ABSTRACT

A PROCEDURE FOR MEASURING THE SEPARATE EFFECTS OF MAN-CONTROLLED INPUTS AND WEATHER ON YIELDS-- APPLIED TO GRAIN SORGHUM YIELDS

by

Fred H.erman Abel

There were two principal objectives in this study. The first was to estimate how changes in inputs have affected yield, and the second was to determine the effect of specifying alternative models.

A single equation model was developed. The parameters were estimated by least squares regression analysis. The dependent variable was yield of grain sorghum per acre. There were 645 observations; observations on 129 counties in each of the agricultural census years, 1939-1959. Three kinds of independent variables were included--man-controlled input variables, dummy (0, 1) variables, and weather variables.

The seven man-controlled input variables were: (1) Percent of grain sorghum acreage irrigated, (2) dollars spent on gas and oil per acre of cropland harvested, (3) pounds of fertilizer nutrients applied per acre of grain sorghum, (4) ratio of acres fallowed to acres of cropland harvested, (5) average acres of grain sorghum per farm harvesting grain sorghum, (6) number of tractors per acre of cropland harvested, and (7) per acre value of land (to measure the interaction effects of land with technology).

Two sets of dummy (0, 1) variables were included--27 variables to represent the crop reporting districts and 4 variables to represent years.

Four sets of weather variables were included: (1) Preseason precipitation, (2) season precipitation, (3) season temperature, and (4) season interaction (temperature times precipitation). Three forms of season weather variables were considered in detail: (a) A weather variable for each week of the growing season for each weather factor, (b) a polynomial of seventh degree for each weather factor, and (c) a season total variable for each weather factor.

Estimates of the effect on average yield of changes in the level of the independent variables were obtained from the "complete" equation. This equation contained the seven man-controlled input variables, the 27 dummy variables for crop reporting districts, the four dummy variables for years, the preseason precipitation variable, the 23 season precipitation variables, the 23 season temperature variables, and the 23 season interaction variables.

On the basis of this equation, it was estimated that of the 1,146 pound per acre increase in yield between 1939 and 1959, 27.4 percent was explained by changes in the level of the explicit man-controlled inputs, 46.1 percent by changes in the level of implicit man-controlled inputs, and 26.5 percent by changes in weather. Of the increase due to changes in explicit man-controlled inputs, almost all is due to changes in two inputs--fertilizer, irrigation, and their interaction with land (value of land). Changes in weather during the growing season accounted for 85.4 percent of the total weather effects. Shifts in the location of production, 1939 to 1959, caused average yield to increase 50 pounds.

Three hundred and eight other equations were estimated to estimate the effects of specifying alternative models. The $\bar{R}^2$ for the "complete" equation was .855. When polynomial weather variables were substituted for the weekly variable, $\bar{R}^2$ was .821. When season total weather variables were substituted for the weekly variables, $\bar{R}^2$ was .786. Omitting any set (man-controlled inputs, years, crop reporting district, season precipitation, season temperature, or season interaction) of variables from the "complete" equation caused R^2 to decrease significantly. In almost all cases the magnitude of the coefficients remaining in the equation was affected. In some cases the level of significance and sign were also affected.

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Fred H. Abel

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CHAPTER I

INTRODUCTION

This study is concerned with developing a physical "production function" for grain sorghum. A single equation model is used and estimates of the parameters are obtained by regression analysis. An attempt is made to measure simultaneously the influence of weather, man-controlled inputs, and location of production on per acre yields of grain sorghum. The effects of omitting a variable or set of variables on the ability of the model to explain yields and on the coefficients of the variables remaining in the submodel are considered. Also alternative forms of the weather variables and some of the man-controlled input variables are considered.

The objectives of this study and relevant background information are presented in this chapter. The model and a detailed description of each of the variables included in the model are the subjects of the second chapter. The third chapter contains a discussion of problems and procedures. The results of the analysis are presented in the fourth through the seventh chapters. The eighth and final chapter contains the summary and conclusions. Detailed lists and discussions of the sources of data and the results (coefficients and indicated level of significance) are presented in the appendix.

Need for Study

There are three principal needs for physical production function studies. They are listed and briefly discussed below.

Understanding the Physical Relationship

Botanists, agronomists, plant physiologists, horticulturists, and other plant scientists have a continuing interest in determining the relationship of environmental conditions and levels of man-controlled inputs to yields.

Other groups that can use information about these relationships are:

(1) Farmers, so they can make "correct" production decisions;

(2) Agricultural supply firms, so they can anticipate demand for their products;

(3) Agricultural policy makers, so they can estimate the effect of policy alternatives;

(4) Agricultural marketing firms, so they can estimate supply; and

(5) Agricultural economists, so they can determine optimum resource use.

Predicting Crop Yields

Producers, purchasers of agricultural crops, as well as persons concerned with agricultural policy and/or national planning have a continuing interest in obtaining good projections of yields.

This interest is so strong that the Crop Reporting Board of the United States Department of Agriculture makes monthly estimates during the growing season of the prospective yields of many crops. Knowledge of the relationship of location, weather, and man-controlled inputs to yields would facilitate this estimating procedure.

Knowledge of these relationships would also aid in making long-run predictions of yields. This could be done by assuming "average" or "normal" weather and predicting changes or possible changes in the level of the man-controlled inputs. The projected level of the man-controlled inputs for some years in the future could then be "plugged" into the model with average weather to estimate yields in that year. Such predictions are relevant for answering many questions concerning our ability to feed a rapidly expanding population or to feed the world.

Explaining Changes in Yields

The large changes in yields of certain crops in recent years has led to a desire to (1) determine the factors causing the change in yield and (2) measure the effect of each factor. The factors can be grouped as (1) man-controlled factors and (2) environmental factors.

It is important that the relationships of man-controlled inputs and environment to output be known so: (1) Activity analysis at all levels of aggregation can use "good" input-output coefficients; (2) the behavior of farmers and their supply response can be understood; (3) "correct" production recommendations to farmers and to agricultural industries can be made; (4) producers can make "correct" profit-maximizing decisions; and (5) agricultural policy that best meets the short- and/or long-run objectives of society and/or agriculture can be made.

An example of current and major importance is the need to determine how much of the agricultural surplus was the result of changes in the level of man-controlled inputs and how much the result of "good" weather. The determination of this could have a major influence on agricultural policy.

A great many studies have been conducted in an attempt to determine the influence of man-controlled inputs (MCI) and/or weather on yields. The lack of success in measuring the effect of weather and indeed the need

for a technique to do this are attested to by the large number of alternative techniques developed in recent years.

Of the three "needs" discussed above (understanding physical relationships, predicting yields, and explaining yield changes), this study is primarily concerned with the last one. It is concerned with explaining yield changes and with developing a technique to explain yield changes.

Using Aggregate Data

At an early stage of this study, a choice existed as to whether a model should be developed using experiment station data or using aggregate farm data. The principal advantage of using experiment station data is that very detailed information exists concerning such factors as: Date of planting, soil type, variety of seed, seedbed preparation, fertilizers applied, date of irrigation and amounts of water applied, chemicals applied, plant population, date of harvesting, etc. Also weather data are obtained at a location very near the plots, minimizing the problem of obtaining relevant weather data.

This choice was rejected in spite of its advantages because it was decided that a model that explained experiment station yields was of little value save the implication that it would also be useful with aggregate data. Whether the model would give meaningful results when aggregate data were used would still have to be determined. It was decided that it would be better to determine if a model could be constructed that would give meaningful and useful results using available aggregate data. It was rejected also because of the desire to explain the change in aggregate yields.

Objectives

There are two major objectives of this study. The first is to estimate how changes in inputs have affected changes in the per acre yield of grain sorghum. The second is to estimate the effect of alternative model specifications. Two minor objectives concerning alternative models are: (1) What are the effects on $\bar{R}^2$ and on the coefficients in the model of dropping certain variables or sets of variables; and (2) what are the effects of alternative ways of representing or measuring the factors.

The objectives above include answering the following questions.

(1) Can a model using time series-cross sectional data by agricultural census years and counties and containing as independent variables (a) man-controlled inputs, (b) years, (c) location, (d) preseason precipitation, (e) weekly values during the growing season for precipitation, (f) weekly values during the growing season for temperature, and (g) weekly values during the growing season for precipitation multiplied by temperature (interaction) explain the observed change in yield of grain sorghum?

(a) How much of the change in the yield can be explained by changes in the man-controlled inputs? Changes in weather? Changes in man-controlled inputs not included explicitly in the model (years)? Shifts in the location of production?

(b) How much of the differences in yields between locations is explained by variables associated with location but not included explicitly in the model?

(2) What are the effects on $\bar{R}^2$ and on the coefficients in a submodel of dropping variables or sets of variables from the complete model?

(a) How well does a submodel containing only man-controlled inputs compare to the complete model?

(b) How well does a submodel containing only weekly weather variables compare to the complete model?

(c) How well does a submodel containing only years and locations compare to the complete model?

(d) How does dropping the man-controlled input variables affect the coefficients for the weather variables? The years variables? The location variables?

(e) How does dropping each man-controlled input variable affect the coefficients for other man-controlled input variables?

(f) How does dropping the weather variables, the location variables, or the years variables affect the coefficients of the other variables remaining in the submodel?

(3) What is the effect on $\bar{R}^2$ and on the coefficients in a submodel of substitution of variables?

(a) How does substituting season total weather variables for the weekly weather variables affect the $\bar{R}^2$ and the coefficients of the other variables in the submodel?

(b) What is the effect on $\bar{R}^2$ and on the coefficient of other variables in the submodel of substituting for the weekly weather variables weather polynomials of degrees one, two, three, four, five, six, or seven?

(c) What is the effect of substituting average planting date variables for crop reporting district variables on $\bar{R}^2$ and the coefficients of other variables in the submodel?

(4) Based on the alternative submodels estimated, what are the advantages and disadvantages of various submodels?

(5) Can the effect of weather on per acre yields be better estimated by dividing the relevant growing season into weeks and obtaining an estimate of the effect of the weather in each week: (a) Using weekly weather variables, or (b) using polynomial weather variables?

Review of Literature

Grain Sorghum

Grain sorghum was used for this study because of the great increase in per acre yields realized in the last twenty years. Also grain sorghum was an important grain crop in the United States in 1963 and is increasing in importance (Table 1-1).

Table 1-1.--Production of feed grains in the United States, 1956-63[a]

Year	Corn for grain	Oats	Barley	Sorghum grain
	---	--- 1,000 bushels ---	---	---
1956	3,075,336	1,151,398	376,661	204,881
1957	3,045,355	1,289,880	442,761	567,506
1958	3,356,205	1,401,410	477,368	581,012
1959	3,824,598	1,052,059	422,383	555,211
1960	3,908,070	1,155,312	431,309	619,867
1961	3,625,530	1,011,398	395,669	479,751
1962	3,636,673	1,020,371	436,448	509,685
1963	4,091,685	979,400	405,577	587,909

a/ Supplement for 1963 to Grain and Feed Statistics, USDA, ERS, Economic and Statistical Analysis Division, Statistical Bulletin No. 159, March 1964 and Agricultural Statistics, 1965, USDA.

Grain sorghum is also important as a world food grain where it ranks third, being exceeded only by rice and wheat. Most of the sorghum grain produced in the United States is used as animal feed, but about 75 percent of the world crop is consumed by humans (130).1/

About 90 percent of the 1958 world crop was grown in China, India, Manchuria, and French West Africa. It is also grown in many other areas including Asia Minor, Iran, Turkestan, Pakistan, Korea, Japan, Australia, Southern Europe, Central America, and South America (100).

Sorghum grain is very similar to corn in nutrient content, containing about 12 percent protein, 3 percent fat, and 70 percent carbohydrates (130).

Besides the use for food or feed, grain sorghum also has many industrial uses. The starch can be used for adhesives, sizing for paper and fabrics, and as drilling mud for the petroleum industry. Grits obtained from the endosperm can be used in brewing. The seed coat contains wax similar to cornauba wax that is used in making carbon paper, sealing wax, electrical insulation, and other products. Dextrose sugar, oil, and syrup, by-products of the wet milling industry, are used in foods. The sugar and syrup are used in canned fruit, and the oil is suitable for salad oil (130, 132).

The recent development of hybrid varieties which can be grown in areas where previous varieties could not and which produce higher yields than previous varieties makes it likely that grain sorghum will become even more important.

1/ The numbers in parentheses refer to the publications listed in the Bibliography.

History of Sorghum in the United States

Grain sorghum was introduced into the United States in the last half of the 19th century (133, 176). The first sorghum grown was tall like corn and was harvested by hand (130). In the 1910's dwarf varieties were introduced. These varieties were affected less by extreme weather and were rapidly adopted. In the 1920's double dwarf varieties were developed and again because of their advantages rapidly replaced other varieties (66, 170). The double dwarf varieties were small enough that they could be harvested with a combine.

These standard varieties were continually improved by systematic breeding and selection to give higher yields and to be more resistant to insects, diseases, and extreme weather (43, 130, 170).

Hybrid grain sorghum had been studied for many years before a technique for large-scale production of hybrid seed was discovered in 1954. The first commercial seed field was planted in 1955 and hybrid varieties were grown on a large scale for the first time in 1956 (1, 158). By 1960, 70 percent of all grain sorghum acreage was planted to hybrids (1).

In 1958 there were more than 500 varieties of grain sorghum grown in the United States (130). It is certain with the increased development of hybrid varieties that there are even more varieties grown now.

Grain Sorghum Botany

Sorghum generally is divided into these two main classes: Forage types and grain types.1/ All sorghum varieties produce grain and almost all varieties can be used for forage. However, there are great varietal

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1/ Although Broomcorn, Sudan grass, and Johnson grass belong to the sorghum genus, they are generally considered as separate crops because of their specialized uses (130).

differences. Those varieties that do well for forage produce poor yields of grain and grain varieties produce poor yields and possibly poor quality forage. There are dual purpose varieties that produce reasonable yields of both, but they do not do as well for either purpose as the specialized varieties.

The grain of sorghum is small and the number of seeds per pound ranges from 12,000 to 35,000 seeds. This compares to about 14,000 seeds per pound for wheat (167). Grain sorghum weighs about 56 pounds per bushel.

The rate of germination is poor with field germination being about 60 percent when the seed germinates 90 percent in the laboratory (167).

Sorghum is not sensitive to soil types and can tolerate considerable quantities of alkali or salts (133, 167). The amount of moisture necessary to produce a crop does depend on soil type. Very low yields or even crop failure may be expected if the precipitation is less than 12 inches on sandy soil or 14 inches on heavier soils. In moist seasons, highest yields are obtained on the heavier soil (100). In most years 21 to 25 inches of water are needed for high yields (82, 130). Grain sorghum can tolerate too much moisture (flooding) better than many other crops (133).

The timeliness of precipitation is also important. It has been shown that at the time of flowering there is a great increase in transpiration without any change in the environment (3). It has been demonstrated that grain sorghum can utilize moisture from a depth of 90 inches (133).

Grain sorghum can withstand greater extremes of heat than most other crops (133). However, yields are influenced by heat. If the temperature is high during the time that the crop is producing seed there will be higher rates of transpiration and less storage of sugar, starches, and other products of photosynthesis (160). The most favorable mean temperature for the growth of sorghum is about 80° F. (130). The timing of temperature is also important. High temperature at the time the plant heads and flowers is particularly harmful. Better yields are obtained if the plant comes to head after the period of greatest heat is past (176).

New varieties have been developed that have changed the sensitivity of sorghum to temperature. At one time sorghum could only be grown where the frost-free season was at least 160 days and with a mean July temperature of at least 75° F. Now sorghum can be grown with a frost-free season as short as 130 days and a mean July temperature of near 70° F. (100, 174).

Most of the grain sorghum varieties grown in the United States grow to maturity in 90 to 120 days (130). The actual range is from 85 days to 140 days (100). The length of time to grow to maturity (to mature) is primarily a function of variety, but it is also a function of temperature and length of day.

Sorghum is a "short day" species, which means that flower initiation is hastened if the days are short and is delayed if the days are long (130). For example, a deviation of one hour from an average day length of 12 hours will alter the growing period by about 10 days (100).

