HAY PRODUCTION AND ITS STABILITY IN KANSAS

by

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INTRODUCTION

The big problem in agricultural production is its variation and its subjugation to uncertainity and risk. The uncertainty and risk in agricultural production play a considerable role and make the decision making difficult. Before proceeding further, two key terms have to be defined in order to obtain the proper perspective.

In the first instance there is risk which "refers to variability of outcomes which are measurable in an empirical or quantitative manner."[1] There are two ways in which empirical probabilities can be found:

"(1) The a priori probability of outcome can be established when the characteristics of the eventuality are known beforehand.

(2) The statistical probability of outcome can be established when: (a) the sample of observations is large enough, (b) the observations are separated in the population, (c) the observations (cases) are independent (are randomly distributed in the manner of a stochastic variable)"[2]

The second factor is uncertainty which differs in several

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[1] Earl O. Heady, Economics of Agricultural Production and Resource Use (Englewood-Cliffs, New Jersey: Prentice Hall, Inc., 1965), P. 440

[2] Ibid., P. 440

important aspects from risk. "The probability of an outcome cannot be established in an empirical or quantitative sense for uncertainity. The anticipations of the future can be formed, but there is no way that the entrepreneur or administrator can assemble enough homogeneous observations to predict the relevant probability distribution."[3]

In essence then, the difference between risk and uncertainity is that in the case of risk, objective anticipations can be formed while in the case of uncertainty the anticipations are subjective.

In this report it will be attempted to probe into a specific aspect of agricultural production, i.e., the production of hay. The data are to be analyzed as to whether there exists uncertainty or risk, and as to the magnitude and relative importance of the influences of the variables which govern the pattern of production and the value of production of hay. Furthermore, the data are analysed for the presence of certain trends in order to establish possibilities of prediction for future events.

Hay Production Trends

Production of tame hay has varied to a great extent from 1910 to 1963. The pattern of production is of such a high irregularity that it is difficult to make any predictions as to future developments. In the last 7 years (1957 to 1963) hay production was at an all-time high. Most likely this phenomenon represents the upward sloping part of a cyclical movement, the continuation or discontinuation of which is difficult to predict

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[3]Ibid., P. 440

since production to a large degree depends on the rainfall pattern.[4] In the case of alfalfa hay a strong cyclical behavior can be observed. Production of alfalfa hay was 2,500,000 tons in 1919, it decreased to a low of 642 tons in 1941 and it increased to a high of 3,300,000 tons in 1962. This movement is similar to that for tame hay.

Clover and timothy hay too underwent very considerable fluctuations in production. On the whole, it appears that the acreage has been decreasing which reflected to some degree the decreases in total production.

The behavior of the production of lespedesa hay is strongly cyclical too. It increased from 22,000 tons in 1939 to a high of 192,000 tons in 1951, and then it has decreased to a low of 20,000 tons in 1963. It appears that variations in acreage played a considerable role in bringing about changes in production.

Wild hay production experienced a marked decline until 1934, after which it levelled off. The cause for the long-term decline appears to be the long-term decline in its acreage.

Problem and Objectives

The considerable year-to-year variation in the production of hay places a large burden on beef-feeding operations in regard to

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I. L. Launchbaugh, "The Effect of Stocking Rate and Cattle Gains and on Native Shortgrass Vegetation in West-Central Kansas". Kansas State Agricultural Experiment Station Bulletin 394, November 1957, P. 4

the maintenance of optimum feed inventories. It is quite difficult therefore, to determine for the individual producer what combination of beef animals and feed reserves would result in optimum net returns over a period of time (years).

Furthermore, the large shifts of production result in large shifts in prices which in turn cause shifts in livestock production. The value of tame hay production for example changed from a high of $29,651,400 in 1962 to a low of $5,170,320 in 1938. In other words, income received from hay production is rather unstable and subject to violent fluctuations. In the long run profits could be increased if it were possible to stabilize the value of production to some degree. This could be established if one could set up a probability distribution based on the variations of the data and past experiences. In this manner planning would be facilitated.

The study has the following main objectives: (a) to determine the size of the variations of hay production from 1910 to 1963, (b) to determine the main factors causing the changes in hay production and, (c) determine the main factors causing the variations in the value of production.

Procedure and Method

The data analyzed were taken from the 47th annual report of the Kansas State Board of Agriculture. The set of raw data offers the following information: acres harvested (thousands), yield (tons per acre), production (thousands of tons), price per ton, and value of production. The data, to which most attention is given, range from 1868 to 1963.

Since all the prices are given in terms of current values they had to be adjusted in order to obtain a common unit of measurement. Index numbers are available from 1910 on. This means that the data before that date could not be used because of the distortions which would have resulted due to price increases. The useful time series data stretched over 54 years, a sample of sufficient size for the task to be undertaken. For alfalfa hay, lespedeza hay, timothy and clover, and wild hay, the time series are much shorter, thus, the prediction of their trends is less reliable.

From 1910 to 1963 index numbers for all farm commodities are available. From 1950 to 1963, index numbers are available for all feed grains and hay and from 1955 to 1963 index numbers for hay only are available. For adjusting all the data to a common denominator index numbers for all commodities were used, assuming that the correlation between production and prices would not be distorted to a large extent.[5] By comparing the two sets of data, adjusted and unadjusted prices of table 1, it can be seen that there is hardly any distortion due to the fact that index numbers for all commodities instead of those for hay only were used.

