from vegetable crops is more variable than that from field crops, and owners of small farms are more inclined to produce crops that will yield a lower but more stable level of income.

Though several studies have shown that risk is an important factor in enterprise selection [1, 2, 5, 8, 9, 10, 11, 12] and that producers consider risk when selecting enterprises, few data are available on price, yield, and income variability for principal crops produced in Georgia. The variate difference method [13], which was applied to isolate and estimate the random component of the data series variation, has been used in similar studies by scientists in California [1], Illinois [5], and North Carolina [8, 9]. However, because of several misuses in previous studies, the purposes of this study are (1) to review critically previous studies in which the variate difference method was used and (2) to estimate the coefficient of variation for the price, yield, and gross revenue series of principal Georgia crops.

Variation of gross revenue, instead of that of profit, is used as a proxy measure for the income risk associated with the production of individual crops because of the absence of historical production cost data. Farmers are not completely ignorant of the costs and yields in producing competitive crops on their individual farms. By combining these individual farm data on costs and yields with the "state average" information on the expected trend and the variation of the trend deviations for the price, yield, and gross revenue of alternative crops, a producer has some information (although rough) to use in his production decisions. In other words, in the absence of ideal knowledge, some information, if it is accurate and reliable, is always better than none.

MEASUREMENT OF VARIABILITY COEFFICIENTS

Because the outcome of a given production decision is not known *ex ante* with certainty, one must rely on past experiences when making decisions. Accordingly, the variability coefficients of a data series must be estimated from past observations.

A series can be decomposed into the systematic (or mathematical expectation) and random (or residual) parts. Isolation of the random component can be accomplished by using either the regression method [6, 12] or the variate difference method [13]. The latter is preferred as it does not require the *a priori* specification of the functional form of the systematic part of the time series and thus it is used in this study. The only assumption necessary is that the series is composed of the two components additively,

$$(1) \qquad Y_t = X_t + e_t, \qquad t = 1, 2, ..., T$$

where X, the systematic part, is some polynomial function of time and e, the random part, is distributed with zero expectation, spherical and interdependent of X.

One property of a polynomial of degree m is that its $(m+1)^{th}$ and higher order difference series vanish. Therefore, if a sufficient number of finite differencing operations are performed on the data series Y, the X component will be

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removed. The question then arises of how far differencing should be carried before X is significantly removed. One rule is to continue with finite differencing until the variance of the kth differences, V_k, is not significantly different from the variance of the (k+1)th differences, V_{k+1}. This can be accomplished by computing the test statistic R_k, where

$$(2) \qquad R_k = (V_k - V_{k+1}) / V(V_k - V_{k+1}), \quad K = 0, 1, 2, ...$$

According to Tintner [14, p. 311], this statistic is distributed approximately N(0, 1) for large samples. Thus, a standard normal R_k is used to test the hypothesis H_0: $V_k = V_{k+1}$ against H_a: $V_k \quad V_{k+1}$ for K = 0, 1, 2, ...

The following formulae are used to compute total and random variability, respectively. Total variability coefficient:

$$(3) \qquad = [\ \Sigma^T_{i=1}(Y_i-\mu)^2/(T-1)]^{1/2}/\mu$$

Random variability coefficient:

$$(4) \qquad = [\Sigma^T_{i=1}(\Delta^{(k)}Y_j)^2/(T-k)C^{2k}_k]^{1/2}\mu$$

where

μ = the mean of Y observations
T = the number of observations
$\Delta^{(k)}Y$ = the kth difference series for Y and
C^{2k}_k = the number of combinations for 2k, taking k at a time.

In application of the standard normal test, Carter and Dean [1] and Mathia [8, 9] chose three as the critical value which implies a significance level of 0.26 percent. This is not a commonly used level of significance.

Grossman and Headley [5] used the fourth difference series to estimate the random variability coefficients for all the time series in their study. This approach implies that the "trend" component of each and every data series in their study is, or is approximately, a cubic function. This may be too strong a statement to make because most economic data are stochastic, dynamic, and interdependent. Data homogeneity seldom is observed in the real world. One possible alternative interpretation of Grossman and Headley's approach is that all the series in their study had the "trend" component significantly removed at or before the fourth differencing transformation. If this is the case, several different levels of significance must have been used in the tests.