The fact that the length of time for sorghum to mature is a function of temperature is illustrated by the fact that the period from planting to pollination is twice as long at an average temperature of 68° F. as it is at 86° F. (100).

All varieties are not affected to the same extent by day length and temperature. Thus, two varieties that may mature in the same length of time at one location may differ at another location where temperature and/or day length are different (130).

Grain sorghum can be harvested when the moisture content of the heads is 25 to 30 percent. However, because the grain does not dry well in the bin, the moisture content should be less than 13 percent or else the grain must be artificially dried. Much of the recent interest in growing grain sorghum in the Corn Belt States is because of the availability of farm grain dryers (133).

Sorghum is subject to four general groups of diseases: (1) Those that reduce stands by rotting the seeds or killing the seedlings; (2) those that attack the leaves; (3) those that attack the heads; and (4) those that cause root or stalk rot. The most severe losses are generally caused by the root or stalk rot. Control of these diseases lies in the use of resistant varieties, seed treatment and/or crop rotation (167).

Sorghum is also subject to insect attacks. The more common ones are chinch bugs, corn ear worm, corn leaf aphids, sorghum midge, and grasshoppers. Ordinarily, injury to sorghum from insects is not very great or widespread (167).

Grain Sorghum Culture

Sorghum should be planted in a well prepared seedbed. In the more humid areas it is planted in the top of the seedbed but in drier areas planting is done in the bottom of a furrow (130).

Sorghum may be planted in southern Texas as early as February 15 or as late as September 1 (100). The further north the growing area, the shorter is the range of possible planting dates. The general rule is not to plant until the soil is warm (60° F.) and to plant so that the crop will head after the hottest part of the growing season has passed (176).

Plant population is an important factor affecting yields (100). The desired plant population depends on whether the crop will be irrigated, planted in rows, or drilled. Given the desired plant population, the amount of seed to plant depends on germination rate, size of kernel, ability of variety to tiller, and hardness of endosperm of the kernel (167).

Irrigation is an important cultural practice. It has been observed that irrigated sorghum yields two to five times as much as dry land sorghum1/ (43, 78). There are two major methods of irrigating sorghum. One is to apply 10 to 12 inches of water previous to planting and then no further irrigation. The second is to apply water when and as much as is needed (130).

The importance of fertilization as a cultural practice depends on whether the crop is irrigated or not. Under dry land conditions sorghum shows little or no response to fertilizers (31, 67, 100, 130, 133). However, there is a great response to fertilizer, particularly nitrogen, if sorghum is irrigated (100, 130, 133).

Since 1945, almost the entire crop of grain sorghum has been harvested with combines. The proportion of the crop harvested with combines had increased to 100 percent from about 10 percent in 1940 (130).

Fallowing is another important cultural practice. The yields of sorghum on land fallowed the previous year are 50 to 90 percent greater than on similar land not fallowed (174, 167). The total production per acre from the two crop years of a three-year grain-grain-fallow rotation is about the same as from three years of continuous cropping (130).

1/ This is partly due to the fact that generally irrigated sorghum is fertilized while dry land sorghum is not.

Weather Studies

A large number of weather-crop yield studies have been made. Most have been concerned with understanding the physiology of the plant and/or with the prediction of yields and/or production. As this study is primarily concerned with the need to explain change in yields, only those techniques and studies related to this will be discussed. It will be noted if any technique used to explain yield changes also provides information pertinent to the other two "needs" discussed above.

The techniques used to explain yield changes take weather effects into account in two ways. One way is to use actual weather variables and/or some transformation of the weather variables. The second way is to use "weather" variables derived from production figures. This technique assumes the unexplained variation in production is all due to weather.

Actual Weather Variable Techniques

This section contains a review of techniques that contain actual weather variables, such as precipitation or temperature, or some transformation of actual weather variables.

One of the principal advantages of these techniques is that the information obtained contributes to a better understanding of plant physiology and can be used in predicting yields. Other advantages are that it is possible to determine if a particular weather factor limits production and if and how much yields in the future can be changed by controlling or influencing weather. The final advantage that will be listed is that these techniques can be used on any crop and with any kind of units of observation.

One of the principal arguments against these techniques is that no matter how many weather variables are used and no matter how they are transformed it is inconceivable that all the effects of weather could be measured. This argument is indisputable but it remains to be determined if the major portion of the effects of weather can be measured by a few correctly specified weather variables. One of the principal disadvantages of this technique is that in general several variables are needed. This is a particularly severe disadvantage if the number of observations is small. Another disadvantage is that the time and effort needed to collect the data is quite large if the number of observations is large.

Four different methods of including weather variables to explain yields will be discussed. The first method is the use of actual weather variables. The number of actual weather variables that could be used is almost limitless. Some of the actual weather variables used in weather-crop studies (but not necessarily for the purpose of explaining the effects of weather on yields) are: Annual precipitation, seasonal precipitation, preseason precipitation, soil moisture, temperature, humidity, light, evaporation, wind velocity, and soil temperature.

Only a limited number of studies have been conducted where actual weather variables have been used to explain yields. Of these some of the most important are those by Dr. Louis M. Thompson of Iowa State University. In his studies of wheat (156), grain sorghum (159), soybeans (159), and corn (159, 160), he used monthly totals of precipitation and monthly average temperatures for the principal months of the growing season as independent variables. Regression models containing these weather variables and a trend variable to capture the effects of changes in technology were estimated.

Another method of using the weather variables but allowing for nonlinear effects of the weather variables on yields is to consider in addition to the direct weather variables these same variables raised to some power. The most common practice is to consider in addition to the linear term a quadratic term. The studies by Thompson illustrate this technique (155, 158, 159, 160).

A third method of using weather variables to explain changes in crop yields which takes into account the effects of distribution as well as amount is to fit a polynomial in time to a set of weather data representing consecutive short time periods within the growing season. To elaborate, the growing season (or year) is divided into a number of comparatively short time periods (such as weeks or two-day periods). The information on a particular weather variable within each of the time periods and the position of the particular time period in the sequence are the basic information used. The weather information for each period is weighted by the position of the period in the sequence and then summed to form a "new" variable. The number of variables needed and thus the number of different weightings needed depends on the degree of the polynomial to be fitted.1/

This technique has, to the writer's knowledge, never been used explicitly for the purpose of explaining the effect of weather on yields so that other factors affecting yields could be investigated. The technique itself was introduced by R. A. Fisher in 1924 (52). It was used again and somewhat clarified by Floyd E. Davis, J. E. Pallesen and some

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1/ This process is discussed in greater detail in the following chapter. Also, Dr. Fred H. Sanderson gives a very comprehensive treatment of this subject in chapter nine of his book, Methods of Crop Forecasting, Harvard Economic Studies, Vol. 93, 1954.

of their colleagues in the early 1940's (36, 37, 120). All of these investigators used a computational procedure called "orthogonal polynomials" to estimate the coefficients of their regression equations.

In 1943, W. A. Hendrick and J. C. Scholl (65) demonstrated that the same objectives could be attained with usual regression analysis if the data were appropriately transformed into new variables.[1/] They went on to compare the results obtained by using monthly data and weekly data. They concluded, "The weekly data do not enable one to estimate the average state yields more accurately, but they facilitate the measurement of seasonal changes in weather effects."

Two recent studies using polynomials to capture the effects of weather were conducted by E. Ruge and R. O'dell (136, 137). Their first study was on corn and the second on soybeans. Both studies use data obtained from experimental plots. Plots were selected upon which most of the technology had been constant. The corn yields had to be adjusted for the effects of changing from nonhybrid to hybrid varieties. Adjusted yields were used as the dependent variable in the analysis. The effects of changing soybean varieties were accounted for by the inclusion of a trend variable in the analysis. Other than for changes in varieties grown, technology was not different on the plots considered in the study.

The last method used to include actual weather variables in a model to be discussed is the index method. In this method, actual weather variables are combined to form a single weather variable (an index of weather). This variable is then included in the model. The major weakness of all the indices considered here is their failure to take into account the effects of the distribution of the weather factors.

1/ This transformation is explained in more detail in the following chapter.

Many indices derived from weather variables are discussed in detail in a recent paper by Bernard Oury (119). A few of the indices discussed there are listed below to illustrate the nature of these indices.

Thornthwaite developed a moisture index that was expected to express the relative humidity or aridity during a period in a given location:

$$\text{Moisture index} = \frac{\text{precipitation} - \text{potential evaportranspiration}}{\text{potential evaportranspiration}}$$

Lang suggested the following index:

$$\text{Index} = \frac{\text{precipitation}}{\text{temperature}} = \frac{p}{T}$$

where precipitation is measured in millimeters and temperature in degrees centigrade. These units of measurement for precipitation and temperature are the same for all indices considered here.

De Martonne modified this to avoid the problem of negative values by adding 10 to temperature, i.e.,

$$I = \frac{P}{T+10}$$

Köppen suggested the following three alternatives:

$$I = \frac{8P}{5T+120}$$

$$I = \frac{2P}{T+33}$$

$$I = \frac{P}{T+7}$$

Angström considered this index:

$$I = \frac{P}{1.07^T}$$

The indices were designed to use annual values of the weather variables. However, they can be modified to use data based on shorter time periods. For example, De Martonne's index can be written,

$$I = \frac{P}{T+10} \times \text{number of periods in a year}$$

where P and T are averages of the periods. If P and T were averages of the monthly totals, the index $I = \frac{P}{T+10}$ would have to be scaled upward by a factor of 12 (119).

A variation of the index method is involved in the moisture stress concept developed by O. T. Demmead and R. H. Shaw (44). A plant is said to have experienced a moisture stress day if for a day the water needed by the plant was not available. Although the concept is simple the actual determination of both water need and water availability is extremely complex. Interested readers are referred to the original article (44).

The moisture stress concept was used by Robert F. Dale in a recent study (35). The variable actually used was the number of nonstress days during the growing season. The results were quite good. However, the determination of nonstress days demands at present special empirical investigations. To be useful in aggregate models it is necessary that the number of nonstress days be determinable from regularly obtained weather data such as precipitation and temperature.

Yield Index Techniques

These techniques derive measures of the effects of weather on crop yields by considering how plant yields have varied on plots where technology has remained "constant." The major reason that these techniques are considered is well stated by Robert F. Dale as follows, "After all, the plant experiences and integrates the same weather recorded only in part by our instruments as well as the complex plant-soil-weather interaction and the side effects of insects and disease" (35).

One of the principal advantages of these techniques is that only one variable for weather is needed in the model. Another advantage is that if the index is "correct" the influence of all weather factors and their interactions are taken into account.

Some of the disadvantages are:

(1) No information is obtained that will allow the determination of which, if any, weather factors are limiting production;

(2) No information is obtained that will aid in understanding the relationship of plants to environmental factors;

(3) No information is obtained that will aid in either short- or long-run predictions;

(4) Data of the kind used to date (experimental control plots and variety test plots) are not available in sufficient quantity (if at all) to derive indices for most crops; and

(5) There is no reason to believe that weather at the test plot location(s) is typical or representative of the State or region.

The yield indices are obtained by using data from experimental control plots or variety test plots. A linear trend is fitted to the data to remove the effects of factors which have changed consistently over time such as soil fertility. The index value is the ratio of actual yield to the trend yield.

This method was used by Glenn L. Johnson in his study of burley tobacco in 1952 (84). Dale Hathaway used it again in 1954 in his study of the dry bean industry in Michigan (60). James L. Stalling, a student of G. L. Johnson, used this method to obtain indices for some major crops by States, regions, and for the United States (145). In all of these studies control plots for yield experiments were used.

This method was modified somewhat by Lawrence Shaw who used data from variety yield test plots (143). Technology is not held constant on these plots as it is for the experimental control plots. Thus the problems of separating the effects of weather and technology are much greater. However, these trial plots are located throughout the State on farms and so they are much more likely to be representative of the State.

Functions Used to Explain Changes in Yield

Functions reviewed will be limited to those that are for a particular crop and that include weather and man-controlled inputs as variables.

Principal studies containing the characteristics listed above can be classified into two groups. The first group are those that include a number of MCIV and a single variable (usually an index) to represent weather. The second group are those that have a number of weather variables and a single variable (usually a time trend) to represent the MCIV.

Good examples of studies using several non-weather variables and a single weather variable are those by D. Gale Johnson and Robert L. Gustafson (83), by Ludwig Auer (6), and by Shaw and Durost (143).

In their study, Johnson and Gustafson used the following non-weather variables: Fertilizer, mechanization, variety index or degree of hybridization, summer fallow, labor, value of land per acre, total cropland harvested, and irrigation. The only weather variable was average annual precipitation. Functions were estimated for wheat and corn. The value assigned to each variable was the <u>change</u> in the average level of the variable between two selected time periods. The time periods in the case of wheat were for the base period 1928-41, excluding 1933-36, and for comparison period 1945-54.

Auer in his study also concentrated on MCI (6). However, his functions were based on time series data (1939-1960). He estimated functions by crops and by States. A total of 180 functions were estimated. The MCIV were an index of variety, pounds of fertilizer applied per acre, crop acreage, and a trend variable (to represent technology). The "weather" variable was a yield index calculated from data on experimental and test plots.

The study of corn yield by Shaw and Durost (143) is similar to the studies by Gustafson and Auer as a single variable is used to capture the effects of weather and several MCIV are included. A yield index was constructed to represent weather for crop reporting districts in Ohio, Indiana, Illinois, Iowa, and Missouri. However, these were aggregated to obtain an index for the Corn Belt as a whole. The analysis was of a time series of yields.

Examples of studies emphasizing weather variables are those by Thompson (156-160) and Studnes (150). In these studies technology was taken into account by the inclusion of a trend variable. Several weather variables (monthly totals or monthly averages of specific weather factors such as rainfall or temperature) were also included. Studnes' study differs from Thompson's in that a longer time series was considered and he attempted (after the results of the regression on yield) to decompose the trend term (technology) into its component parts using other data.

It appeared to the author that the studies by Johnson and Gustafson, Auer, and Shaw and Durost did not take weather into account adequately and the studies by Thompson and Studnes did not take technology into account adequately. It was in the desire to remedy these inadequacies that this study was undertaken.

CHAPTER II

THE MODEL

In this chapter a detailed discussion is made of the model and of each variable in the model. The model is a single equation model and the parameters are estimated by least squares regression analysis.

The Model

$$Y_{st} = \alpha + \sum_i \beta_i X_{ist} + u_{st}$$

$$s = 1,2,\ldots,129$$

$$t = 1,2,3,4,5$$

$$i = 1,2,\ldots,I$$

where Y_{st} is the average yield per acre in county s in year t, and X_{ist} is the value of the i^{th} independent variable for county s in year t. α is the overall constant term, β_i is the effect on Y of X_i increased by one unit and u_{st} is the disturbance term for county s in year t.

Necessary and sufficient conditions for obtaining best linear unbiased estimates of the β_i's are: (1) The expected value of the disturbances be zero, (2) the disturbances be independent, (3) the disturbances have equal variance, (4) the independent variables in the model be independent of the disturbances, and (5) the matrix of independent variables be non-singular.

It is assumed that the disturbances are distributed with mean zero. The non-singularity of the matrix of independent variables is verified by

the estimation procedure. The extent to which other conditions hold is discussed below.

The second condition states that the disturbances are independent. In this study a criterion was established and all counties meeting this criterion were included in the sample. As a result, there are cases (about 300[1/]) where two counties included in the study have a common boundary. It is possible that observations on such adjacent counties may not be independent. To the author's knowledge, no tests have been developed to determine if cross section observations in a combined time series-cross section analysis are independent. However, a naive procedure used by the author is discussed in the analysis chapter. Also, to the author's knowledge, no reports have been made showing what effects such dependence among the disturbances would have on the estimates of the coefficients.[2/] These problems need to be investigated, but such investigations are beyond the scope of this study.

The third condition states that the disturbances must have equal variances. It was recognized early in the study that the variance of the dependent variable (yield per acre) could be a function of the number of acres upon which it is based. That is, as the number of acres upon which the yield per acre is based increases, the variance would probably decrease. Awareness of this was the reason that no observations based on less than 1,000 acres were included in the sample.