The first method used in estimating significant relationships between the variables was the two variable linear regression method. The following set of hypotheses is applicable:

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[5]Kansas State Board of Agriculture. Kansas Agriculture. Kansas State Printing Office, 1947, 1948, 1950, 1964.

$$Y_i = \alpha + \beta X_i + \mu; \quad i = 1,2,\ldots.n$$

$$E(\mu_i) = 0 \text{ for all } i$$

$$E(\mu_i \mu_j) = \begin{cases} 0 \text{ for all } i = j; & i, j = 1,2,\ldots.n \\ \sigma_\mu^2 \text{ for all } i = j; & i,j = 1,2,\ldots.n \end{cases}$$

where α, β and σ_μ^2 are the unknown parameters which are to be estimated.[6] The test of significance which was used in all two-variable regressions is as follows:

"Use $$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$ and inferring a significant correlation between X and Y if $|t| > t\alpha$, where $t\alpha$ is an appropriate value from the t- distribution with n-2 degrees of freedom."[7]

In order to determine whether there is any serial correlation between production and price of tame hay the Theil-Nagar test for serial correlation was used. The following calculations had to be made.

$$\hat{\mu} = Y - \hat{Y}$$

where Y = actual value of price per ton

$\hat{Y}$ = estimated value of price per ton

$$\Delta\mu = \hat{\mu}_t - \hat{\mu}_{t-1}$$

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[6] J. Johnston, Econometric Methods (New York: Mcgraw-Hill Book Company, Inc., 1963,) P. 9.

[7] Ibid., P. 33.

The test statistic was

$$d = \frac{\Sigma(\Delta\hat{\mu})^2}{\Sigma\hat{\mu}^2}$$

The test criterion is as follows: When d_α (The table value for d)<d, there is evidence that there is no serial correlation.

For the determination of the relative influences of changes of yield and acreage upon production and for the determination of the relative influence of changes of prices and production upon the value of production S. M. Sackrin's procedure was used.[8]

The original relationship to be estimated is P = A Y where P = production, A = acreage harvested and Y = yield per acre. In order to obtain a linear relationship the data had to be transformed into logarithms, after which the following linear equation is obtained:

$$\log P = \log A + \log Y$$ [9]

Furthermore, once the logarithms have been found for the data, the first differences of the logarithms are determined in order to obtain changes from the previous year. Then, the equation takes on the following form:

$$\Delta \log P = \Delta \log A + \Delta \log Y$$ [10]

In this manner it is assured that the equality of both sides of the equation can be preserved in the sums. A least-

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[8] S. M. Sackrin, "Measuring the Relative Influence of Acreage and Yield Changes on Crop Production," U. S. Agricultural Economics Research, Vol. IX, No. 4. (October, 1957, 136-39.

[9] Ibid., P. 137.

[10] Ibid., P. 137

squares regression is computed, with Δ log P as the dependent variable X_1 and Δ log A and Δ log Y as the independent variables X_2 and X_3 respectively. "The only statistical coefficients required are--and this is important--b_{21} and b_{31}. Their sum will exactly equal 1.00. The coefficients may be interpreted as follows: On the average of each 1-per cent change in production from the preceding year a given per cent is ascribable to X_2 (acreage changes) and a given per cent is ascribable to X_3 (yield changes). This follows because the coefficient b_{21} measures the change in X_2 associated with a one-unit change in X_1, while the coefficient b_{31} measures the change in X_3 associated with a one-unit change in X_1. As the data are expressed in first differences of logarithms, the unit change involved here is a 1-per cent change from the previous years. This unit is the exact sum of the changes in the two determining variables, hence the coefficients b_{21} and b_{31} represent the proportion that each comprises of the total."[11]

In calculating the first differences of the logarithms the following computations have to be made:

"(1) The direct effects of each (variable) are averaged for the period, disregarding the direction of the change. (2) The average direct effect of acreage and the average direct effect of yield are then each expressed as a percentage of their sum."[12]

Once the first differences of the logarithms have been

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[11] Ibid., P. 137.

[12] Ibid., P. 138.

obtained, the coefficients can be obtained as follows:

$$b_{21} = \frac{\Sigma x_1 x_2}{\Sigma x_1^2} \quad \text{where } \Sigma x_1 x_2 = \Sigma X_1 X_2 - \bar{X}_2 \Sigma X_1$$

$$\text{and } \Sigma x_1^2 = \Sigma X_1^2 - \bar{X}_1 \Sigma X_1$$

$$b_{31} = \frac{\Sigma x_1 x_3}{\Sigma x_1^2} \quad \text{where } \Sigma x_1 x_3 = \Sigma X_1 X_3 - \bar{X}_3 \Sigma X_1$$

Furthermore, it has to be mentioned that

$$\Sigma x_1^2 = \Sigma x_1 x_2 + \Sigma x_1 x_3.$$ [13]

ANALYSIS

Production - Price Relationship

Since there exists the possibility of serial correlation between production and price of adjacent years, the results of this particular regression have to be tested because in the above mentioned model serial independence of the disturbance term was assumed.[14] The test used was the Theil-Nagar Test for serial correlation and it was found that according to all evidence there is no serial correlation. In the case of serial correlation, an autoregressive process of the first order would have been used (being a special case of the "Markoff Process").

The equation of the fitted line is as follows:

$$Y = 11.126 - \underset{(.00039)}{.0013}X$$

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[13] Ibid., P. 138.

[14] See above, P. 5.

where Y = price per ton (tame hay)

X = production in thousands of tons (tame hay)

From this it can be seen that there is an inverse relationship between price and production. The coefficient of correlation is r = -.4230 which means that there is not much correlation between production and price. When tested at the .005 level it became apparent that the correlation between X and Y was significant (Table 14). However, when tested of the .001 level, the relationship between X and Y turned out to be non-signigicant. The standard error is .00039, indicating that the regression coefficient can be considered relatively reliable.

Some important conclusions can be drawn from the results of the Theil-Nagar Test. Since there is no serial correlation, production of year t does not have any significant influence on the price of the year t + 1. This means that in regard to hay production we have a relationship which is different from that of other agricultural products, as for example wheat, where the cobweb theorem can be applied.