Variability coefficient is based on the concept of "coefficient of variation," which is the ratio of the standard deviation to the mean, σ/μ. However, many authors [1, 5, 8, 9, 12] have used the average of the last four or five years' observations for the mean, simply because it is more relevant for future planning. This approach may create an over- or underestimation problem. Abnormally high or low values of the four or five periods' data would greatly affect the value of the estimated variability coefficient. Unidentical degrees of over- or underestimation among the competing crop series will give misleading conclusions. The mean of all samples, which is less vulnerable to abnormality, is preferred. To meet planning needs which the other authors considered, one may furnish the estimated variability coefficients together with the projected "trend" value for the planning periods (which may be obtained from extrapolation of the fitted systematic function) at the same time for comparison.

Several authors [5, 8, 12] have made probability statements about the estimated variability coefficients. One property of the normal distribution is that the area between the plus and minus one standard deviation from the mean is about 68 percent, which implies that the area between the plus and minus one unit of the coefficient of variation on a standardized normal scale of $(Y-\mu)/\mu$ is about 68 percent. However, if σ is unknown and the standard deviation of the random residuals from the "trend" (calculated by either the variate difference method or regression method) is substituted for σ, or if μ is not used but some average measurement other than the arithmetic mean of all observations is substituted, the probability value will not be approximately equal to .68 and must be determined case by case. One suggestion is not to make probability statement at all. Being relative measures and expressed in percentage form, the estimated variability coefficients are directly comparable among series.

RESULTS

The data used in this analysis are state annual average series of price, yield, and gross revenue for 15 crops commonly produced in Georgia. These are the only crops that have been covered in Georgia crop reporting since 1924 or earlier. The period selected for study is 1929-1975 (the variate difference method requires a large sample). A 1 percent level of significance is selected in statistical tests in this study.

Total and random variability indices for price, yield, and gross revenue series for the six horticultural and nine field crops are presented in Table 1.[1] Note that two data series with the same degree of random variability may show marked difference in the corresponding total variability. This difference is primarily due to the way in which the estimates are computed. The total variability coefficient is calculated from the sum of squared deviations from the mean, whereas the random variability coefficient is calculated from the sum of the squared deviations from the "trend," Given the mean, the value of a total variability coefficient is determined solely by the scatter of the observations. But this is not the case for a random variability coefficient, whose value is determined by the deviation of the observations from the fitted polynomial trend. A perfect trend fitting for the observations, irrespective of scattering, always gives zero random variability.

Total variability indices for prices of horticultural and field crops are shown in columns 2 and 3 of Table 1, respectively. As expected, the prices of horticultural crops vary more widely than those of field crops. Total price variability indices for horticultural crops ranged from 56 percent for sweet potatoes to 72 percent for tomatoes, and random price variability indices ranged from 11 percent for sweet potatoes to 48 percent for cabbage. Total price variability indices for field crops ranged from 29 percent for oats to 52 percent for tobacco, and random variability indices ranged from 3 percent for peanuts to 11 percent for corn. The geometric means for horticultural crops were 63 and 21 percent for total and random price variability, respectively, whereas the geometric means for field crops were 38 and 6 percent for total and random price variability, respectively. The lower price variability among field crops is probably a result of government price support programs as well as the storability of field crops in comparison with horticultural crops.

TABLE 1. TOTAL AND RANDOM VARIABILITY INDICES OF PRICE, YIELD AND GROSS REVENUE PER ACRE FOR SELECTED GEORGIA CROPS, 1929-75.