1/ There are 8,256 possible distinct pairs of counties from the sample, of these about 300 pairs have a common boundary. To put it another way, of the 417,380 off-diagonal elements in the matrix of variances and covariances of the disturbances, about 15,000 or four percent would have non-zero values, if disturbances for all adjacent counties were not indepent.

2/ The special case of autocorrelated disturbances has been investigated but it is not known whether the consequences of other kinds of dependence of the disturbances would be the same.

The dependent variable is still based on acreages varying from 1,114 to 245,987 acres. However, it is believed that the data based on 1,000 or more acres is quite reliable and that the variance of the disturbances will not vary greatly for acreages greater than this.

The fourth condition is that the independent variables in the model be independent of the disturbances. Marschark and Andrews have demonstrated that if firms maximize by differentiating current (actual) revenue with respect to inputs the input variables will be correlated with the disturbances of the production function (107). However, the author believes that farmers maximize by differentiating anticipated or expected revenue. Hoch has shown that if this is the case, then the input variables are not necessarily correlated with the disturbance terms of the production function (71).

Significance tests and confidence intervals for the estimated coefficients may be obtained by assuming that the disturbances are normally distributed. However, even without an explicit assumption of normality, the tests can be justified as being approximately correct by appealing to the Central Limit Theorem (89).

The Dependent Variable

The single dependent variable considered in this study is average pounds of grain sorghum obtained per acre of grain sorghum harvested.

The Independent Variables

Three sets of independent variables considered are: Man-controlled input variables (MCIV), dummy variables (for location and time), and weather variables.

Man-Controlled Input Variables

Acres of Grain Sorghum Harvested per Farm Harvesting Grain Sorghum

This variable is included to determine the effect the size of the enterprise has on per acre yield. It is expected to "capture" indirectly the effects of specialization of machinery, changes in land quality used, and changes in management proficiency.

As per farm acreage of grain sorghum increases, it is expected that better quality land will be used. This is because sorghum competes with wheat, cotton, or corn for land and these latter crops are grown on the best land. Government acreage controls on wheat, cotton, and corn may have "forced" an increase in acreage of sorghum grown (43, 84, 130). In any case, it is expected that the effects of using better land leads to increases in per acre yields.

The effect of increased mechanization is measured explicitly by two other variables, tractor numbers and dollars spent on gas and oil. These two variables do not measure the effect of a shift to more specialized equipment. An increase in acreage of sorghum is expected to lead to a shift to more specialized equipment. Such a shift is expected to lead to a very small increase in yields.

A third factor related to this variable is management. Two opposing views exist concerning increasing acreage per farm of a particular crop and management of that crop. First, it is expected that management effort per acre is greater on small acreages than on large acreages. Thus, increasing acreages would lead to lower per acre yields. The second view is that given a particular size of farm, the specialization in production leads to more effective management of the remaining crops. It is believed that the effect on yields from such changes in management effect is small.

Number of Acres of Cropland Harvested Per Tractor or Number of Tractors Per Acre of Cropland Harvested

These variables are indicators of the quantity of machines available for production operations. The only way that mechanization can affect yields is by timeliness and thoroughness of production operations (85). Thus, if quantity of machines increases relative to acres farmed, there should be better timing of production operations and an increase in yields. If, on the other hand, the quantity of machines decreases relative to acres farmed, there is likely to be poorer timing of production operations and a decrease in yields.

It is believed that the change in quantity of machines available for production operations had very little effect on average yield.

Dollars Spent on Gas and Oil Per Acre of Cropland Harvested

This variable is an indicator of the use and the change in size distribution of machines. That is, as large machines are substituted for small machines, the quantity of fuel used would increase even though the number of machines would not. In addition, the extent that machines available are used is reflected in fuel expense.

The change in size and use of machines can affect yields only through timeliness and thoroughness of production operations. It is believed that the effect of changes in the size and use of machines on average yield is very small.

Acres of Grain Sorghum Irrigated as Percentage of Total Acres of Grain Sorghum Harvested

Moisture is the most important factor limiting yields in almost all of the grain sorghum producing regions. The cost of varying this factor is high but the yield response to additional moisture is also high.

Increasing the proportion of the crop that is grown under irrigation is expected to greatly increase yields.

Per Acre Value of Land

The real value of land (value of land deflated by the consumer price index) was included as an independent variable because intuitively it seemed a good proxy variable for the interaction effect of technology with land. The changing per acre value of land is a priori related to the changing potential productivity of the land. The potential productivity is changing because (1) the quality, quantity, and mix of other factors of production available change over time, (2) accessibility of other factors of production varies cross-sectionally, and (3) there are basic differences in soil structure and composition. It is the interaction effects of other factors of production with land that need to be measured. Value of land is used as a proxy variable for this.

The fact that value of land may be a reasonable proxy for the interaction effects is illustrated below. Suppose the production relation is:

$$Q = \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_1^{\gamma_1} Z_2^{\gamma_2} Z_3^{\gamma_3}$$

where Q = output,

Z_1 = acres of land,

Z_2 = amount of input 2, and

Z_3 = amount of input 3.

The last term represents the "interaction."

Yield per acre is:

$$Y = Q/Z_1 = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 Z_1^{\gamma_1 - 1} Z_2^{\gamma_2} Z_3^{\gamma_3}$$

where $X_i = Z_i/Z_1$ = amount of input i per acre.

Now setting the value of the marginal product of land equal to its price, we have:

$$\delta Q/\delta Z_1 = \beta_1 + \gamma_1 \beta_4 Z_1^{\gamma_1 -1} Z_2^{\gamma_2} Z_3^{\gamma_3} = (P_1 r)/P_o$$

where P_1 = value of land

P_o = price of product

r = interest rate on land (so that the "price" of land is rP_1)

From this $\beta_4 Z_1^{\gamma_1 -1} Z_2^{\gamma_2} Z_3^{\gamma_3} = (r/\gamma_1)(P_1/P_o) - \beta_1/\gamma_1$

and substituting this into the above expression for Y_1

$$Y = \beta_1 (\gamma_1 -1)/\gamma_1 + \beta_2 X_2 + \beta_3 X_3 + (r/\gamma_1)(P_1/P_o).$$

Note that:

(1) The coefficients in the Y function are directly interpretable in terms of the parameters of the Q function.

(2) Even though the Y function is simply linear in the X's and the price ratio, the Q function can display diminishing, constant, or increasing marginal products, and decreasing, constant, or increasing returns to scale (depending on the value of the γ's).

(3) The model is directly extendible to include any number of non-land inputs.

(4) The price of land (rP_1) is deflated by the price of the product (P_o) rather than the consumer price index.

The interest rate (r) has been relatively constant over time[1] and probably is relatively constant cross sectionally as well. Thus using the

1/ The average for all lenders and for U. S. interest rate paid on mortgages was: 4.6, 4.4, 4.6, 4.6, and 4.9, respectively, in 1939, 1944, 1949, 1954, and 1959.

value of land (P_1) instead of the "price" of land (P_1r) probably does not create any major biases. The coefficient estimated is approximately (r/γ_1) instead of ($1/\gamma_1$).

Using the wrong deflater probably does bias the resulting coefficient. This can be shown by comparing the C.P.I. index used with a similar index based on the product price. The product price index is simply the price of the crop in each year divided by the price in 1949. The values of the index are 56, 94, 100, 111, and 88, respectively, for the years 1939, 1944, 1949, 1954, and 1959. The corresponding consumer price indexes with 1947-49=100 are 59, 75, 103, 115, and 125. The major difference is in the 1959 indices. Deflating the 1959 value of land by the C.P.I. reduced the magnitude of the variable appearing in the model. Deflating by the product price, on the other hand, would have substantially increased the magnitude. Since yields also increased substantially between 1954 and 1959, the value of land variable deflated by the product price would probably have been more highly correlated with yield than was the variable used.

A weakness of this variable for statistical purposes is that it is probably not completely exogenous with respect to, or unaffected by, the dependent variable. Clearly, if yields increase, other things constant, the value of land should (under competition) increase. However, since other things are not equal it is more correct to reason that as net returns per acre increase value of land would increase. Net returns per acre is a function of many things besides yield. To the extent that it is determined by things other than yield it may be reasonably exogenous with respect to the dependent variable. Also the value of land is determined by the demand for land for many purposes besides its value in the production of grain

sorghum. Among these demands for land are the demands for the production of other crops such as wheat and cotton, the demand for conservation and recreation uses, the demand for highways and urban growth, and the demand for land for speculative and investment purposes.

All of these factors affect the value of land. In this model, treating the price of land as exogenous is essentially just assuming that the supply of land to sorghum growing is infinitely elastic over the relevant range (other things equal). Thus, an increase in the demand for land for sorghum (such as would presumably occur due to an exogenous increase in sorghum yields, other things equal) would not by itself bring about an increase in price. To the degree that this assumption is not correct, there probably is some "simultaneous equations" bias in the least squares regression estimates.

Although it was not possible to obtain an estimate of the extent of such bias, it was possible to obtain an indication of the effect of including the value of land variable on conclusions reached concerning the model and the other variables in the model. Although a detailed discussion of this point is left to Chapter V, it may be mentioned here that including the value of land variable apparently did not seriously affect any of the major conclusions reached concerning the model and the other variables.

It is expected that if the relative value of land increases, yield will increase. It is also expected that the influence will be significant.1/

Man-hours of Labor Per Acre

A priori, increasing the amount of labor would increase the timeliness and thoroughness of the production operation and thus increase yields.

1/ Unless otherwise stated, "significant" means the estimated coefficient is significantly different from zero at the 0.10 level.

Decreasing labor would be expected, a priori to decrease yield. However, it is expected that the changing amounts of labor did not significantly affect yields. It is believed that the change in yield as a result of an increase in timeliness and thoroughness of the production operation is very small.

Acres Cultivated Summer Fallow

It has been established that in dry areas of the country, if grain is planted in fields fallowed the previous year, yields are up to 50 percent greater than yields on similar fields cropped the previous year (24, 130, 174). It is assumed that if acres fallowed increased, the proportion of sorghum grown on fallowed land would also increase. It is expected that increased acreage of sorghum on fallow would increase yields.

Ratio: Acres Fallowed to Acres of Cropland Harvested

This variable was constructed to remove the confounding influence of county size included in the acres fallowed variable. Both variables are not included in the same question.

Pounds of Commercial Plant Nutrients Applied Per Acre of Grain Sorghum

For most of the grain sorghum producing region, moisture is the limiting factor of production. It has been shown that when this is the case the application of fertilizer will have very little effect on per acre yields. However, when a crop is irrigated, the yield response to fertilizer is very great. Since fertilizer is generally used in large quantities only when the crop is irrigated, the expected effect of increased fertilizer use is a large increase in per acre yields.

Dummy Variables

Three sets of dummy (zero-one) variables are considered. One set is concerned with years and the others with location.

Years

This set contains five variables, one for each year included in the study. The variable representing 1939 will be dropped to allow estimation of the parameters. Nineteen thirty-nine was selected because the coefficients for the remaining variables will indicate the amount per acre yields have changed since the "base" period of 1939, due to factors that have changed over time and were not otherwise considered in the analysis.

Several such factors known a priori to have changed with time and to have increased per acre yields are: Improved cultural practices, introduction and increased use of chemical weed killers, and improvement in varieties.

The last factor, improvement in varieties, is believed to have increased per acre yields greatly between 1954 and 1959. This increase is due to the advent of commercial production of hybrid grain sorghum seed and the extremely rapid adoption of this new technology.

Because of the development and acceptance of hybrid seed between the years 1954 and 1959, the coefficient for 1959 is expected to be substantially larger than that for any other year. Other than this, the increase in per acre yields due to factors related to time but not included in the study is expected to be small.

Crop Reporting Districts

Within each State, counties are grouped into crop reporting districts which in turn generally reflect the different type-of-farming areas. It is

believed that the resulting districts are relatively homogeneous with respect to climate, soil type, topography, and so forth. Counties included in the study were located in 28 crop reporting districts. The number of counties included in a district ranged from one to thirteen.

A set of 28 dummy variables is used to represent these districts. It is believed that the use of this set of variables will lead to meaningful estimates of consistent differences in productivity between districts. These differences in productivity are assumed to be related to difference in physical factors of production associated with location. Some such factors are: Soil type, topography, elevation, and climate.

Growing Seasons

The counties included in this study are located in widely differing climatic regions. The seven growing seasons established for purposes of collecting relevant weather data reflect these climatic differences. A set of seven dummy variables is used to represent the different climatic regions. When this set is included in the analysis, it is expected that the coefficients obtained will give meaningful estimates of the consistent differences in yields due to climate.

Weather Variables

It has been recognized that weather is one of the primary factors influencing per acre yields. It is highly desirable that some technique be devised that can measure the effects of weather. In this study, three techniques will be developed and compared.

While it is impossible to include all relevant weather variables in an analysis of this kind, it is believed that the major influences of weather can be measured by the principal weather factors, precipitation

and temperature. The effect of the distribution and interaction of these two factors over the relevant growing season will be taken into account.

It was determined that the "relevant growing season" was a 23-week period beginning two weeks before the average planting date for grain sorghum. Because of the wide geographical spread of the counties included in the study, seven different average planting dates (growing seasons)1/ were used.

Weekly Estimates Technique

The distribution aspect of precipitation is taken into account by constructing 24 precipitation variables. The first variable is preseason precipitation and is the total precipitation occurring in the 203- (in 1944 the 204) day period preceding the first day of the relevant growing season.

Each of the next 23 precipitation variables represent one of the 23 weeks in the growing season. The value of each variable is the total precipitation in inches that occurred during a particular week. Each coefficient obtained from the analysis will indicate how much final per acre yields respond to a one-inch change in precipitation in that particular week.

Twenty-three variables for temperature were used, one for each week in the growing season. The value of each variable is the sum of the daily maximum temperatures that have occurred during a particular week. The coefficient obtained from the analysis will indicate how the per acre yield will respond to a one-degree change in the total maximum temperature in a particular week.

1/ Growing seasons used are discussed in detail in Appendix A.

Twenty-three interaction variables were calculated, one for each of the weeks in the growing season. The value of a particular interaction variable is the total precipitation during that week times the total maximum temperature during the same week. The coefficients obtained will indicate how final yield per acre will change with a one-unit change in the interaction variable.

It is not expected that all 70 coefficients will be significant, but it will be of interest to determine which of them are. Another relevant question is whether each weather factor with distribution taken into account is significant. To answer this, the 23 coefficients representing the weekly variables for each weather factor will be tested to determine if together they are significant.

<u>Weather Polynomial Technique</u>

One of the principal advantages of this technique over the previous method is that it uses fewer degrees of freedom. In many studies, particularly those using only time series data, the number of observations may not be large enough to allow the previous method. For these cases the weather polynomial is suggested as an appropriate method to determine the influence of weather on yields. It is of interest to determine how well the polynomial method compares to the method of estimating coefficients for each week for each weather factor.

The preseason precipitation variable is used in this technique in the same way that it was used in the previous technique.

The 23 weekly totals of precipitation for the growing season are transformed in the following manner.