Yield - Production Relationship

In estimating this relationship, the same regression model as above was used, giving the following results:

$$Y = -238.662 + \underset{(185.48045)}{1521.096X}$$

where Y = production in thousands of tons (tame hay)

X = yield per acre in tons (tame hay)

Here a small change in yield causes a relatively large change in production, i.e., the regression coefficient is large. Since the standard error is relatively small in relation to the regression coefficient b, b can be considered a relatively reliable estimate. The coefficient of correlation is r = .753 which indicates that there is a strong correlation between yield and production. When tested at the .005 level, r turns out to be significant (Table 14).

Acreage - Production Relationship

The estimated relationship is

$$Y = -13.397 + \underset{(.22801)}{1.663X}$$

where Y = production in thousands of tons (tame hay)

X = acreage (tame hay)

This seems to indicate that there is some relationship between X and Y. The coefficient of correlation is Y = .716, showing that there is a good amount of correlation between acreage and production of hay. The standard error of .22801 indicates that the regression coefficient is a good measure of the relationship between X and Y. The correlation coefficient (r) is significant at .005 level (Table 14).

Yield - Price Relationship

The estimated relationship is as follows:

$$Y = 2.108 - 3.686X$$
$$(.65628)$$

where Y = price per ton (tame hay)

X = yield per acre (tame hay)

It is apparent here that there is an inverse relationship between price and yield. As yield goes up, price goes down. Since the standard error of b is relatively small it can be said that b gives a reliable estimate. The coefficient of correlation is r = .588, which, when tested at the .005 level is significant (Table 14).

Production - Value Relationship

In order to obtain some idea of the magnitude of the relative influences of price, production, yield, and acreage upon the value of production, the method of simple, two variable regression is used. The method is preferred to multiple regression because of the considerable amount of multicollinearity which exists between the above mentioned variables.

After fitting the data the following equation was obtained:

$$Y = 5{,}493.76 + 5.446X$$
$$(.66923)$$

where Y = value of production of tame hay (in thousands of dollars)

X = production of tame hay (thousands of tons)

The coefficient of correlation of .747 indicates that there is a reasonably strong relationship between production and value. Furthermore, when tested at the .005 level, the relationship is significant, indicating that production and the value of production vary together to a considerable degree (Table 14). The regression coefficient is a good indicator of the relationship between X and Y because the standard error is quite small.

Yield - Value Relationship

The data are fitted to the following equation:

$$Y = 8{,}795.36 + 5{,}490.085X$$
$$(1{,}879.62868)$$

where Y = value of tame hay production (in thousands of dollars)

X = yield per acre for tame hay (tons)

The coefficient of correlations is .375, which indicates a relatively poor relationship between yield and value. When tested at the .005 level the relationship is not significant (Table 14). At the .01 level of significance, it appears to be significant, however. In general, it can be said that the yield of tame hay has a relatively small influence on the value of hay production. The reason for this might be that the value is directly influenced by changes in production and price which in turn are influenced by other variables, such as yield. Therefore, yield is exerting only an indirect influence upon value. However, this influence is tempered by the influence of other variables which might exert an influence in the opposite direction. The value of the regression coefficient can be relied upon in general, because its standard error is relatively small.

Price - Value Relationship

The estimated relationship is as follows:

$$Y = 14{,}871.20 + \underset{(318.49175)}{362.676X}$$

where Y = value of tame hay production in thousands of dollars.

X = price per ton (tame hay)

The value of the coefficient of correlation is .155, which implies that Y is not much influenced by changes in X. Using the test of significance at the .005 level the relationship between X and Y is not significant (Table 14). In other words, a change in price alone does not cause an appreciable change in the total value of production. The reason for this appears to be that production has a strong direct influence on price. Since the standard error of the correlation coefficient is quite large, it is not too reliable an indication of the influence of X on Y.

Acreage - Value Relationship

Fitting the data the following results were obtained:

$$Y = 501.23 + 12.645X$$
$$(1.77236)$$

where Y = value of production of tame hay (thousands of tons)

X = acreage harvested of tame hay.

The correlation coefficient of r = .694 seems to indicate a relatively strong relationship between X and Y. It is significant at the .005 level which means that a change in X will cause an appreciable change in the variable Y. However, the influence of X upon Y is not a direct one, since changes in acreage exert their influence through changes in production. Therefore, changes in acreage could be counteracted by changes in yield which tend to diminish the real influence of X. The estimated relationship above, however, does not take into consideration the fact that X does not influence Y in a direct manner. X exerts its influence on Y through production and price which are the primary determinants of Y. Hence, there is the possibility that the above relationship does not estimate in a correct manner the influence of X on Y, in spite of the fact that the standard error of the correlation coefficient indicates a reliable relationship (Table 14).

Comparing the results of the tests of significance for r it becomes apparent that acreage and production have a relatively strong influence upon the value of production while the other two variables (yield and price) have a negligible influence. However, since the estimated relationships are only reliable in the case of direct influences, only the results for the impact of price and production can be accepted. The results for the impact of acreage and yield may over--or under--state their actual influence on the value because of the influence of other factors.

A relatively accurate result of the relative importance of the variables with direct influence on value can be obtained by fitting a regression for the first differences of the logarithms of the data. It can then be determined how much of a change in price and in production is needed to cause a 1% change in the value of production.

Relative Influence of Price and Production Changes on the Value of Production

In order to obtain a clearer picture of the relative influence of changes in price and production upon the value of production, the log-transformation is applied. This method has been used by Sackrin for the determination of the relative influence of changes of yield and acreage upon production.[15]

First, average values are computed for the whole time series, including all 54 of tame hay data and the following values obtained for b_{12} and b_{13}:

$$b_{12} = .18649$$

$$b_{13} = .81351$$

The interpretation of the above coefficients is as follows: On the average of each 1 per cent change in the value of production from the preceding year, .18649% is ascribable to X_2

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[15]Sackrin, <u>op. cit.</u>, P. 136 - 39.