Crop	Price		Yield		Gross Revenue		Unit of measurement for data used in estimation		
	Total	Random	Total	Random	Total	Random	Price	Yield	Gross revenue
	(percent)		(percent)		(percent)				
Horticultural crops									
Cabbage	69	48[a]	15	9[c]	71	48[a]	$/cwt	cwt/ac.	$/ac.
Cantaloups	64	20[b]	18	14[a]	73	-[f]	"	"	"
Snap beans	57	16[a]	24	-[f]	72	12[b]	"	"	"
Sweet potatoes	56	11[b]	36	8[b]	84	9[c]	"	"	"
Tomatoes	72	23[b]	31	19[a]	98	20[b]	"	"	"
Watermelons	62	23[a]	16	11[a]	67	23[b]	"	"	"
Geometric mean	63	21	22	12	77	19			
Field crops									
All hay	34	5[c]	62	8[a]	90	-[f]	$/ton	tons/ac.	$/ac.
Corn	43	11[d]	64	19[a]	100	13[d]	$/bu.	bus./ac.	"
Cotton (lint)	47	-[f]	31	12[a]	68	-[f]	$/cwt	cwt/ac.	"
Oats	29	9[c]	36	-[f]	54	18[a]	$/bu.	bus./ac.	"
Peanuts	48	3[d]	61	10[b]	108	12[b]	$/cwt	cwt/ac.	"
Rye	30	6[c]	47	12[a]	57	16[a]	$/bu.	bus./ac.	"
Soybeans	36	5[e]	54	18[a]	82	16[d]	"	"	"
Tobacco	52	6[b]	34	11[a]	76	-[f]	$/cwt	cwt/ac.	"
Wheat	35	-[f]	47	-[f]	60	-[f]	$/bu.	bus./ac.	"
Geometric mean	38	6	47	12	75	15			

[a]Estimated from the first difference series, according to testing results.

[b]Estimated from the second difference series.

[c]Estimated from the third difference series.

[d]Estimated from the fourth difference series.

[e]Estimated from the fifth difference series.

[f]The variate difference method failed. No estimate is obtained.

[1]For several data series the absolute value of the test statistic R_k did not converge as k increased in value. The variate difference method failed for these cases; thus estimates of the random variability coefficients were not obtained and reported.

Both factors prevented the prices of field crops received by farmers from going below certain floor levels.

Total and random yield variability coefficients are shown in columns 4 and 5 of Table 1, respectively. Random variability values for the two groups of crops are approximately equal (geometric means of 12 percent each), which means that the degrees of random variation are about the same. Total yield variability is much larger for field crops (geometric mean of 47 percent) than for vegetable crops (geometric mean of 22 percent). The vast differences between total variabilities for field and horticultural crops are due primarily to the trend. Yields of field crops increased considerably more than yields of vegetables during the periods studied, mainly because a large proportion of vegetables are sold fresh to the consumers for human consumption. Quality requirements are much more rigid for vegetables than for field crops, which are mainly for feedstuffs. Thus yield is usually not as important a consideration in vegetable variety development as such attributes as taste, flavor, fiber and sugar content, color, etc. Varieties with high yields have been slow to be developed. Another explanation lies in the basic physiological difference between the so-called C_3 and C_4 plants [7].[2] The C_3 crops include vegetables and several small field crops. Plant scientists have observed marked and significant differences in anatomy, physiology, and biochemistry between these two groups. Simply stated, vegetables are more vulnerable to unfavorable environmental conditions, are less photosynthetically efficient, and are less responsive to cultural practices than C_4 crops. These factors make it more difficult to transform technological advances into realized yield increase for horticultural crops.

Total and random variability indices for gross revenue are shown in columns 6 and 7 of Table 1, respectively. There is very little difference in variation in gross revenue between horticultural and field crops, geometric means for total variability being 77 and 75 percent, respectively, and geometric means for random variability being 19 and 15 percent, respectively. The high total variabilities, in relation to random variabilities, are mainly a result of trend.

SUMMARY

Random variability coefficients estimated in this study indicate that the growing of vegetable crops involves somewhat more risk than the growing of field crops. Price variability is much higher among horticultural crops than field crops, yield variability is about the same, and the result is more variable gross revenue for vegetable crops. However, the degrees of gross revenue risk for these two groups of crops do not differ much, 19 versus 15 percent.

Additional study, for example risk programming analysis, is needed to determine the optimal cropping system, given the resource constraints. Localized production data, especially the farm records, are much better than state average series for use in production economic analysis of individual farms or representative farms.

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