What is desired is a model that relates yield per acre to the amount and distribution of precipitation. Such a model can be written:

$$\widetilde{Y}_t = \beta_o + \sum_{h=1}^{H} f(h)r_{th} + u_t \tag{1}$$

where $\widetilde{Y}_t$ is yield adjusted for the effects of nonweather variables; h designates the particular seven-day weather observation period, $h = 1,\ldots,H$; t designates the year, $t = 1,\ldots,T$; r_{th} is precipitation in period h in year t; u_t is a distrubance term; f(h) is assumed to be a polynomial in h (time), say,

$$f(h) = a_o + a_1h + a_2h^2 + \ldots + a_ph^p \tag{2}$$

The value of f(h), $h = 1,\ldots,H$ gives the effect on final per acre yield of a one-inch increase in precipitation in period h (if r_{th} is measured in inches). This may be rewritten as:

$$\widetilde{Y}_t = \beta_o + f(1)r_{t1} + f(2)r_{t2} + \ldots + f(H)r_{tH} + u_t \tag{3}$$

and substituting in the values for f(h) from 2

$$\begin{aligned}\widetilde{Y}_t = \beta_o &+ a_or_{t1} + a_1r_{t1} + a_2r_{t1} + \ldots + a_pr_{t1} \\ &+ a_or_{t2} + a_12r_{t2} + a_22^2r_{t2} + \ldots + a_p2^pr_{t2} \\ &+ \ldots \\ &+ a_or_{tH} + a_1Hr_{tH} + a_2H^2r_{tH} + \ldots + a_pH^pr_{tH} \\ &+ u_t\end{aligned} \tag{4}$$

Rearranging and collecting terms leads to:

$$\begin{aligned}\widetilde{Y}_t = \beta_o &+ a_o(r_{t1} + r_{t2} + r_{t3} + \ldots + r_{tH}) \\ &+ a_1(r_{t1} + 2r_{t2} + 3r_{t3} + \ldots + Hr_{tH}) \\ &+ a\ (r_{t1} + 2^2r_{t2} + 3^2r_{t3} + \ldots + H^2r_{tH}) \\ &\vdots \\ &+ \ldots \\ &\vdots \\ &+ a_p(r_{t1} + 2^pr_{t2} + 3^pr_{t3} + \ldots + H^pr_{th}) \\ &+ u_t\end{aligned} \tag{5}$$

Rewriting the terms in parentheses and redefining them as follows:

$$X_{to} = \sum_{h=1}^{H} r_{th} = \text{total season precipitation}$$

$$X_{t1} = \sum_{h=1}^{H} hr_{th}$$

$$\vdots$$

$$X_{tp} = \sum_{h=1}^{H} h^p r_{th} \qquad (6)$$

and obtain:

$$\tilde{Y}_t = \beta_o + a_o X_{to} + a_1 X_{t1} + \ldots + a_p X_{tp} + u_t$$

$$t = 1,\ldots,T$$

The values of the variables X_{ij} are first computed from the weekly weather data (r_{th}) in accordance with definitions (6). These calculated variables are inserted in the regression equation (generally along with other explanatory variables; here the effect of those other variables has been removed to obtain $\tilde{Y}$) and the coefficients a_j (i.e., the coefficients of the polynomial f(h)) estimated by least squares.

In this study $h = 1,2,\ldots,23$; $t = 1,2,3,4,5$; and $p = 0,1,2,\ldots,7$. In other words, all possible polynomials up to degree seven will be considered and compared to determine which degree of polynomial is "best."

It is apparent that the above derivation can be recalculated with m_{th} = total maximum temperatures or i_{th} = interaction = $r_{th}m_{th}$ in place of r_{th} and similar results will be obtained. In this study three weather polynomials (precipitation, temperature, and interaction) will be included in the analysis with the technology and dummy variables. The "appropriate" degree of polynomial for each factor will be determined by trial regressions.

Seasonal Total Technique

This technique is included to establish a benchmark with which to compare the other two techniques. Unless the other two techniques do much better, it may be wise for researchers to continue to use this easier technique.

Preseason precipitation is handled in this technique in the same manner as in the other techniques. The weekly data is combined, however, to form a single variable representing the season total for each weather factor. It should be noted that the above variables are identical with the variables representing the zero degree term in each of the weather polynomials.

It is expected that the other two techniques will do significantly better than this one. However, it is expected that the coefficients for these four variables will be significant.

Conclusion

Many regressions will be considered but it is expected that the "best" results will be obtained with a regression containing all of the technology variables, the weekly weather variables, and the dummy variables representing time and crop reporting districts. "Best" in the sense that it has a high $\bar{R}^2$ and that coefficients are meaningful.

CHAPTER III

PROCEDURE

This chapter is divided into three major sections. The first section contains a discussion of the procedure used to determine (1) the unit of observation; (2) the selections of counties (observations); and (3) the data. The second section contains a discussion of the procedure used to select equations to be estimated. The third section contains a discussion of how the results are presented in the analysis chapters.

The Unit of Observation, the Observations and the Data

The Unit of Observation

It is desirable to have the geographical unit small to obtain as much homogeneity with respect to weather, topography, soil, climate, and production techniques as possible. It is necessary that the unit be one for which there are detailed and reasonably complete data. Such a unit, and the one used in this study, is a county. Use of the county as the basic unit of observation necessarily limits this study to agricultural census years as they are the only years for which there are reasonably complete and detailed data for counties.

A combination of time series and cross section data are used in this study. The basic unit of observation being a county in a census year. The census years of 1959, 1954, 1949, 1944, and 1939 are included. Grain sorghum was a separate entry in agricultural censuses in 1929 and

1934, but many of the other variables in the model were not, and so these years were not included.

The Observations

It was not feasible to include all counties that had produced grain sorghum in these years. Since counties that had a "large" acreage contributed most to average yield, and one of the main objectives is to explain the change in average yield, it was decided that all counties that had a "large" acreage should be included. It was decided that the same counties would be included for all years.1/ Thus, it was important to select counties that had produced enough grain sorghum in each of the years included in the study to provide meaningful data. All counties which had 30,000 or more harvested acres of grain sorghum in 1959 and 1,000 or more in 1954, 1949, 1944, and 1939 were included. A total of 129 counties from 6 States met this criterion.

The acres and production of grain sorghum in these 129 counties and for the United States for years included in this study are given in Table 3-1. These counties contained over 50 percent of U. S. acres and produced over 50 percent of U. S. production of grain sorghum for all years considered. The average yield for these counties does not differ greatly from the U. S. average as shown in Table 3-2. The difference in 1959 suggests that the effect of hybrid sorghum on yields was greater outside the counties included in the analysis. This may also explain why the proportion grown in the 129 counties was less in 1959 than in 1954.

1/ This symmetry is not a necessary condition for combined time series-cross section analysis.

Table 3-1.--Acres harvested and production of grain sorghum in the United States and in 129 counties included in study

Year	Acreage			Production		
	129 counties	United States	Percentage 129 counties are of U. S. total	129 counties	United States	Percentage 129 counties are of U. S. total
	Acres	Acres	Percent	Pounds	Pounds	Percent
1939------	2,586,377	4,693,000	55.1	1,579,606,844	2,936,752,000	53.8
1944------	8,599,977	9,061,000	94.9	9,751,492,421	9,951,312,000	98.0
1949------	4,489,318	6,325,000	71.0	5,916,174,420	7,886,760,000	75.0
1954------	8,398,600	11,204,000	75.0	9,582,582,800	12,544,784,000	76.4
1959------	9,389,514	14,561,000	64.9	18,207,820,237	28,456,344,000	64.0

Table 3-2.--Average yield of grain sorghum

Year	Yield for 129 counties in study[a]		U. S. yield[b]	Difference
	Pounds	Bushels	Bushels	Bushels
1959-----	1,931.7	34.5	37.6	-3.1
1954-----	1,147.1	20.5	20.1	.4
1949-----	1,291.7	23.1	22.5	.6
1944-----	1,119.6	20.0	19.7	.3
1939-----	636.1	11.4	11.2	.2

a/ Census of Agriculture.

b/ Agricultural Statistics, U. S. Department of Agriculture.

The Data

A detailed discussion of data sources, data transformations, and procedures for estimating missing data is presented in Appendix A. The data used in this study on man-controlled inputs and yields are presented in Appendix A.

Man-controlled Inputs and Yields

The data on output and man-controlled inputs listed below were obtained entirely from the U. S. Agricultural Censuses of 1959, 1954, 1949, 1944, and 1939:

(1) Pounds of grain sorghum harvested

(2) Acres of grain sorghum harvested

(3) Acres of cropland harvested

(4) Number of tractors

(5) Number of farms harvesting grain sorghum

(6) Acres of grain sorghum irrigated (except 1944; see Appendix A for discussion of procedure used to estimate 1944 values)

(7) Dollars spend on gas and oil (current dollars) except 1944 (see Appendix A)

(8) Value of land and buildings per acre (current dollars)

(9) Acres cultivated summer fallow, except 1939 and 1944 (see Appendix A)

The data on dollars spent on gas and oil were deflated by the Index of Average Prices Paid by Farmers for Motor Supplies1/ to obtain dollars spent on gas and oil in constant dollars.

The values for "value of land and buildings" were adjusted to contain only the values of land. Estimates of the proportion of value of land and buildings that was land for States were obtained from U. S. Department of Agriculture worksheets.2/ The value of land and buildings per acre by counties was adjusted by the appropriate State value to give value of land per acre. The resulting value of land was then deflated by the Consumer Price Index.3/

The data on man-hours of labor used per acre of grain sorghum were obtained from USDA.4/ Data were available only for farm production regions. The value for the region was used for each county in the region.

Data on pounds of plant nutrients applied per acre of grain sorghum were not available on a county basis. Values used were derived from more

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1/ Obtained from USDA Statistical Bulletin No. 319, 1962. Values used are presented in Table A-6, Appendix A.

2/ Obtained from William H. Scofield, Agricultural Economist, Farm Production Economics Division, Economic Research Service, USDA. The values used are presented in Table A-10, Appendix A.

3/ Obtained from Business Statistics, 1961 Biennial Edition of the U. S. Department of Labor. Values used from this series are presented in Table A-10, Appendix A.

4/ Obtained from personal correspondence with Reuben W. Hecht, Agricultural Economist, Farm Production Economics Division, Economic Research Service, USDA. Data used are presented in Table A-11, Appendix A.

aggregate data. Data by State parts of U. S. agricultural subregions were used for the 1959 estimates.1/ The 1954 estimates were derived from data for States.2/ The 1949 values were estimated from data for 1950 by farm production regions.3/ The value of this variable was estimated to equal zero for all counties in 1939 and 1944.

Dummy Variables

The value for these variables is always either zero or one. A variable is set up to represent a particular class; if an observation belongs to the class, it is assigned a value of one, otherwise a zero.

A set of four dummy variables to represent years was included. They represent the years 1959, 1954, 1949, and 1944.

Counties from 28 crop reporting districts were included in the study.4/ A set of 27 dummy variables was used to represent all but one of these districts.

A set of six dummy variables was used to represent six of the seven growing seasons (average planting dates).5/ A growing season is a 23-week period beginning two weeks before the average planting date. The average planting date is primarily a function of location. Thus, this set of variables and the set for crop reporting districts is expected to estimate

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1/ Data used for 1959 are presented in Table A-14, Appendix A.

2/ Data used for 1954 are presented in Table A-15, Appendix A.

3/ Data used for 1949 are presented in Table A-16, Appendix A.

4/ A detailed list of the counties and the crop reporting districts in which they are located is presented in Tables A-17 and A-18, Appendix A.

5/ A detailed discussion of the growing seasons (average planting dates) and how they were determined is presented in Appendix A. The growing seasons used are listed in Table A-19 and the growing season appropriate for each county is listed in Table A-17, Appendix A.

the effects of location on yields. Both sets cannot be included in the same equation because they are linearly dependent; i.e., would create a singular matrix.

Weather Variables

All the weather data were obtained from Climatological Data, by States, by months, U. S. Weather Bureau, U. S. Department of Commerce.

Preseason Precipitation

Preseason precipitation was the total precipitation in inches that had occurred from the end of the growing season the previous year to the beginning of the growing season in the current year.

The data were those reported by the Weather Bureau for the weather stations selected.1/ The weather stations were selected according to the following criteria: (1) If there were four or more weather stations in a county reporting precipitation, then three were selected; (2) if there was at least one but less than four, all were selected; and (3) if there were none, up to three nearby stations were selected.

Seasonal Precipitation

The average precipitation in inches was obtained for each week of the growing season. The selection of weather stations was the same as for preseason precipitation.

Seasonal Temperature

The total (sum of seven days) maximum temperature in degrees Fahrenheit was obtained for each week in the growing season. The stations used were selected according to the following criteria:

1/ A list of the weather stations used is presented in Table A-20, Appendix A. The procedure used to estimate missing data is discussed in Appendix A.

(1) If there was at least one reporting maximum temperatures in a county, one was selected; and

(2) if there were no weather stations in the county reporting maximum temperatures, then the nearest weather station that did report was selected.

Change in Data

The dependent variable, yield per acre, was obtained in the computer prior to estimating the equations. Acres harvested and production in pounds were the raw data supplied to the computer. Because the dependent variable was generated in the machine, it was not until a list of residuals, per acre yields, and estimated per acre yields were examined that two errors in the raw data for production were discovered. For observation 482, yield per acre was calculated as 93.7 instead of the correct 941.3 and for observation 519 a value of 5275.5 was calculated instead of the correct 549.77.

The data were corrected and equations 2 and 244 were re-estimated as equations 293 and 283, respectively. As expected, the change in $\bar{R}^2$ was large, from .77 (equation 244) to .85 (equation 283). The changes in the value of the coefficients were not large and it was decided that conclusions based on the equations using the incorrect data (equations 1-284) would be reasonably valid.

Twenty-seven equations were estimated using the corrected data. Most of the conclusions in the analysis chapters will be based on these 27 equations.

Procedure Used to Select Equations (Submodels) to Estimate

The procedure used depended upon the particular objective being considered. The two major objectives are: (1) Estimate the effect of changes

in inputs on yield of grain sorghum, and (2) estimate the effect of alternative model specifications. With respect to the second objective there are two minor objectives: (1) Estimate the effect of dropping variables or sets of variables from the model, and (2) estimate the effect of substituting variables or sets of variables with variables in the model. These are different because in the first case the question asked is, "Should this variable (set of variables) be included in the model?" In the second case, it is, "Which of the alternative variables (set of variables) should be included in the model?"

Factors Affecting Changes in Yields

An equation to meet this major objective was specified *a priori*. It was specified to include all the man-controlled inputs (MCI), years (Y), crop reporting districts (C), preseason precipitation (P), and weekly (during the growing season) precipitation (R_i), temperature (T_i), and interaction (I_i) variables.

The equation (equation 285, referred to as the "complete" equation) used to meet this objective differed from the one specified *a priori* in three respects. First, the man-hours of labor per acre variable (L) was dropped from the equation. Second, for ease of interpretation, the acres per tractor (A/T) variable was transformed to tractors per acre (T/A). Finally, to avoid the confounding influence of size of county, the acres fallowed variable (FO) was transformed to the ratio of acres fallowed to acres of cropland harvested (FO/A).

Consequences of Leaving Variables Out of the Equation

The principal reason for constructing submodels is to determine the effects (relative to the "complete" equation) of specifying alternative models. The question being answered is, "How do the $\bar{R}^2$'s and coefficients for variables in the submodels compare with those in the "complete" equation and/or other submodels?"

Although the information obtained from these submodels is not used in this study to determine the "complete" equation (except to drop the man-hours of labor variable), it is believed that it will be of value to others constructing models.

Man-controlled Inputs

Many production functions have been constructed that contain only man-controlled inputs as independent variables. It is of interest to compare several equations of this type with the "complete" equation. This comparison should provide some idea of the effect on our ability to explain yield of excluding the weather, years, and location variables.

With this in mind, 21 submodels containing only man-controlled input (MCI) variables were estimated. All such submodels (equations) estimated are listed in Table 3-3 with a list of the variables each includes.

The following "shorthand" will be used to facilitate presentation of the lists of submodels.

Y = years

C = crop reporting districts

G = growing seasons (average planting dates)

V = value of land

L = man-hours of labor

FO = acres fallowed

FO/A = ratio acres fallowed to acres of cropland harvested

FT = pounds of plant nutrients

A/T = acres per tractor

T/A = tractors per acre

A/F = acres of grain sorghum per farm

% = percent irrigated

$ = dollars spent on gas and oil

P = preseason precipitation

R_i = weekly precipitation for each of the 23 weeks in the growing season; i.e., $i = 1,\ldots,23$

T_i = weekly temperature, $i = 1,\ldots,23$

I_i = weekly interaction, $i = 1,\ldots,23$

R^{ij} = all terms of the precipitation polynomial from ith through jth degree; $i,j = 0,1,\ldots,7$. A single superscript indicates the single variable.

T^{ij} = all terms of temperature polynomial from ith through jth degree; $i,j = 0,1,\ldots,7$. A single superscript indicates the single variable.

I^{ij} = all terms of interaction polynomial from ith through jth degree; $i,j = 0,1,\ldots,7$. A single superscript indicates the single variable.

R^0 = total precipitation during growing season

T^0 = total of maximum temperature during growing season

I^0 = total interaction during growing season

M = represents the following set of man-controlled inputs: V, L, FO, FT, A/T, A/F, %, and $

M(L) = represents the set above except the labor variable is not included

MT = represents the following set of man-controlled inputs: V, FO/A, FT, T/A, A/F, %, and $. (All models containing this set are estimated using the corrected data.)