(changes in tame hay production) and .81351% is ascribable to X_3 (changes in price). This shows, considering the period as a whole, that prices are the main factors responsible for fluctuations in total value of production while production itself has much less influence. However, the influence of production upon value has two components, the direct part and the indirect part. The indirect part exerts its influence on production through prices, which means that the actual influence of price is not as large as indicated by the coefficient above.

However, the above coefficients are only average figures over the whole period, which means that possible trends within the time series cannot be detected by this method. Avoiding this difficulty, the time series is subdivided into three strata.

The criterion for determining the number of strata was the frequency of occurrence of above or below average production. The reason for this choice is the possibility of changes in the relative influences when the level of production changes, especially changes in prices, which are, as has been seen above, of considerable magnitude.

After examining the data, the following strata were established:

(1) Stratum I - from 1910 to 1928 which was a period of predominantly above average production.

(2) Stratum II - from 1929 to 1946 which was a period of exclusively below average production.

(3) Stratum III - from 1947 to 1963 which was a period of predominantly above average production.

For stratum I the following results were obtained:

$$b_{12} = .22046$$

$$b_{13} = .77954$$

The interpretation of the above data is as follows: On the average, of each 1 per cent change in the value of production from the preceding year .22046% is ascribable to X_2 (changes in production) and .77954% is ascribable to X_3 (changes in price).

The analysis of stratum II resulted in the following data:

$$b_{12} = .26494$$

$$b_{13} = .73506$$

which can be interpreted as follows: on the average of each 1 per cent change in the value of production from the previous year .26494% is ascribable to X_2 (changes in production) and .73506% is ascribed to X_3 (changes in price).

For stratum III the following results were obtained:

$$b_{12} = .53758$$

$$b_{13} = .46242$$

The interpretation of the results is as follows: On the average of each 1 per cent change in the value of production from the previous year, .53758% is ascribable to X_2 (changes in production) and .46242% is ascribable to X_3 (changes in price).

Comparing the results of the three strata it appears that the relative influence on the total value of production due to price changes and production changes has been undergoing a marked shift. b_{12} increased from .22046% to .53758% while b_{13} decreased from .77954% to .46242%, which indicates the presence of a definite trend. The relative influence of production has been increasing while the relative influence of price has been decreasing up to a point where the two are much closer together in stratum III than in stratum I and II.

However, it has to be kept in mind that the precision of these estimates might be affected by multicollinearity. "This is the name given to the general problem which arises when some or all of the explanatory variables are so highly correlated one with another that it becomes very difficult, if not impossible, to disentangle their separate influences and obtain a reasonably precise estimate of their relative effects."[16]

Relative Influences of Acreage and Yield Changes on Hay Production

Considering the data for all 54 years, the following results for the coefficients are obtained:

$$b_{12} = .01099$$

$$b_{13} = .98901$$

Therefore, on the average of each 1 per cent change in production from the preceding year, .01099% is ascribable to X (acreage changes) and .98901% is ascribable to X (yield changes). From

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[16] Johnston, op. cit., P. 201.

the above it becomes apparent that the influence of acreage changes is almost negligible while the influence of the yield changes is predominant. Since we are dealing with average influences it is possible that considerable deviations from the mean might not be given due consideration. Therefore, it is advisable to split up the data into several strata in order to give more attention to variations of the relative influences.

The criterion for determining the number of strata is the frequency of occurrence of above or below production. The reason for this choice is the possibility of changes in relative influences when production shifts, especially changes in yield which are, as has been seen above, of considerable magnitude.

The choice of strata, therefore, is the same as that used in the determination of the relative influences of price and production changes on the total value of production above. Fitting the data to the difference equations in the strata the following results are obtained:

For stratum I:

$$b_{12} = .00729 \text{ (acreage change)}$$

$$b_{13} = .99271 \text{ (yield change)}$$

Here the influence of yield changes is even more pronounced than that which is obtained when the relative influences are averaged over the whole time series.

For stratum II:

$$b_{12} = .00772 \text{ (acreage change)}$$

$$b_{13} = .99228 \text{ (yield change)}$$

It can be seen that the influence of yield is greater in stratum II than that obtained for the average deviations without stratification.

For stratum III:

$$b_{12} = .13844 \text{ (acreage change)}$$

$$b_{13} = .86156 \text{ (yield change)}$$

In stratum III apparently a pronounced change has taken place because the relative influence of acreage changes increased roughly 19 times as compared to the relative influences in stratum I and stratum II. In other words, the influence of yield is still predominant. Its value, however, has decreased from roughly .99 in stratum I and stratum II to roughly .86 in stratum III. This represents a loss of 13 percentage points in influence of yield changes on production.

It can be seen now that the use of strata makes it possible to examine some variations of the relative values of the influences on production by subdividing the relatively heterogeneous data into three subgroups which within themselves are relatively homogeneous. In this manner, the relative influences can be determined with increasing accuracy. Theoretically, the best determination of the influences could be achieved by having one observation per stratum. Since there is a total of 53 observations, there would be 53 strata. However, from the practical point of view the method would not be feasible, mainly due to computational difficulties, and the fact that for strata with only one observation variances cannot be computed.

Relative Influences of Acreage and Yield Changes on Different Hay Varieties

The following hay varieties were examined: Alfalfa hay, clover and timothy hay, and lespediza hay.

The time series for alfalfa hay extends from 1919 to 1963. For the determination of the relative influences of yield and acreage changes on production the log transformation method suggested by Sackrin is again applied[17] with the following results:

b_{12} = .03132 (change in acreage)

b_{13} = .96868 (change in yield)

This means that changes in yields have been by far the most important factor in influencing production.

For the determination of the possible presence of trends the data are divided into two strata. As a criterion for determining the point of division the transition from a period of below average to a period of above average production was welected. Stratum I extends from 1919 to 1940 while stratum II extends from 1941 to 1963. It is assumed that the relative influences of acreage changes are connected with the level of production.

The examination of stratum I yields the following results:

b_{12} = .00546 (acreage change)

b_{13} = .99454 (yield change)

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[17]Sackrin, op. cit., P. 137.

Here again, yield changes appear to be the predominant influence upon production.

Analyzing stratum II, the following results are obtained:

b_{12} = .33713 (acreage change)

b_{13} = .66287 (yield change)

A marked change has taken place in the relative influences; b_{12} increased from .00546 to .33713 while b_{13} decreased from .99454 to .66287. In other words, the relative influence of acreage changes has increased, and correspondingly there is a decrease in the influence of yield changes.

The examination of the production of clover and timothy hay gives the following results:

b_{12} = .39188 (acreage change)

b_{13} = .60812 (yield change)

This shows that the influence of yield is still predominant, while the influence of acreage is considerable.

Changes in the production of lespedeza hay are made up of the following components:

b = .27475 (acreage change)

b = .72527 (yield change)

where of a 1 per cent change in production from the previous year .27475% is ascribable to X_2 (change in acreage) and .72527% is ascribable to X_3 (change in yield). As previously, yield is the predominant influence in regard to changes in production.

Relative Influence of Acreage and Yield Changes on Wild Hay Production

The time series, which reaches from 1914 to 1963, indicates a decline of production which at first is rapid and later levels off and turns into a slight increase. On the average, tame hay production is several times larger than wild hay production. In the last decade the difference has increased due to the considerable increase in tame hay production.

The application of the log transformation method to the data gives the following results:

$$b_{12} = .02067 \text{ (acreage change)}$$

$$b_{13} = .97933 \text{ (yield change)}$$

Just as in the case of tame hay production, yield changes exert the predominant influence, whild the influence of acreage changes is relatively unimportant.

Variability of the Variables

The first aspect of tame hay production considered was the relationship between production and value of production. There appears to be a reasonably close correlation between above and below average values of the two variables. In 61.4% of the 54 years, below average production corresponds with below average value of the production, and above average production corresponds with the above average value of production.

Furthermore, the pattern of production is one of considerable irregularity. For the data examined, there does not seem to be any definite pattern. If there were relatively regular fluctuations between above average and below average production, it might be possible to store hay in order to eliminate the effects of the fluctuations. Since, however, there is a wide range of the length of the fluctuations (from 1 to 18 years for below average production and from 1 to 7 years for average production) it does not seem to be feasible to counteract the effects of the variations by inventory methods, i.e., there is no regularity, and the amount of time during which hay would have to be stored is too long. Too, due to the irregularity of production it would be quite difficult to predict below or above average production, or the length of the time period in question.

By constructing a frequency distribution for tame hay production (table 11), it can be seen that the distribution of the production variable does not approximate the normal distribution very closely. The frequency in the central interval is not large enough and the variable are not distributed equally on both sides of the mean. Therefore, prediction of a certain production is quite difficult, or impossible, since for making adequate predictions, there has to be a certain definite mathematical distribution of the variable in question, as for example, the normal distribution. It appears therefore that the attempt to approximate the actual distribution by a mathematical distribution will introduce some degree of unreliability for prediction purposes.

The value of tame hay production also varies greatly from year to year. The total value of the production could be increased if the yearly production were closer to the mean. To show this, it was assumed that each year's production is equal to the average production and that the average price prevails. The total value, computed over the 54 years came out to be larger than the actual total value. It is apparent, however, that this theoretical value cannot be approached, but that it could be possible to increase the total value by decreasing the variations of production in some way or other.

For the determination of the relative variations of the variables which are relevant for tame hay production, their respective coefficients of variation were determined (Table 12). Production is the variable with the relatively highest variability while yield has the relatively smallest variability. Yield is correlated to a very high degree with the amount of rainfall received, i. e., during years of average precipitation or above, high yields can be expected, while the below normal years have poor results.[18] Production varies more than yield, since factors other than yield have an influence too, as for example acreage harvested.

Another way of indicating the magnitude of the variations is to determine the ranges of the variables. As can be seen in tables 6 - 10, the ranges of all hay varieties are of considerable magnitude, indicating that the data are subject to large fluctuations.

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[18] I. L. Launchbaugh, "The Effect of Stocking Rate and Cattle Gains and on Native Short Grass Vegetation in West-Central Kansas." Kansas State Agricultural Experiment Station Bulletin 394, November 1957, P. 4.

SUMMARY

The analysis of the data reveals that the hay producer is faced with the problem of uncertainity and not with that of risk due to the difficulty of establishing a probability distribution for production. Since the difficulty arises mainly because of the influence of exogenous factors, the most important of which is precipitation, income stabilization programs would be quite difficult to establish.

On the whole, yield was found to be the variable having the strongest influence upon changes in production. Fitting the data by means of the two variable least-squares regression method it could be established that there exists a considerable amount of multicollinearity among the variables. There was no serial correlation between price and production of tame hay which means that the variables in year t have no influence on the variables in year t + 1, i. e., only production of year t can determine the price of year t.

Production was found to be the variable having the strongest influence upon the value of production. This implies that yield, which very strongly influences production, has a definite influence on the value of production, the influence being indirect. The actual influence of production, however, is stronger than in the estimated relationship due to multicollinearity. Both, the two-variable regression method and the log transformation method indicated production as the variable having the predominant influence on the value of production.