The submodels listed in Table 3-3 provide information about how the presence or absence of a particular MCIV affects the coefficients of the other variables, when only MCIV's are considered. It is also of interest to know the effect of dropping MCIV when other kinds (years, weather, and/or location) of variables are present. Submodels of this type were estimated in "sets.' Each set had a group of variables other than man-controlled input variables which was not changed and the MCIV were added one at a time. The sets with the list of variables held constant are presented in Table 3-4.

Table 3-3.--List of submodels containing only man-controlled inputs as independent variables[a/]

Equation number	Variable							
	V	L	FO	FT	A/T	A/F	&	$
230	X							
229	X					X		
228	X			X		X		
227	X			X		X	X	
226	X			X	X	X	X	
225	X			X	X	X	X	X
224	X	X		X	X	X	X	X
223	X	X	X	X	X	X	X	X
237			X					
236		X	X					
235		X	X					
234		X	X		X			X
233		X	X		X		X	X
232		X	X	X	X		X	X
231		X	X	X	X	X	X	X
238						X		
239				X		X		
240				X		X	X	
241				X	X	X	X	
242				X	X	X	X	X
243		X		X	X	X	X	X

a/ An X in a column means that the variable listed at the top of the column is included in the submodel listed in left hand column. All equations estimated using the not corrected data.

Table 3-4.-- List of sets of equations omitting some man-controlled input variables[a]

Other variables included	Equations in set and equation numbers
P, R^{07}, T^{07}, I^{07}	103-109, 132-138
P, R^{07}, T^{07}, C, Y	12-18
C, Y	51-58
G	88-95
P, R_i, T_i, I_i	252-259
P, R, R_i, T_i	270-279

a/ All estimated using the not corrected data.

To determine the effect on the coefficients of the MCIV of adding or dropping sets of other variables, it is necessary to compare equations containing the same set of MCIV. Three major sets of MCIV were M, MT, and M(L). Table 3-5 contains a list of equations containing these sets.

Table 3-5.-- List of equations containing a complete set of MCIV[a]

Set of MCIV included	Equation numbers
M	1, 4, 18, 26, 34, 86, 87, 88, 97, 109, 171, 179, 187, 205, 222, 223, 252, 276
M(L)	2, 6, 9, 16, 61, 98, 100, 131, 170, 244, 245, 248, 249, 263, 264, 277, 278
MT	See Table 3-6

a/ All equations containing the sets M or M(L) were estimated using the not corrected data.

To determine which sets of other variables have been omitted in these equations, it is necessary to look at the results presented in the Appendix.

Three additional equations estimated using the corrected data and containing the set M(L) were 283, 284, and 293.

The "nearly complete" equations: This set was singled out for special attention because most of the discussion in the analysis chapters will refer to these equations. These 21 equations are listed in Table 3-6.

Table 3-6.--The "nearly complete" equations

Set of variables omitted[a]	Form of weather variables		
	Weekly	Season total	Polynomial[b]
	Equation numbers		
None	285	302	294
MCIV	286	307	295
C.R.D.	288	308	296
Years	287	309	297
Precipitation	289	305	298
Temperature	291	304	300
Interaction	292	303	301
Temperature and precipitation	290	306	299

a/ Relative to the "complete" equation (285), the "complete season total" equation (302), and the "complete polynomial" equation (294).

b/ A polynomial of seventh degree.

They are called the "nearly complete" equations because they omitted only one set (except for the two sets, precipitation and temperature) of variables. This entire set will be referred to as the "nearly complete" equations throughout the analysis chapter.

Three other equations are given "titles" to make presentation of the results more understandable. Equation 285, which contained all sets of variables and the weekly weather variables is referred to as the "complete" equation. Since equations 302 and 294 differ only by the form of the weather variables, they will be referred to,

respectively, as the "complete season total" equation and the "complete polynomial" equation.

Year Variables

The constants estimated for a year (say 1959) gives the consistent difference in yield (cross sectionally) between the year in question (1959) and the year omitted (1939), after the effect of all other variables in the model have been taken into account. It is of interest to see how these change as variables or sets of variables are dropped from the model. The effect of dropping individual MCIV or subsets of MCIV can be obtained by comparing the equations listed in Table 3-4 that also contain the set of year variables. Some equations that can be used to determine the effect of dropping sets of variables are listed in Table 3-6. Others estimated using the not corrected data are: 1, 2, 7, 11, 16, 18, 26, 33, 34, 35, 36, 43, 51, 59, 97, 99, 100, 101, 102, 244, 245, 246, 247, 261, 264, 269, 276, and 278.

Crop Reporting Districts

The constants estimated for a particular crop reporting district gives the consistent difference in yield (over time) between the district in question and the district omitted, after the effects of all other variables in the model (equation) have been taken into account. It is of interest to see how these constants change as variables or sets of variables are dropped. Some of the equations listed in Table 3-4 can be used to determine the effect of dropping a MCIV or a subset of MCIV. Equations, in addition to those listed in Table 3-6, that can be used to determine the effect of dropping entire sets of variables are: 1, 2, 4, 6-11, 16, 18, 26, 33-36, 43, 51, 59, 60, and 244-251. All of these

equations contain the set of crop reporting district variables. To determine which other complete sets were omitted, it is necessary to look at the results presented in the Appendix.

Growing Seasons

The constants estimated for growing seasons (average planting dates) have a meaning similar to that of the constants for crop reporting districts. Some of the equations listed in Table 3-4 can be used to determine the effect of dropping a MCIV or a subset of MCIV on the coefficients for growing seasons. Equations that can be used for this purpose with respect to dropping entire sets of variables are: 61, 85, 87, 88, and 96.

Preseason Precipitation

This variable is included in almost all equations estimated. How the coefficients change as a MCIV or subset of MCIV are dropped from the model can be determined by comparing equations listed in Table 3-4. The effect of dropping entire sets of variables can be determined by comparing equations listed in Tables 3-6, 3-7, and equations: 1, 11, 34, 35, 86, 87, 97, 130, 141, 161, 168, 203, 204, 221, 222, 261, 262, 266, and 267.

Polynomial Weather Variables

Polynomials of degrees zero through seven are considered for each of the weather factors--precipitation, temperature, and interaction. This was done because there was no a priori way to determine what the "correct" degree of polynomial should be. Equations estimated, including the various degrees of polynomials, are listed in Table 3-7.

Table 3-7.-- List of submodels containing weather polynomials of varying degrees[a]

Equation number	Variable						
	M	C	Y	P	R^{07}	T^{07}	I^{07}
213-220---				X	Y		
212-205---	X			X	Y		
36-43-----		X	X	X	Y		
33-26-----	X	X	X	X	Y		
178-171---	X				Y	X	
202-195---				X	X	Y	
194-187---	X			X	X	Y	
44-50, 11-		X	X	X	X	Y	
25-18-----	X	X	X	X	X	Y	
186-179---	X					Y	
168-161---				X	X	X	Y

a/ An X in a column means that the variable or set of variables listed at the top of the column are included in the set of equations listed in the left hand column. A Y in a column means for the weather factor listed at the top of the column, polynomials of degree zero through seven are included respectively in the eight equations listed in the left hand column.

Since it is not necessarily true that the "best" degree of polynomial for one weather factor is also the "best" for another, equations were estimated where the degree of polynomial for the different weather factors differed. Three "sets" of 24 equations were estimated. In each set, the sequence of adding weather polynomials was the same. The weather polynomial variables were added singularly in the following sequence: R^0, T^0, I^0, R^1, T^1, I^1, R^2,...R^7, T^7, I^7.

In the first set estimated, the only other variable included was preseason precipitation. The equations estimated, following the sequence listed above, were: 213, 204, 141-160, 162, and 161. In the second set (equations 85-63), growing seasons and (M) were included. The third set (equations 212, 203, and 130-109) included (M) and preseason precipitation.

Additional equations estimated containing seventh degree polynomials are: 1, 2, 4, 6-10, 16, 61, 79, 86, 87, 97-101, 131, and 170. All equations containing only the season total variable (zero degree polynomials) are included in the lists above.

Weekly Weather Variables

Each of the weather factors (precipitation, temperature, and precipitation multiplied by temperature) was represented by a set of 23 weekly variables. Only complete sets were considered. Some equations containing these sets are presented in Table 3-6 and others are: 244-252, 261-267, 269, and 276-282.

Location Variables

Two sets of dummy variables for location (crop reporting districts and average planting date) were considered. Both sets could not be included in any one equation because they form a linearly dependent set, i.e., cause the matrix to be singular. The crop reporting districts represent different kinds of farming situations. The growing seasons represent different climatic situations. The question asked was, "Which set will do the "best" job of explaining cross sectional differences in yields?" Equations estimated to answer this question were: 61 and 6 (with M(L), P, R^{07}, T^{07}, and I^{07} included); 87 and 18 (with M, Y, P, R^{07}, and T^{07} included); and 96 and 60 (with no other variables).

Procedure Used to Present Results

Because of the multiple objective and because of the large amount of information obtained from the 309 equations estimated, it was necessary to be selective in presenting and discussing the results.1/ The order of

1/ All coefficients estimated for all 309 equations with an indicated level of significance are presented in the Appendix.

presenting the results and procedure used in selecting results to present are explained below. The results are presented in Chapters IV, V, VI, and VII.

Chapter IV

The objective of relating the change in the level of the inputs to yield is discussed. The "complete" equation (285) is discussed in detail. In the last section of this chapter, the $\bar{R}^2$ for all the "nearly complete" equations (see Table 3-6) are presented and discussed.

Chapter V

This chapter has three sections. Models (equations) composed entirely of man-controlled input variables are discussed in the first section. The simple correlation coefficients among the MCIV are discussed in the second section.

The third and final section contains a discussion of the effects of dropping a set of variables from the equation on the coefficients of the man-controlled input variables. It is not feasible to present in the text (all results are presented in the Appendix) or discuss the consequences of all the combinations of variables considered. Presentation in the text and discussion are limited to (1) the set of "nearly complete" equations, and (2) equations containing unusual or interesting results. Unusual in the sense of being greatly different from a priori expectations. Interesting in the sense of containing information that would be of value to other researchers when they construct models.

Chapter VI

This chapter is devoted to a discussion of the location and year variables. The effect of substituting the growing season variables for the crop reporting district variables is examined.

Also considered is the effect on the coefficients for the location and year variables of dropping variables or sets of variables from the equation. All combinations included in the equations are not discussed in the text. Equations included in the text were selected on the basis of their containing unusual or interesting results.

The effects on the coefficients for years when the man-hours of labor are dropped from the equation are given special attention. It is primarily on the basis of these results that the decision to drop the man-hours of labor variable from the "nearly complete" equations was made.

Chapter VII

The weather variables are discussed in this chapter. In the first section, the coefficients for the preseason, weekly, polynomial, and season total variables and how they are affected by model specification are discussed. In the second section the estimated effects of weather in each week of the growing season as obtained from the three forms of weather variables are compared.

It was not possible to determine the "correct" or "best" degree of polynomial for the weather factors a priori. The third section contains a discussion of why the seventh degree polynomials were selected to be included in the "nearly complete" equations.

Conclusion

A large number of equations were estimated. Although each equation provides some additional information about the effects of specifying alternative models, it was not feasible to present and discuss all of these in the body of the thesis. All results are presented in the Appendix.

This chapter was intended to provide the reader with an overall view of the study. Use of the tables and lists of equations presented in this chapter, with the results presented in the Appendix, should permit the reader to find equations of interest.

CHAPTER IV

THE "COMPLETE" EQUATION

One of the major objectives of this study was to estimate how changes in inputs affected changes in yields of grain sorghum. How well this objective has been met by the "complete" equation will be the subject of this chapter.

The "complete" equation (equation 285) was chosen for detailed discussion because it is most comparable to the equation stated a priori as being of principal interest. This equation differs from the one stated a priori in three ways. First, the man-hours of labor per acre variable was dropped from the equation. The acres per tractor variable was transformed to tractors per acre and the acres fallowed variable was transformed to ratio of acres fallowed to acres of cropland harvested.

A significantly higher R^2 could have been obtained if the labor variable was included. The reasons for dropping it are presented in Chapter V. The two transformations did not materially affect the R^2 but did make it easier to interpret the results.

The "complete" equation contained 69 weekly weather variables, a preseason precipitation variable, variables for crop reporting districts, dummy variables for years, and seven man-controlled input variables. The coefficients obtained and an indication of their level of significance are presented in Appendix B, part 37, equation 285.

The Coefficients

Man-Controlled Input Variables

Seven man-controlled input variables were included. The coefficient for each variable will be discussed briefly.

Percent Irrigated

The coefficient for this variable was 1,761 and was significantly different from zero at the one-percent level.1/ This coefficient indicated that irrigating an acre of sorghum increased the yields by 1,761 pounds per acre. In recent years grain sorghum has sold for about $1.80 per hundredweight. If this value is assumed, then irrigating one acre of grain sorghum increased gross income per acre by $31.70. The cost of irrigating varied greatly over the area covered by the analysis. Since the range was from well below to well above the marginal return figure shown above, no precise statement about net marginal return can be made.

Acres Per Farm

The coefficient obtained for this variable was .0332. This indicates that there were positive returns to size of enterprise. That is, if the acreage of grain sorghum per farm was increased one acre, yield per acre increased .03 pounds. This coefficient was not significantly different from zero.

Tractors Per Acre

The coefficient for this variable (209.9) indicates that as mechanization (as measured by tractor numbers) increased, yields per acre increased. This effect was not significant.

1/ Unless otherwise stated, significant means the estimated coefficient is significantly different from zero at the 0.10 level. Also this coefficient underestimates the effect of irrigation as part of the effect is included in the coefficient of the interaction (value of land) variable.

Dollars Spent on Gas and Oil

The coefficient obtained for this variable (-15.92) indicates that as mechanization (as measured by machinery operating expense) increased yield decreased. This effect was not significant.

Value of Land

The coefficient obtained for this variable was 2.858 and was significant at the .01 level. This indicates that if the value of land increased one dollar, yield increased 2.858 pounds. Of course, the value of land cannot directly affect yield. It was assumed here that the value of land variable was a proxy variable for the interaction effect of man-controlled inputs with land.

Under this assumption, the coefficient can be interpreted as follows. If the value of land increased one dollar, the interaction effects of man-controlled inputs were such as to increase yields 2.858 pounds per acre.

Ratio Acres Fallowed to Acres of Cropland Harvested

The coefficient for this variable (-129.15) was not significantly different from zero. The sign was contrary to what priori knowledge suggests. The reason the sign was negative is that where fallowing was practiced, moisture and yields were low. This variable clearly did not measure the influence of fallowing on yields.

Fertilizer

The coefficient for pounds of plant nutrient applied per acre was 11.29 and was significant at the one-percent level. The coefficient indicates that the addition of one pound of plant nutrients to an acre of

grain sorghum increased the yield 11.29 pounds.[1/] The marginal value of one pound of plant nutrient (assuming $1.80/cwt. for grain sorghum) was 20.32 cents. This compares to a cost per pound (in 1965) of $0.115 for N, $0.23 for P, and $0.07 for K.

Years

Four dummy (0,1) variables were included to represent the years, 1944, 1949, 1954, and 1959. The coefficients obtained were assumed to primarily measure the effect on yields of changes in man-controlled inputs not included explicitly in the analysis. The coefficient for a particular year measured the net effect of such changes between the year omitted (1939) and the year in question.

The coefficients obtained were 367.6, 419.5, 346.4, and 528.2, respectively, for the years 1944, 1949, 1954, and 1959. All were significant at the one-percent level.

The 368-pound increase in yield between 1939 and 1944 was larger than expected. It is possible that this was due to the change to shorter combine varieties, the increased use of combines, and changes in other cultural practices. It is also possible (and likely) that some of the effects of "good" weather in 1944 were included.

The average increase in yields of 52 pounds between 1944 and 1949 is consistent with the hypothesis of a gradual increase in yields due to improved varieties and improved cultural practices.