Furthermore, the application of the log transformation indicated that the factor which is mainly responsible for year-

to-year changes in production is yield. When the results of the log method are compared with those which were obtained by the two-variable regression method it can be seen that yield is the predominant factor in both cases. The log method gives the best indication of the relative influences since it includes both of the variables which influence production, while the application of the two-variable regression method necessitates the assumption that there is only one variable which influences production, resulting in somewhat distorted results.

The data vary greatly as is indicated by the large ranges of occurrences of the values. It appears that the values follow some cyclical pattern which is of high irregularity. Only wild hay production showed a definite trend, i. e., a long term decline of production has been taking place.

The results which were obtained in the study are average values for the state of Kansas as a whole. Since precipitation varies greatly within the state, i. e., "precipitation decreases from east to west, about 1 inch for each 17 miles from the Missouri border to the Colorado line," the yield of hay per acre decreases as one moves from east to west.[19]

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[19] L. Dean Bark. "Chances for Precipitation in Kansas," Kansas State Agricultural Experiment Station Bulletin 461 Manhattan: Kansas State University, May 1963, P. 3.

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APPENDIX

TABLE 1 TAME HAY 1910-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	PRICE PER TON ADJUSTED	VALUE OF PRODUCTION	PRICE PER TON NOT ADJUSTED
1910	1,650	1.50	2,475	7.72	19,107.00	7.80
1911	1,550	0.90	1,395	10.88	15,177.60	9.90
1912	1,630	1.65	2,690	7.52	20,228.80	7.60
1913	1,500	1.10	1,650	12.63	20,839.50	12.50
1914	1,650	1.55	2,558	6.98	17,854.84	7.40
1915	1,770	1.85	3,274	4.96	16,239.04	5.60
1916	1,680	1.65	2,772	6.08	16,853.76	7.60
1917	1,700	1.40	2,380	8.47	20,158.60	16.60
1918	1,780	1.20	2,137	9.33	19,928.88	19.40
1919	1,722	1.77	3,044	7.15	21,764.60	15.80
1920	1,739	1.56	2,707	4.93	13,345.51	10.20
1921	1,575	1.46	2,297	6.72	15,435.84	8.00
1922	1,531	1.53	2,347	8.09	18,987.23	9.30
1923	1,478	1.66	2,452	9.30	22,803.60	10.60
1924	1,575	1.57	2,474	9.33	23,082.42	11.20
1925	1,554	1.52	2,356	7.96	18,753.76	12.10
1926	1,389	1.29	1,795	8.90	15,975.50	13.00
1927	1,424	1.99	2,839	6.19	17,573.41	8.60
1928	1,242	1.89	2,325	6.62	15,391.50	9.40
1929	1,042	1.66	1,733	8.43	14,609.19	11.80
1930	999	1.57	1,567	8.43	13,209.81	9.70
1931	1,064	1.44	1,528	8.33	12,728.24	6.50
1932	1,082	1.68	1,813	8.39	15,211.07	4.70
1933	1,103	1.39	1,534	9.53	14,619.02	6.10

TABLE 1 TAME HAY 1910-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	PRICE PER TON ADJUSTED	VALUE OF PRODUCTION	PRICE PER TON NOT ADJUSTED
1934	1,022	0.78	793	19.64	15,574.52	16.30
1935	1,146	1.58	1,812	5.65	10,237.80	6.50
1936	1,076	0191	978	10.00	9,780.00	11.80
1937	818	1.08	886	6.95	6,157.70	8.90
1938	655	1.53	1,002	5.16	5,170.32	4.90
1939	597	1.40	838	8.37	7,014.06	7.70
1940	773	1.65	1,273	7.14	9,089.22	7.00
1941	882	1.92	1,695	7.11	12,051.45	8.60
1942	1,069	2.06	2,206	6.51	14,361.06	9.90
1943	1,070	1.77	1,893	8.94	16,923.42	16.00
1944	1,091	2.03	2,213	8.30	18,367.90	15.10
1945	1,145	1.87	2,141	7.87	16,899.67	14.10
1946	1,108	1.69	1,876	8.74	16,396.23	19.40
1947	1,357	1.76	2,393	7.42	17,681.16	21.30
1948	1,342	2.02	2,715	6.69	18,163.35	19.80
1949	1,415	1.79	2,531	6.50	16,451.50	16.90
1950	1,423	1.15	2,628	7.18	18,896.05	19.90
1951	1,496	1.84	2,751	7.80	21,457.80	25.40
1952	1,322	1.43	1,889	11.33	21,402.39	333.30
1953	1,645	1.36	2,230	10.35	23,080.50	26.30
1954	1,830	1.53	2,799	9.55	26,730.45	26.60
1955	1,921	1.50	2,891	8.93	25,816.63	20.80
1956	1,705	1.16	1,977	11.59	22,913.43	26.30

TABLE 1 TAME HAY 1910-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	PRICE PER TON ADJUSTED	VALUE OF PRODUCTION	PRICE PER TON NOT ADJUSTED
1957	1,762	2.00	3,526	6.77	23,871.02	15.90
1958	1,600	2.37	3,797	4.90	18,605.30	12.10
1961	1,317	2.12	2,789	7.44	20,750.16	17.70
1960	1,396	2.36	3,295	5.97	26,261.15	18.50
1961	1,443	2.40	3,468	7.19	24,934.92	16.90
1962	1,593	2.43	3,876	7.56	29,651.40	18.60
1963	1,558	1.99	3,103	9.26	28,733.78	22.40

(1) Kansas State Board of Agriculture. Kansas Agriculture. Kansas State Printing Office, 1964.