The 73-pound decrease in yields between 1949 and 1954 was unexpected. It is possible that poorer varieties and poorer cultural practices were used in 1954. However, it is more likely that some of the effects of "bad" weather in 1954 were included.

1/ Of course this coefficient is an underestimate of the effects of fertilizer, as part of the effect is included in the coefficient for interaction (value of land) variable.

The 182-pound increase in yield between 1954 and 1959 was smaller than expected. This is particularly true if the effects of "good" weather in 1959 were included. It was hypothesized that the yield-increasing effect of hybrid grain sorghum (which took place between 1954 and 1959) would be about 400 pounds. It is possible and likely that some of the yield-increasing effects of hybrid sorghum are captured by other variables. It is also possible that the hypothesized effect of hybrids of about 400 pounds (as indicated by experiment station results) was not realized on the farms.

Although the coefficients for years were meaningful (could be rationalized) they suggest that further refinement is necessary to completely separate the effects of weather from those of "technology."

Crop Reporting Districts

Coefficients were obtained for 27 or the 28 crop reporting districts (C.R.D.). Eleven of these coefficients were significantly different from zero. However, since no hypotheses were being tested concerning the individual coefficients and the C.R.D. omitted was essentially arbitrary, the number of significant coefficients has little meaning.

The individual coefficients are examined in more detail later in this chapter when the difference in yields between crop reporting districts is explained.

It was hypothesized that including this set of variables would allow a significantly greater amount of the variation in yields to be explained. An equation (equation 288), differing from the "complete" equation only by the omission of the set of variables for crop reporting districts, was estimated so that the significance of the set could be determined.

The R^2 for the complete equation (equation 285) was .8792 and for equation 288 was .8451. These were significantly different ($F = 5.60$ with 27 and 536 degrees of freedom), indicating that this set of variables was significant at the one-percent level.1/

Preseason Precipitation

The coefficient obtained (20.34) was significantly different from zero at the one-percent level. It indicates that one additional inch of preseason precipitation increased yields by 20 pounds.

Season Precipitation

Coefficients were obtained for the 23 weekly precipitation variables. Statements of significance would have little meaning since no a priori hypotheses concerning the individual coefficients were made.2/

The significance of the set was important. An equation (289) which differed from the "complete" equation only by the omission of the set of season precipitation variables was estimated so that the significance of the set could be determined. An R^2 of .8639 was obtained. This was significantly different from .8792 (from the "complete" equation) at the one-percent level. The F value was 2.94 with 23 and 536 degrees of freedom.

1/ The following is from a mimeo "Procedure for Testing the Significance of A Subset of Regression Coefficients" by R. L. Gustafson, Michigan State Univ., Oct. 27, 1960. These formulas were derived from results presented in Anderson and Barcroft, Statistical Theory in Research, page 72. For convenience, let the variable to be tested by represented by X_{p+1} to X_q. Let the remaining variables in the model be represented by $X_1, \ldots, X_p$. Obtain R_p^2 from the regression on $X_1, \ldots, X_p$. Obtain R_q^2 from the regression on $X, \ldots, X_p, X_{p+1}, \ldots, X_q$. Then under the null hypothesis (i.e., $\beta_{p+1} = \beta_{p+2} = \ldots = \beta_q = 0$ and the assumption that the disturbances are normally distributed:

$$F_{q-p,\ N-q-1} = \frac{R_q^2 - R_p^2}{1 - R_q^2} \cdot \frac{N-q-1}{q-p}$$

2/ The individual coefficients and an indication of their level of significance are presented in Appendix B.

Season Temperature

Coefficients were estimated for the 23 weekly temperature variables. Individual coefficients are of little interest.[1/] The significance of the set was determined by testing whether there was a significant increase in R^2 when this set is added to an otherwise "complete" equation. The change in R^2 (from equation 291 to equation 285) is .0225. This difference leads to an F value of 4.33 with 23 and 536 degrees of freedom which was significant at the one-percent level.

Season Interaction

The set of 23 interaction variables caused the R^2 to increase from .8631 in equation 292 to .8792 in the "complete" equation. This increase was significant (F = 3.1 with 23 and 536 degrees of freedom) at the one-percent level.

All four sets of weather variables were significant at the one-percent level.

Explaining the Change in Yield

One of the major objectives of the study was to estimate how changes in the level of inputs and the shifts in the location of production have affected yields.

The change in weighted average yield is due to three components as shown below.

We have:

$$Y_{it} = C_i + \sum_{j=1}^{J} X_{itj}\, b_j$$

where Y_{it} and X_{itj} are yield and levels of the J independent variables

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1/ The individual coefficients and an indication of their level of significance are presented in Appendix B.

respectively, in district i in year t; b_j are the estimated regression coefficients, and C_i a constant estimated for district i. For simplicity, we omit residual terms so "yield" really means estimated "expected" yield. It should be remembered that the four dummy variables for years are included in the X_j's as are all the man-controlled input variables and the weather variables.

Weighted average yield in year t then is:

$$\bar{Y}_t = \sum_{i=1}^{n} P_{it} Y_{it}$$

where $P_{it} = \dfrac{A_{it}}{\sum_{k=1}^{n} A_{kt}}$, i=1,...,n is the proportion of total acreage in district i in year t.

So:

$$\bar{Y}_t = \sum_{i=1}^{n} P_{it} C_i + \sum_{j=1}^{J} \sum_{i=1}^{n} P_{it} X_{itj} b_j$$

The change in average yield between two years, t-1 and t, is:

$$\Delta\bar{Y}_{t,t-1} = \bar{Y}_t - \bar{Y}_{t-1} = \sum_{i=1}^{n} C_i (P_{it} - P_{i,t-1})$$

$$+ \sum_{j=1}^{J} \sum_{i=1}^{n} (P_{it} X_{itj} - P_{i,t-1} X_{i,t-1,j}) b_j$$

Let $K = \sum_{i=1}^{n} C_i (P_{it} - P_{i,t-1})$

Let $X_{itj} = X_{i,t-1,j} + X^*_{i,t-1,j}$

$$\Delta\bar{Y}_{t,t-1} = K + \sum_{j=1}^{J} \sum_{i=1}^{n} (P_{it} [X_{i,t-1,j} + X^*_{i,t-1,j}]$$

$$- P_{i,t-1} X_{i,t-1,j}) b_j$$

$$= K + \sum_{j=1}^{J} \sum_{i=1}^{n} (P_{it} - P_{i,t-1}) X_{i,t-1,j} b_j$$

$$+ \sum_{j=1}^{J} \sum_{i=1}^{n} P_{it} X^{*}_{i,t-1,j} b_j$$

$$= K + \sum_{j=1}^{J} \sum_{i=1}^{n} (P_{it} - P_{i,t-1}) X_{i,t-1,j} b_j$$

$$+ \sum_{j=1}^{J} \sum_{i=1}^{n} P_{it} (X_{itj} - X_{i,t-1,j}) b_j$$

Then, because weather, years and technology (man-controlled inputs) are represented by the X_j's,

$K = \sum_{i=1}^{n} C_i (P_{it} - P_{i,t-1})$ is the effect on average yield of shifts in the location of production, independent of the effects of time, weather and technology.

$L = \sum_{j=1}^{J} \sum_{i=1}^{n} (P_{it} - P_{i,t-1}) X_{i,t-1,j} b_j$ is the effect on average yield of shifts in the location of production due to the fact that technology and weather are not the same in all districts, based on their levels in year t-1.

$M = \sum_{j=1}^{J} \sum_{i=1}^{n} P_{it} (X_{itj} - X_{i,t-1,j}) b_j$ is the effect on average yield of changes in the level of technology and weather between years, with the location of production as it was in year t.

If $X_{i,t-1,j} = X_{itj} - X^{*}_{itj}$ is substituted in place of $X_{itj} = X_{i,t-1,j} + X^{*}_{i,t-1,j}$, K remains the same, but

$$L \overset{say}{=} L^{*} = \sum_{j=1}^{J} \sum_{i=1}^{n} (P_{it} - P_{i,t-1}) X_{itj} b_j$$

and

$$\text{say } M = M^* = \sum_{j=1}^{J} \sum_{i=1}^{n} P_{i,t-1} (X_{itj} - X_{i,t-1,j}) b_j$$

Thus there are two estimates of the components of the effects of weather and technology on yield. Of course, L + M = L* + M*, so the total effect of weather and technology is the same regardless of how the components are estimated.

Under certain conditions, some of the above values become equal and/or zero.

If $P_{it} = P_{i,t-1}$ for all i, i.e., if there is no change in the distribution of acres, then

$$K = L = L^* = 0 \text{ and } M = M^*$$

If $X_{itj} = X_{i,t-1,j}$ for all i and j, i.e., if there is no change in the level of the independent variables (of course this is not possible if there are dummy variables for time included in the X_j's),

$$L = L^* \text{ and } M = M^* = 0$$

If $X_{itj} = X_{ktj}$ for all i, j and k, i.e., the level of each of the independent variables is the same (and necessarily the average, $\bar{X}_{tj}$) in all districts, then:

$$L = L^* = 0 \text{ and } M \text{ can be written}$$

$$M = \sum_{j=1}^{J} \sum_{i=1}^{n} P_{it} (\bar{X}_{tj} - \bar{X}_{t-1,j}) b_j$$

$$= \sum_{j=1}^{J} (\bar{X}_{tj} - \bar{X}_{t-1,j}) b_j \sum_{i=1}^{n} P_{it} = \sum_{j=1}^{J} (\bar{X}_{tj} - \bar{X}_{t-1,j}) b_j = M^*$$

$$\text{since } \sum_{i=1}^{n} P_{it} = \sum_{i=1}^{n} P_{i,t-1} = 1$$

Clearly, if $\bar{X}_{tj} = \bar{X}_{t-1,j}$ for all j, i.e., if the average level of each technology, weather and year variable (of course this is impossible for the year variables) is the same in the two years, then:

$M = M^* = 0$ and the only non-zero term is K.

In the thesis a constant (C_i) was not obtained for every district; rather an overall constant term was obtained. However, adding or subtracting (as is the case with an overall constant term) any constant to all the C_i would not change the results, since

$$\sum_{i=1}^{n} (P_{it} - P_{i,t-1}) = 0$$

Constants (C_i) were obtained only for districts in this study because computer capacity was too limited to allow estimating the 129 county constants in the computer and hand computation of them would have been too tedious. However, there is no reason why county constants could not have been estimated.

The procedure outlined above for deriving the components of change in average weighted yields was not developed until after the analysis was completed. It was decided that it was not worthwhile going back and computing L, L*, M and M*. Rather, the change in the unweighted yields was explained using the unweighted average level of each of the independent variables. That is,

$$\overline{Y}_t - \overline{Y}_{t-1} = K + \sum_{j=1}^{J} (\overline{X}_{tj} - \overline{X}_{t-1,j})\, b_j$$

where the $\overline{Y}$ and $\overline{X}_j$ refer to unweighted averages and K is the same as shown above.

Explaining the Change in Yield Over Time

One of the major objectives of the study was to estimate how changes in the level of inputs over time have affected changes in yields over time. The changes in yields over time that were to be explained are presented in Table 4-1. The changes in the level of inputs (except for seasonal weather) are also presented.

Table 4-1.--Changes in yields and levels of factors between years[a]

Factor	Unit	Change between--				
		1939-44	1944-49	1949-54	1954-59	1939-59
Average yield---	Pounds	515.0000	90.3000	-223.0000	763.4000	1145.7000
Percent irrigated----------	Percent	-.0240	.0290	.0230	.0210	.0490
Acres /farm-----	Acres	47.7000	-10.4000	48.3000	7.9000	93.5000
Tractors/acre---	Tractors	-.0001	.0010	.0014	.0005	.0028
Fuel expense----	Dollars	-.0200	.5800	.2600	.1000	.9200
Value of land---	Dollars	6.0700	14.4200	10.5100	14.5900	45.5900
Percent fallowed	Percent	-.1234	.0608	.0451	.0162	-.0013
Fertilizer------	Pounds	0	1.3500	3.9100	4.3900	9.6500
Preseason precipitation-----	Inches	5.2300	-.1100	-3.6100	.6600	2.1700

a/ All values are unweighted; i.e., the distribution of acres between counties was <u>not</u> taken into account. The yield was given equal weight, regardless of acres harvested.

Given the change in the level of inputs (Table 4-1) the effect on yield was determined by multiplying the change by the coefficient from equation 285.[1] This was done and the results presented in Table 4-2.

The effects of changes in seasonal weather were not obtained directly, i.e., the change in each of the 69 variables between years was <u>not</u> obtained. The effect was determined as the residual amount explained.

Because of the constant terms obtained for years, the average yield for a year exactly equaled the average predicted yield for that year: i.e., $\bar{Y}_A = \hat{Y}_A$.

1/ This procedure does not take into account the difference in the level of inputs between crop reporting districts, i.e., uses unweighted averages.

Table 4-2.--Effect of changes in level of factors on changes in yields[a]

Factor	Coefficient from equation 285	Effect of change between-- 1939-44	1944-49	1949-54	1954-59	1939-59
		Pounds per acre				
Man-controlled inputs:						
Percent irrigated	[b]1,761.0000	-42.3	51.1	40.5	36.9	86.2
Acres/farm	.0332	1.5	-.3	1.6	.3	3.1
Tractors/acre	209.9000	0	.2	.3	.1	.6
Fuel expense	-15.9200	.3	-9.2	-4.1	-1.6	-14.6
Value of land	[b]2.8580	17.3	41.2	30.0	41.7	130.2
Percent fallowed	-12.9100	1.5	-.7	-.6	-.2	0
Fertilizer	[b]11.2900	0	15.2	44.1	49.6	108.9
Total M.C.I.	----	-21.7	97.5	111.8	126.8	314.4
Years[c]	----	367.6	51.9	-73.1	181.8	528.2
Weather:						
Preseason precipitation	[b]20.3400	106.3	-2.2	-73.4	13.4	44.1
Season weather[d]	----	62.8	-56.9	-188.3	441.8	259.0
Total weather	----	169.1	-59.1	-262.1	454.8	303.1
Total = average yield difference[e]	----	515.0	90.3	-223.0	763.4	1145.7

a/ All values are unweighted; i.e., the distribution of acres between counties was not taken into account.

b/ Significantly different from zero at the .01 level.

c/ Constants for years obtained in equation 285.

d/ Instead of obtaining the 69 season weather values for each year and multiplying by the appropriate coefficient, this effect was obtained by subtracting the effects of all other factors from the total effect (see text).

e/ Average yield difference $(\bar{Y}_j - \bar{Y}_k)$ equals $(\hat{\bar{Y}}_j - \hat{\bar{Y}}_k)$ average predicted yield difference.

$$\text{So:} \quad (\bar{Y}_A - \bar{Y}_B) = \sum_i b_i \, (\bar{X}_{iA} - \bar{X}_{iB}) + \sum_{j=1}^{69} b_j \, (\bar{X}_{jA} - \bar{X}_{jB})$$

Where A and B are different years, the i's refer to independent variables other than seasonal weather, the j's refer to the weekly weather variable, $\bar{Y}$ is average unweighted yield and $\bar{X}_i$ or $\bar{X}_j$ unweighted average level of factor. When differences are taken, the overall constant drops out. Thus the effect of the changes in weekly weather is:

$$\sum_{j=1}^{69} b_j \, (\bar{X}_{jA} - \bar{X}_{jB}) = (\bar{Y}_A - \bar{Y}_B) - \sum_i b_i \, (\bar{X}_{iA} - \bar{X}_{iB})$$

The Change in Yields, 1939-1944

The decrease in percent of acres irrigated between 1939-1944 completely dominated the influence of the explicit man-controlled inputs. The change in the level of the explicit M.C.I. 1939-1944 caused unweighted average yield to decrease 22 pounds. However, the effect of implicit M.C.I. (years) caused a substantial (368-pound) increase in yields. The weather in 1944 was better than in 1939, and enough better to have increased unweighted average yields 170 pounds.

The explicit M.C.I. explained a -4.2 percent of the yield increase 1939-1944. Implicit M.C.I. explained 71.4 percent of the increase. Better weather explained 32.8 percent of the increase. Most of the effect of better weather (62.9 percent) was due to more preseason precipitation.

The Change in Yields, 1944-1949

The increased use of irrigation, fertilizer and their interaction effect with land (value of land) caused yields to increase 107.5 pounds per acre. The effect of all explicit M.C.I. was to increase yields 97 pounds. The change in the implicit M.C.I. also caused yields to increase. Weather in 1949 was worse than in 1944 and caused a decrease in yields of 60 pounds.

The change in M.C.I. explained 108 percent of the increase in yields. Implicit M.C.I. changes explained 57.5 percent of the increase. Poorer weather explained a decrease of 65.5 percent. Most of this decrease (96 percent) was due to poor weather during the growing season. With average weather the average yield would have increased 149.4 pounds instead of the 90.3 pounds actually achieved.

The Change in Yields, 1949-1954

Unweighted average yield decreased 223 pounds between 1949 and 1954. The effect of changes in the explicit M.C.I. was to increase yields 112 pounds. The effect of implicit M.C.I. was to decrease yields 73 pounds. It is unlikely that the changes in the implicit M.C.I. would actually decrease yields. Rather, it is expected that some of the effects of "bad" weather were included in the years' coefficient. Poorer weather in 1954 caused yields to decrease 262 pounds.

With average weather, and implicit M.C.I. at the same level in 1954 as in 1947, the 1954 average yield would have been 122 pounds greater than in 1947. Changes in M.C.I. "explain" a negative 50.1 percent of the decrease in yields. Changes in implicit M.C.I. explain 32.8 percent of the decrease. Poorer weather explained 117.3 percent of the decrease in yields. Of this, 72 percent was caused by poorer weather during the growing season.

The Change in Yields, 1954-1959

The change in the level of explicit M.C.I. from 1954 to 1959 caused unweighted average yield to increase 127 pounds (16.6 percent of the total increase). The change in the level of the implicit M.C.I. caused an increase of 182 pounds (23.8 percent). Better weather in 1959 than in 1954 caused yields to increase 455 pounds (59.6 percent of the total).

The Change in Yields, 1939 to 1959

The unweighted average yield increased 1,145.7 pounds between 1939 and 1959. Of this increase, 27.4 percent was explained by changes in the levels of the explicit man-controlled inputs, 46.1 percent by changes in the level of implicit man-controlled inputs1/, and 26.5 percent by changes in weather.

Of the increase due to changes in explicit man-controlled inputs, almost all is due to changes in two inputs, fertilizer and irrigation and their interaction with land (value of land). Changes in the weather during the growing season accounted for 85.4 percent of the total weather effects.

The relative importance of the implicit M.C.I. was unexpected. Although it was hypothesized that the effect would be large, it was not expected to be 60 percent <u>more</u> important than the explicit M.C.I. This is somewhat disturbing because it suggests that some of the most important factors affecting yields have not been explicitly identified or quantified.

<u>Explaining Cross-Sectional Differences in Yields</u>

In addition to trying to explain changes in yields over time, it was also important to try and explain yield differences between crop reporting districts.

The differences were determined relative to some base. In this case crop reporting district 19 was used as the base. The difference in yields between C.R.D. 19 and another district was explained by differences in levels of M.C.I., weather, and location (a constant which is really an unexplained residual that was consistent over time).

1/ Of course, the effect of other unquantified factors is also included, but it is believed that the unquantified man-controlled factors are by far the most important.

The average (over time and over counties within a crop reporting district) deviations in level of man-controlled inputs of crop reporting districts relative to C.R.D. 19 are presented in Table 4-3. The effects of differences in the level of M.C.I. are presented in Table 4-4. The effect of differences in weather and location are also presented in Table 4-4. Coefficients from the "complete" equation (equation 285) were used to calculate effects of M.C.I. and location. The effects of weather were derived in the same manner as were weather effects between years.

Considering Table 4-3, it is apparent that the level of two of the most important M.C.I. (percent irrigated and pounds of plant nutrient per acre) were lower in all districts than in district 19. The level of the value of land (the only other important input) was lower in some districts and higher in others. The consequences of these lower levels of M.C.I. are shown in the second column of Table 4-4. The lower level of these M.C.I. in all districts relative to district 19 would explain substantially lower yields in these districts.

Yield differences are not always great (see column one, Table 4-4) because the effects of location (soil, climate, topography) and weather gave yield advantage to some of these districts.

Perhaps it will be clearer if one district as an example is discussed. District 1 had an average yield of 74 pounds per acre greater than district 19. What explains this difference? The difference in the level of the M.C.I. would suggest that average yield in district 1 should have been 445.2 pounds less than in district 19. However, this effect was more than offset by a location which gave district 1 a 383.9-pound per acre yield advantage, and better weather which gave a 135.3-pound yield advantage.

Table 4-3.--Deviation in average (over time) level of man-controlled inputs for crop reporting districts relative to level in district 19

C.R.D.	Factors a/						
	%	Ft	V	A/F	FO/A	$	T/A
	Percent	Pounds	Dollars	Number	Number	Dollars	Number
1	-.264	-7.14	+34.73	-132.99	-.0914	-.23	+.00291
2	-.271	-6.89	+10.37	-124.03	-.0778	-.30	+.00212
3	-.265	-6.72	-14.79	-126.19	+.0516	-.27	+.00237
4	-.274	-8.31	-25.18	-83.87	+.4307	-.48	-.00009
5	-.278	-8.39	-12.73	-127.25	-.0187	-.40	+.00222
6	-.279	-6.53	+5.47	-141.25	-.0961	-.22	+.00346
7	-.240	-8.31	-23.81	-54.86	+.4711	-.28	-.00026
8	-.255	-8.21	+14.82	-122.83	+.0301	-.21	+.00277
9	-.279	-6.00	-10.32	-137.39	-.1022	-.13	+.00238
10	-.222	-8.31	-20.15	+44.47	+.4018	-.50	-.00057
11	-.270	-8.19	+21.60	-117.88	-.0158	-.42	+.00176
12	-.279	-6.96	-2.64	-124.51	-.0709	+.10	+.00428
13	-.271	-8.63	-30.59	-19.57	+.1352	-.70	-.00075
14	-.279	-7.92	+9.18	-132.48	-.0880	-.48	+.00308
15	-.278	-7.92	-6.67	-134.37	-.0830	-.22	+.00480
16	-.276	-8.96	-42.27	-59.62	+.4606	-.34	-.00023
17	-.130	-8.98	-39.40	-38.36	+.4258	-.08	+.00073
18	-.208	-7.56	-31.99	-6.63	+.0489	-.07	+.00148
19	0	0	0	0	0	0	0
20	-.219	-6.93	+6.26	-20.92	-.0584	-.30	+.00068
21	-.276	-8.18	-26.06	-76.58	-.0820	-.43	-.00179
22	-.277	-8.18	-10.62	-94.50	-.0752	-.33	+.00280
23	-.267	-7.38	-34.87	+81.73	-.0681	+.13	+.00312
24	-.278	-7.03	+7.25	-133.67	-.0767	-.17	+.00544
25	-.273	-7.24	+3.55	-122.04	-.0632	+.56	+.00768
26	-.277	-7.38	+34.17	-15.48	-.0784	+.36	+.00321
27	-.276	-7.38	-20.27	-73.28	-.0861	+.17	+.00415
28	-.120	-7.63	+82.41	-61.52	-.0773	+1.68	+.00704

a/ % means percent of grain sorghum acreage irrigated; Ft means pounds of fertilizer applied per acre; V means value of land per acre; A/F means acres of sorghum per farm; FO/A means ratio acres fallowed to acres of cropland harvested; $ means dollars spent on gas and oil per acre; and T/A means number of tractors per acre.

Table 4-4.--Yields of crop reporting districts relative to crop reporting district 19 and factors explaining the differences

C.R.D.	Yield difference	Factors: M.C.I.	Factors: Location	Factors: Weather
	Pounds per acre			
1	74	-445.2	383.9	135.3
2	-126	-523.3	239.5	157.8
3	-421	-500.3	-1.1	80.4
4	-680	-505.0	-47.3	-127.7
5	-585	-545.0	-28.0	-12.0
6	-301	-548.6	182.8	64.8
7	-552	-451.8	-7.2	-93.0
8	-559	-499.9	-131.1	72.0
9	-336	-530.2	72.9	121.3
10	-624	-422.8	-88.7	-112.5
11	-685	-502.9	-231.9	49.8
12	-576	-566.3	-118.4	108.7
13	-891	-478.3	-242.1	-170.6
14	-690	-549.5	-20.3	-120.2
15	-849	-558.8	-345.3	55.1
16	-1,062	-468.9	-451.2	-141.9
17	-935	-223.1	-389.6	-322.3
18	-1,008	-359.6	-108.6	-539.8
19	0	0	0	0
20	-673	-441.0	-286.6	54.6
21	-959	-498.2	-262.6	-198.2
22	-885	-546.1	-227.2	-111.7
23	-728	-451.7	-7.8	-268.5
24	-460	-547.8	-13.1	100.9
25	-543	-562.9	-282.3	302.2
26	98	-478.0	115.7	460.3
27	-442	-514.6	-197.5	270.1
28	-252	-88.2	-414.4	250.6

It is not possible to make any general statement about the relative importance of M.C.I., location, or weather in explaining yield differences between districts. The relative importance depends to a large extend upon which districts are being compared.

Any two districts can be compared simply by taking the difference between the numbers presented in Table 4-4. For example, to compare district 18 with district 28: Average yield in district 18 was 756 pounds lower than in district 28. The difference in the level of M.C.I. would have explained yields being 271.4 pounds lower in district 18. However, locational factors caused yields in district 18 to be 305.8 pounds higher. Poorer weather in district 18 would have explained yields being 790.4 pounds lower. The net effect was to have yield 756 pounds lower in district 18.

Effect of Shift in Acres on Average Yields

The estimate of the effects of shifting the location of production is not entirely consistent with estimates of the effects of man-controlled inputs and weather. The estimate would be consistent if the effect of the man-controlled inputs and weather had been estimated taking into account the distribution of acres among the districts. The effect of shifts in location of production (the K terms discussed earlier in this chapter) on average yield was estimated by using the constants for crop reporting districts from the "complete" equation (equation 285). Since the constants were location effects, independent of weather and technology, the estimate of the effect of changes in the location of production using these constants is also independent of the effects of weather and technology.

The effect of shifting acreages between any two years was computed by taking the change in the proportion acreage in a district is of the total multiplied by the constant for that district and summed over all districts.

That is, $K_{AB} = \sum_{i}^{28} C_i\left(\frac{A_{iA}}{A_A} - \frac{A_{iB}}{A_B}\right)$ where K_{AB} is the change in yield due to shift in location of production between years A and B; C_i is the constant from equation 285 for crop reporting district i, A_{iA} and A_{iB} are the acreages in crop reporting district i in years A and B respectively, and A_A and A_B are the total acreages in years A and B, respectively.

The effects for selected years are presented in Table 4-5.

Table 4-5.--Effect of shifts in location of production between selected years

Years	Effect
	Pounds per acre
1939-1944	8.1
1944-1949	17.1
1949-1954	18.3
1954-1959	6.8
1939-1959	50.3

The effect between any two consecutive periods was small. The effect over the entire period was less than one bushel. This was less than 2.8 percent of the 1959 average yield. The effects have been positive over time, indicating that production has been shifting slowly toward higher yielding areas.

Independence of Residuals

If the residuals from an equation are to be examined, it seemed reasonable to use the residuals from the "complete" equation. That is why this section is included in this chapter. The residuals examined are from equation 285.

In a combined time series and cross section analysis there is the possibility of dependence of disturbances in two dimensions--cross sectional and over time.

The observations on the same county are separated by five years. Thus, the assumption that disturbances for a single county over time are independent seems warranted. This conclusion can be extended to the set of all counties. In addition, any consistent variation among all counties would be removed by the constants (coefficients for the dummy year variables) for years. Thus, it is concluded that there was no serious problem with auto-correlated disturbances in the time dimension.

Cross sectionally, the counties included in the study were not selected at random and the disturbances, particularly in adjacent counties, might not have been independent. Of course, nothing can be done in terms of the disturbances, but the residuals are examined.

If the disturbances in adjacent counties were not independent then one might expect to observe some relationship among their residuals. It is hypothesized that the residuals of two counties adjacent east to west (have a common north-south boundary) are correlated. In the test that follows, counties A and B are considered adjacent west to east if a person could move from county A straight east and immediately enter county B.

The residual from county A (on the west) was considered a value of X and the residual from county B (on the east) a value of Y. There are 110 such pairs of values. The simple correlation coefficient of X with Y was obtained for each of the five years. The correlation coefficients obtained were: For 1959, $r^2 = .005$; for 1954, $r^2 = .071$; for 1949, $r^2 = .023$; for 1944, $r^2 = .026$; and for 1939, $r^2 = .040$. It seems reasonable to conclude that there is very little relationship between residuals in adjacent (east to west) counties.

The above procedure is arbitrary. We could, instead of or in addition to the above, have considered north-south adjacent counties. Other, more elaborate criteria (such as the common boundary must have a specified minimum length, etc.) could have been chosen in selecting pairs. With a complex situation such as we have here, it may be as appropriate simply to "look over" a map of the residuals to see if any pattern is apparent. This was done and no pattern was observed that would call into question the assumption that the disturbances are independent.

Comparison of Alternative Models

After the "complete" equation (equation 285) had been estimated, it was of interest to see how its explanatory power would be affected by omitting certain sets of variables and/or when different sets of variables were substituted.

The sets alternately dropped were: (1) Man-controlled input variables, (2) crop reporting district variables, (3) year variables, (4) season precipitation variables, (5) season temperature variables, (6) season interaction variables, and (7) season temperature and season precipitation variables. The results of these seven omissions on $\bar{R}^2$ are presented in the first column of Table 4-6.

Dropping the M.C.I.V. resulted in a decrease of .1454 in $\bar{R}^2$ which was significant at the one-percent level. As measured by $\bar{R}^2$ deletes, this was by far the most important set (as expected). The second most important (as determined by $\bar{R}^2$ deletes) was the set of precipitation and temperature variables. This decrease of .0447 was significant at the one-percent level.

Dropping any one of these seven sets of variables caused R^2 to decrease significantly.

Table 4-6.—$\bar{R}^2$ for equations using corrected data[a]

Set of variables omitted	Season weather represented by—		
	Weekly weather	Season totals	Polynomial of seventh degree
None	.8545 (285)	.7861 (802)	.8213 (294)
M.C.I.	.7094** (286)	.6090** (307)	.6445** (295)
C.R.D.	.8228** (288)	.7462** (308)	.7855** (296)
Years	.8420* (287)	.7361** (309)	.8022** (297)
Precipitation	.8432** (289)	.7864 (305)	.7985** (298)
Temperature	.8349** (291)	.7843 (304)	.8161 (300)
Interaction	.8423** (292)	.7861 (303)	.8005** (301)
Precipitation and temperature	.8101** (290)	.7840 (306)	.7954** (299)

a/ The equation with no sets of variables omitted contain 7 M.C.I.V., set of variables for crop reporting districts, set of variables for years, and weather variables for precipitation, temperature, and interaction. Number in parentheses is the equation number.

* Indicates that the change in R^2 when this set is omitted as compared to when no set is omitted is significantly different from zero at the 5-percent level. Test used was discussed earlier in this chapter.

** Same as for * except at 1-percent level.

It was also of interest to see how representing the season weather with different variables would affect the ability of the model to explain yield variation. The effects of substituting polynomials of seventh degree (24 variables) or season totals (3 variables) for the 69 weekly weather variables are presented in columns 3 and 2, respectively, of Table 4-6.

The effect of substituting polynomials for the weekly variables was to reduce $\bar{R}^2$ by .0335. This was a very small loss to gain 45 degrees of freedom. The .0687 reduction in $\bar{R}^2$ when the season totals were substituted was also quite small. This result suggests that no <u>major</u> error was made

when simple season total weather variables were used instead of very detailed weekly or polynomial weather variables. Of course, this assumes that the remainder of the model is well specified.