TABLE 2 ALFALFA HAY 1919-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS
1919	1,316	1.90	2,500	1941	642	2.15	1,380
1920	1,303	1.60	2,085	1942	802	2.30	1,845
1921	1,134	1.50	1,701	1943	810	1.95	1,580
1922	1,021	1.65	1,615	1944	827	2.26	1,869
1923	980	1.80	1,764	1945	852	2.10	1,789
1924	981	1.80	1,766	1946	826	1.90	1,569
1925	970	1.75	1,698	1947	1,016	1.95	1,981
1926	931	1.50	1,396	1948	1,036	2.25	2,331
1927	968	2.30	2,226	1949	1,026	2.00	2,052
1928	823	2.20	1,811	1950	995	2.10	2,090
1929	730	1.15	1,350	1951	985	2.15	2,118
1930	642	1.80	1,156	1952	906	1.60	1,450
1931	719	1.55	1,114	1953	1,114	1.55	1,727
1932	719	1.90	1,366	1954	1,437	1.65	2,371
1933	705	1.60	1,128	1955	1,538	1.60	2,461
1934	749	.86	644	1956	1,338	1.25	1,672
1935	854	1.75	1,494	1957	1,378	2.15	2,963
1936	777	1.00	777	1958	1,295	2.55	3,302
1937	559	1.15	653	1959	1,049	2.30	2,413
1938	394	1.70	670	1960	1,080	2.60	2,808
1939	380	1.60	608	1961	1,112	2.65	2,947
1940	490	1.90	931	1962	1,201	2.75	3,303
				1963	1,201	2.20	2,642

(1) Kansas State Board of Agriculture, Kansas Agriculture, Kansas State Printing Office, 1964.

TABLE 3 CLOVER AND TIMOTHY HAY 1924-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS
1924	245	1.00	246	1947	114	1.20	137
1925	263	1.00	263	1948	111	1.20	133
1926	240	.80	192	1949	105	1.23	129
1927	218	1.30	213	1950	142	1.30	185
1928	212	1.00	212	1951	160	1.25	200
1929	126	1.10	130	1952	168	1.20	202
1930	51	1.00	151	1953	131	1.05	138
1931	140	1.05	147	1954	100	1.25	125
1932	112	1.10	123	1955	92	1.30	120
1933	108	.90	97	1956	46	.85	39
1934	52	.48	25	1957	30	1.60	48
1935	27	1.05	28	1958	69	1.80	123
1936	38	.80	30	1959	66	1.50	99
1937	19	.95	18	1960	92	1.65	152
1938	14	1.05	15	1961	88	1.65	145
1939	15	1.05	16	1962	104	1.50	156
1940	28	1.25	35	1963	83	1.45	120
1941	36	1.25	45				
1942	44	1.35	59				
1943	55	1.30	72				
1944	72	1.33	96				
1945	75	1.30	98				
1946	95	1.20	114				

(1) Kansas State Board of Agriculture, Kansas Agriculture, Kansas State Printing Office, 1964

TABLE 4 LESPEDEZA HAY 1939-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS
1939	22	1.00	22	1961	38	1.35	51
1940	32	1.05	34	1962	38	1.20	46
1941	36	1.05	38	1963	20	1.00	20
1942	70	1.20	84				
1943	95	1.10	104				
1944	83	1.13	94				
1945	118	1.10	130				
1946	77	.90	68				
1947	117	1.05	123				
1948	104	1.30	135				
1949	121	1.25	151				
1950	136	1.20	163				
1951	160	1.20	192				
1952	70	.90	63				
1953	22	.90	20				
1954	26	1.05	27				
1955	40	1.10	44				
1956	48	1.05	50				
1957	47	1.20	56				
1958	47	1.50	70				
1959	36	1.30	47				
1960	36	1.30	47				

(1) Kansas State Board of Agriculture. Kansas Agriculture, Kansas State Printing Office, 1964.

TABLE 5 WILD HAY 1914-1963 (1)

YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS	YEAR	ACRES HARVESTED THOUSANDS	YIELD TONS	PRODUCTION TONS THOUSANDS
1914	1,205	.90	1,084	1939	585	1.00	585
1915	1,270	1.20	1,524	1940	585	.95	556
1916	1,250	1.05	1,312	1941	573	1.10	630
1917	1,220	.80	976	1942	590	1.25	738
1918	1,210	.65	786	1943	673	1.15	774
1919	1,223	1.06	1,296	1944	693	1.11	769
1920	1,137	.90	1,023	1945	638	1.15	734
1921	1,092	.99	1,081	1946	638	.75	478
1922	1,026	.98	1,005	1947	702	1.10	772
1923	1,047	1.03	1,078	1948	611	1.25	764
1924	1,003	.97	973	1949	642	1.15	738
1925	913	.75	685	1950	642	1.15	738
1926	876	.60	526	1951	693	1.15	797
1927	964	1.20	1,157	1952	686	.70	480
1928	897	1.15	1,032	1953	652	.75	489
1929	919	1.05	965	1954	704	.85	598
1930	901	.80	721	1955	620	.90	558
1931	919	.85	781	1956	570	.80	456
1932	947	1.00	947	1957	627	1.25	784
1933	777	.68	528	1958	539	1.40	755
1934	622	.55	342	1959	596	1.25	745
1935	778	1.00	778	1960	668	1.30	868
1936	622	.55	342	1961	668	1.20	802
1937	591	.85	502	1962	701	1.15	806
1938	650	1.20	780	1963	701	.90	631

(1) Kansas State Board of Agriculture. Kansas Agriculture. Kansas State Printing Office, 1964.

TABLE 6 VARIATION OF TAME HAY PRODUCTION

	ACRES TONS	YIELD PER ACRE	PRODUCTION TONS	PRICE PER TON	VALUE THOUSANDS
Maximum	1,928,000	2.43	3,876,000	19.64	29,651.50
Minimum	597,000	.78	793,000	4.90	5,170.32
Range	1,331,000	1.65	3,083,000	14.74	24,481.08

TABLE 7 VARIATION OF ALFALFA HAY PRODUCTION

	ACRES TONS	YIELD PER ACRE	PRODUCTION TONS	PRICE PER TON	VALUE THOUSANDS
Maximum	1,538,000	2.75	3,303,000		
Minimum	394,000	.86	608,000		
Range	1,144,000	1.89	2,695,000		

TABLE 8 VARIATION OF CLOVER AND TIMOTHY HAY PRODUCTION

	ACRES TONS	YIELD PER ACRE	PRODUCTION TONS	PRICE PER TON	VALUE THOUSANDS
Maximum	263,000	1.80	283,000		
Minimum	14,000	.40	15,000		
Range	249,000	1.32	268,000		

Source: Kansas State Board of Agriculture. Kansas Agriculture. Kansas State Printing Office, 1964.

TABLE 9 VARIATION OF LESPEDESA HAY PRODUCTION

	ACRES TONS	YIELD PER ACRE	PRODUCTION TONS	PRICE PER TON	VALUE THOUSANDS
Maximum	160,000	1.50	192,000		
Minimum	20,000	.90	20,000		
Range	140,000	.60	172,000		

TABLE 10 VARIATION OF WILD HAY PRODUCTION

	ACRES TONS	YIELD PER ACRE	PRODUCTION TONS	PRICE PER TON	VALUE THOUSANDS
Maximum	1,270,000	1.40	1,524,000		
Minimum	510,000	.55	342,000		
Range	700,000	.85	1,182,000		

TABLE 11 FREQUENCY DISTRIBUTION OF TAME HAY PRODUCTION

INTERVALS	FREQUENCY		% OF VALUES
701-1200	5		9
1201-1700	8		15
1701-2200	9		16
2201-2700	16		30
2701-3200	10		19
3201-3700	4		7
3701-4200	2		4
	n = 54	TOTAL	100

Source: Kansas State Board of Agriculture. Kansas Agriculture. Kansas State Printing Office, 1964.

TABLE 12 VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION OF TAME HAY VARIABLES 1910-1963

VARIABLE	VARIANCE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
Price	5.23	2.29	.28
Production	537,228.53	732.96	.32
Yield	.13	.36	.21
Acreage	99,632.00	315.65	.23
Value	28,430,732.00	5,332.05	.30

where $S^2 = \frac{\sum_{1}^{54} (X-\bar{X})^2}{N}$

and the coefficient of variation $= \frac{S}{\bar{X}}$

TABLE 13 STANDARD DEVIATION OF Y GIVEN X, THE ESTIMATED STANDARD ERROR OF THE SAMPLE REGRESSION COEFFICIENT AND THE SAMPLE REGRESSION COEFFICIENT b OF ALL TWO-VARIABLE REGRESSIONS

X	Y	$S_{Y \cdot X}$	S_b	b
Acreage	Production	528.86387	.22801	.663
Yield	Production	496.96997	185.48045	1,521.096
Production	Price	2.10055	.00039	.001
Yield	Price	1.75850	.65628	3.686
Price	Value	5,351.51287	318.49175	362.676
Yield	Value	5,036.21216	1,879.62868	5,490.085
Acreage	Value	4,017.61844	1.77236	12.645
Production	Value	3,604.56044	.66923	5.446

where $$S_{Y \cdot X} = \sqrt{\frac{1}{n-2}\Sigma(Yi-\hat{Y}i)^2}$$

$$Sb = \frac{S_{Y \cdot X}}{\Sigma(Xi-\bar{X})^2}$$

TABLE 14 TESTS OF SIGNIFICANCE FOR COEFFICIENTS OF CORRELATION

REGRESSION	REGRESSION COEFFICIENT	r	r^2	$\lvert t \rvert$	$t\alpha$	SIGNIFICANCE AT $\alpha = .005$
Production-Price	.001	.423	.179	3.37	2.94	Significant
Acreage-Production	.663	.716	.513	7.40	2.94	Significant
Yield-Production	1,521.096	.753	.567	8.26	2.94	Significant
Yield-Price	3.686	.588	.346	5.24	2.94	Significant
Acreage-Value	12.645	.694	.482	6.94	2.94	Significant
Yield-Value	5,490.085	.375	.141	2.91	2.94	Not/Signifi.
Price-Value	362.676	.155	.024	1.13	2.94	Not/Signifi.
Production-Value	5.446	.747	.558	8.11	2.94	Significant

HAY PRODUCTION AND ITS STABILITY IN KANSAS

by

KLAUS DORNSEIF

B. A., Kansas State University, 1965

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Economics

KANSAS STATE UNIVERSITY
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This study was an analysis of the factors influencing the magnitude of hay production and the magnitude of the value of hay production. The data analyzed covered the following years: 1910-1963 (tame hay), 1919-1963 (alfalfa hay), 1924-1963 (clover and timothy hay), 1939-1963 (lespedeza hay), and 1914-1963 (wild hay).

There are considerable year-to-year variations in the production of hay which places a large burden on beef-feeding operations in regard to the maintenance of inventories. It is therefore, difficult for the individual producer to determine the combination of livestock and feed reserves which would optimize net returns in the long run.

The study had the following objectives: (a) to determine the size of the variations of hay production for the years indicated above, (b) to determine the main factors causing the changes in hay production, and (c) determine the main factors causing the variations in the value of production.

The analysis revealed that hay producers in the state of Kansas are faced with the problem of uncertainty since it would be difficult to establish an adequate probability distribution for the production of hay.

On the whole, yield was found to be the variable having the strongest influence on year-to-year changes in production. Production (yield) was also the variable having the strongest influence on the value of production. Furthermore, it was found that acreage and price had some influence on production and the value of production. The values of the data varied extensively from year to year due to the influence of precipitation.