It is interesting to note that the manner in which weather was represented affects how $\bar{R}^2$ changes when a set of variables were deleted. For the case of M.C.I. variables, when weekly weather variables were included the $\bar{R}^2$ decreased .1454. When polynomial weather variables or season total variables were included $\bar{R}^2$ decreased .1768 and .1771, respectively, when M.C.I. variables were dropped. This suggests that the model was more sensitive to specification errors (of this type) when less detailed or less complete weather variables were included. The same pattern held for the other sets of variables.

The order of importance of sets of variables (as judged by $\bar{R}^2$ deletes) was also affected by the manner in which weather was included. When weekly weather variables were used the set of precipitation and temperature variables was the second most important. However, when weather was represented by either of the other forms, the set of crop reporting districts was the second most important. Perhaps this was because when less complete weather variables were used the effects of consistent differences in weather between districts tended to be "captured" by the district variables.

It is also of interest to note that when season totals were used to represent weather, dropping the precipitation term increased $\bar{R}^2$ (see Table 4-6). In this case the value of an additional degree of freedom (even though 602 were already available) was greater than the value of the increased sums of squares explained. The reason for this may have been that the seasonal interaction variable was almost a perfect substitute for the seasonal precipitation variable (simple correlation .992).

Conclusion

The "complete" equation did a reasonable job of explaining variation in yields. The coefficients, for the most part, were meaningful and consistent with expectations.

The amount of variation explained by the model was significantly affected by dropping sets of variables, and greatly affected by substituting in new variables. The maximum effect of dropping variables (dropping the M.C.I. variables) was to reduce the variation explained by 17 percent. The maximum effect of substituting variables (substituting season totals for weekly weather variables) and dropping the M.C.I. variables was 29 percent.

The next three chapters will consider the question, Does dropping or substituting variables affect the coefficient (and thus the interpretation) of variables remaining in the model?

CHAPTER V

MAN-CONTROLLED INPUTS

This chapter has three sections. Models composed entirely of man-controlled input variables (M.C.I.V.) are discussed in the first section. The simple correlation coefficients among the M.C.I.V. are discussed in the second section. The third and largest section contains a discussion of the effects of dropping sets of variables from a model on the coefficients of the M.C.I.V.

Man-Controlled Input Models

Many models containing only M.C.I.V. as independent variables have been estimated by agricultural economists. It is of interest to see how such models compare to the model containing weather variables, time variables, M.C.I.V., and location variables as independent variables.

All the models discussed below were estimated using the not corrected data. However, the relative $\bar{R}^2$ should still be meaningful.

The model containing the weekly weather, time, location, and M.C.I. variables was equation 244. It had an $\bar{R}^2$ of .779. The value (.779) will be compared with the $\bar{R}^2$ of models containing only M.C.I.V. The $\bar{R}^2$'s for selected M.C.I.V. models are presented in Table 5-1. The symbols used are listed in Chapter III.

The highest $\bar{R}^2$ obtained (.454) was, as expected, with the model (equation 223) containing all the M.C.I.V. This, however, does not compare favorably with the .779 from equation 244. Mis-specification by not including weather, location, and time variables had a rather severe effect on $\bar{R}^2$.

Table 5-1.--$\bar{R}^2$'s for models containing only man-controlled input variables as independent variables[a]

Equation number	Man-controlled input variables included	Man-controlled input variables excluded	$\bar{R}^2$
230	VL	L,FO,FT,A/T,%,$,A/F	.278
229	VL,A/F	L,FO,FT,A/T,%,$	.299
228	VL,A/F,FT	L,FO,A/T,%,$	.401
227	VL,A/F,FT,%	L,FO,A/T,$	.440
226	VL,A/F,FT,%,A/T	L,FO,$	.440
225	VL,A/F,FT,%,A/T,$	L,FO	.441
224	VL,A/F,FT,%,A/T,$,L	FO	.453
223	VL,A/F,FT,%,A/T,$,L,FO		.454
237	FO	VL,L,FT,A/T,%,$,A/F	.004
236	FO,L	VL,FT,A/T,%,$,A/F	.163
235	FO,L,$	VL,FT,A/T,%,A/F	.189
234	FO,L,$,A/T	VL,FT,%,A/F	.189
233	FO,L,$,A/T,%	VL,FT,A/F	.356
232	FO,L,$,A/T,%,FT	VL,A/F	.392
231	FO,L,$,A/T,%,FT,A/F	VL	.396
238	A/F	VL,L,FT,A/T,%,$,FO	.015
239	A/F,FT	VL,L,A/T,%,$,FO	.258
240	A/F,FT,%	VL,L,A/T,$,FO	.342
241	A/F,FT,%,A/T	VL,L,$,FO	.346
242	A/F,FT,%,A/T,$	VL,L,FO	.346
243	A/F,FT,%,A/T,$,L	VL,FO	.384

a/ Estimated using the not corrected data.

Considering the models in Table 5-1, there are only three variables that greatly affected $\bar{R}^2$ when they were dropped. They are percent irrigated, fertilizer, and value of land. Not by chance, these were the same M.C.I.V. that had significant coefficients in the "complete" equation (equation 285).

Simple Correlations

The effects of dropping a variable or set of variables from an equation on $\bar{R}^2$ and on the coefficients of variables remaining in the model are influenced by the degree of intercorrelation among the variables. Because of this and because the intercorrelations among the M.C.I.V. are of interest in and of themselves, they are discussed here.

The simple correlation between the M.C.I.V. are presented in Table 5-2.

Percent Irrigated

The correlation of percent irrigated with yield was very high. This is not surprising as moisture is a principal factor limiting yields in the Great Plains.

The positive correlation with acres per farm was not expected.[1] It was expected that large acreages of sorghum were found on farms with extensive operations. Irrigation is a form of intensive farming.

There was very little correlation between number of tractors (T/A or A/T) and extent of irrigation.

As larger irrigation operations require more fuel, it is not surprising that there was a positive correlation between the two. However, the extent (.353) of the correlation is surprising.

The high correlation of value of land with percent irrigated is consistent with expectations. The negative correlation with labor is contrary to expectation. Irrigation certainly requires more labor per acre than non-irrigation. This result was probably due to the poor labor data used. This point is discussed in more detail later in this chapter.

There is very little relationship between fallow and irrigation, contrary to expectations. This may be due to counteracting forces. Irrigation and fallowing are probable positively correlated to the extent that where moisture is limiting both irrigation and fallowing tend to be high and where moisture is not limiting they tend to be low. On the other

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1/ "Expected" in all cases refers to the author's expectations.

Table 5-2.--Simple correlations of the man-controlled input variables[a]

Variable	Variable										
	Yield/A	%	A/F	A/T	T/A	$	VL	L	FO	FO/A	FT
Yield/A	1.000										
%	.485[a]	1.000									
A/F	.130[a]	.207[a]	1.000								
A/T	-.155[a]	-.064	.371[a]	1.000							
T/A	.133[a]	-.00002	-.145[a]	*	1.000						
$	.320[a]	.353[a]	.088[b]	-.299[a]	.231[a]	1.000					
VL	.529[a]	.359[a]	-.032	-.363[a]	.200[a]	.436[a]	1.000				
L	-.383[a]	-.129[a]	-.265[a]	.318[a]	*	-.407[a]	-.424[a]	1.000			
FO	-.071	.029	.265[a]	.318[a]	*	-.028	-.226[a]	-.172[a]	1.000		
FO/A	-.158[a]	.040	.266[a]	.208[a]	-.167[a]	-.022	-.330[a]	*	*	1.000	
FT	.509[a]	.450[a]	.311[a]	-.130[b]	.066	.424[a]	.334[a]	- .452[a]	.016	-.026	1.000

a/ The table of simple correlations of all variables can be obtained from the author. Symbols used are listed in Chapter III. In order to conserve space, the following symbols (appearing as superscripts to the coefficients in this and following tables) are used to indicate the levels of significance. The letter "a" indicates significance at 0.01 level or less; "b" if significance is between 0.01 and 0.05; and "c" if significance is between 0.05 and 0.10. Under the assumption that the variables have independent normal distribution and with 500 degrees of freedom, r is significantly different from zero; at .01 level if $r \geq .147$, at .05 level if $r \geq .088$, and at .10 level if $r \geq .074$.

* Not obtained.

hand, they are probably negatively correlated to the extent that irrigation is a substitute for fallowing.

As hypothesized in Chapter II, high levels of fertilizer application were highly and positively correlated with high percent irrigated. This is probably because the practices are complements.

Acres Per Farm

Acres of grain sorghum harvested per farm harvesting grain sorghum was positively correlated with yield, contrary to expectations. It was expected that large sorghum operations were in areas where extensive dry-land operations were found. Yields in such areas tended to be low so a negative correlation was expected. However, as also indicated by the correlation of acres per farm with irrigation, large sorghum operations tended to be found in the intensively farmed areas.

The correlation with tractor numbers is as expected. That is, where the size of sorghum operations was large, the number of cropland acres to tractor (A/T) tended to be large or conversely the number of tractors per cropland acre (T/A) tended to be small. However, this indicates extensive type of farming where sorghum operations are large, which is contrary to conclusion reached in paragraph above.

Fuel expenses per acre tended to be high when size of sorghum operations were large. This again suggests that more intensive operations were associated with large sorghum operations.

Value of land was not associated with size of sorghum operations. This suggests that the value of land was not determined to any large extent by the profitability of the sorghum enterprise.

Size of sorghum enterprise was negatively correlated with man-hours of labor. This is consistent with the hypothesis that large sorghum enterprises are extensively farmed. However, because of the poor labor data, too much reliance should not be placed on this result.

Sorghum enterprises tended to be large where number or proportion of acres fallowed was high. Since fallowing is practiced more in drier areas, it seems to follow that large sorghum enterprises would tend to be located in these drier areas. Given the correlation (.207) of irrigation with size of enterprise, it seems to follow that higher level of irrigation was also found in the drier areas.

Rates of fertilizer application were positively correlated with size of enterprise. This is consistent with more irrigation being done on large sorghum enterprises and fertilizer being positively correlated with irrigation.

Acres Per Tractor and Tractors Per Acre

Both of these variables are discussed here because they both deal with the relationship of number of tractors to acres of cropland harvested. Yield was positively correlated with tractors per acre. Those areas or years that were more mechanized (as measured by tractor per acre) tended to have higher yields. The negative correlation of yield with acres per tractor leads to the same conclusion.

As would be expected, as the number of tractors per acre increased, fuel expenses per acre increased. Or, the inverse relationship, when acres per tractor increased, fuel expenses per acre went down. Where value of land was high, the number of tractors per acre was also high. This indicates that land was more intensively farmed where land values were high.

There was a high positive (.318) correlation between hours of labor per acre and number of acres per tractor. This is as expected because tractors are a substitute for labor. As the number of acres per tractor decreased (increased tractor numbers) the need for labor per acre of sorghum was less.

The positive correlation (.224) between acres fallowed and acres per tractor and the negative correlation (-.167) of percent fallowed with tractor per acre were consistent with each other. They were also consistent with the idea that if the number of acres fallowed was high the need for tractors would be less.

Where the number of tractors per acre was high (more intensive farming) the level of fertilizer applied tended also to be high (also more intensive farming). However, the correlation (.066) was not very high.

Dollars Spent on Gas and Oil

Dollars spent on gas and oil (fuel expense) was positively correlated with yield. That is, use of machines was positively correlated with yields.

Fuel expense was highly and positively (.436) correlated with value of land. This is consistent with a hypothesis that higher valued land is farmed more intensively. The negative correlation of fuel expense with labor is consistent with the fact that they are substitutes.

There was very little relationship between acres fallowed and fuel expense. Fertilizer level and fuel expense were highly and positively (.424) correlated as expected. Both practices are a priori positively related to more intensive farming.

Value of Land

Yield was very highly correlated (.529) with value of land. This is as expected. Higher valued land would have to support higher yields if the higher value was justified (ignoring for the moment the effect of non-agricultural demand for land).

Where (cross sectionally) or when (time series) the value of land was high, the amount of labor used per acre of sorghum was low. A priori, land which best accommodates the substitution of machines for labor would be the most valuable.

As expected, land which was fallowed was less valuable than land not fallowed. The relationship was clearer when the ratio of fallow land to cropland was considered.

In Chapter II, it was hypothesized that value of land was in part determined by the interaction effect of fertilizer with land. If this hypothesis is true, then it follows that land values ought to be highly and positively correlated with fertilizer use. The simple correlation coefficient (.334) indicates that this was the case.

Labor

The variable man-hours of labor per acre of grain sorghum was negatively correlated with yield. Those areas or years where the man labor requirements have decreased the most tended to have the highest yields.

Labor was negatively correlated with acres fallowed. In those areas or years where fallowed acres were high, labor requirement tended to be low.

Fertilizer was negatively correlated with labor. Those areas and years which have done the most in terms of substituting machines for labor have also done the most in terms of increasing the amount of plant nutrients added.

Acres Fallowed and Ratio: Acres Fallowed to Acres of Cropland Harvested

These two variables are discussed together because they are concerned with the same factor, i.e., fallow. Fallow was negatively correlated with yields. Those areas that practice fallowing tended to have lower yields. Fallowing was negatively correlated with precipitation (-.34 for preseason precipitation and acres fallowed, and -.37 for preseason precipitation and percent fallow). Thus, the negative correlations of fallow with yield can be interpreted as: Where precipitation was normally low, yields tended to be low.

There was no significant correlation between fertilizer and fallow.

Fertilizer

Fertilizer was highly and positively (.509) correlated with yield as expected.

Effect on Coefficients

Mis-specification affects not only $\bar{R}^2$, but also the regression coefficients. But how do the M.C.I. variable coefficients (and thus their interpretation) change as the model is changed?

Acres of Grain Sorghum Harvested Per Farm Harvesting Grain Sorghum

The variable acres of grain sorghum per farm harvesting grain sorghum (acres per farm) was included to estimate the effects of size of the grain sorghum enterprise on yields. Quality of land, specialized equipment, and management effort are three factors expected a priori (1) to be related to changes in size of enterprise, and (2) to affect yields.

It was decided that this variable should be included in the "complete" equation because on the basis of production theory, size of enterprise does affect yield and because its presence influences (and presumably improves) the coefficients of the other variables in the model.

This variable was included in 192 equations. Its coefficient tested significantly different from zero at the ten-percent level or less in 13.9 percent of the equations (see Table 5-3). For the "complete" or nearly complete equations estimated using corrected data, the coefficient was

Table 5-3.--Basic data concerning technology variables included in the analysis

Variable[a]	Number of times included[b]	Percent of coefficients significant at--[c]			
		$\alpha \leq .01$	$.01 < \alpha \leq .05$	$.05 < \alpha \leq .10$	$\alpha > .10$
%----------	180	100.0	0.0	0.0	0.0
A/F---------	192	5.2	2.0	6.7	86.1
A/T---------	139	10.0	20.1	27.3	42.6
T/A---------	21	0.0	0.0	0.0	100.0
$----------	159	3.1	8.1	22.6	66.2
VL----------	189	100.0	0.0	0.0	0.0
L-----------	139	78.4	16.5	0.0	5.1
Fa----------	152	22.3	24.3	9.8	43.6
Fa/A--------	22	4.5	13.6	0.0	81.9
FT----------	188	100.0	0.0	0.0	0.0

a/ Symbols listed in Chapter III.

b/ The number of equations in which this variable is included. All equations, all coefficients, and the level of significance of all coefficients are presented in Appendix B.

c/ Since the equations estimated were not selected at random, no particular significance can be given to the proportions reported.

significant only when the year variables were omitted from the equation (see Table 5-4).

The level of significance, the sign and the magnitude of the coefficient, was affected by model specification as shown in Table 5-4. The significance of the coefficient when year variables were omitted suggests a strong positive correlation with time even though the correlation with individual year variables was low (.223, .179, -.086, -.030 for 1944, 1949, 1954, and 1959, respectively). Although it can be argued that when present

Table 5-4.--Coefficients[a] for acres of grain sorghum per farm variable[b]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial of seventh degree
None	.333	-.161	-.054
C.R.D.	-.037	.250	.072
Years	.547[a]	.593[a]	.477[a]
Precipitation	.168	-.153	-.187
Temperature	-.027	-.079	-.010
Interaction	.171	-.121	-.163
Temperature and precipitation	-.061	-.119	-.141

a/ The coefficient indicates how many pounds per acre yield will change with an increase of one acre of grain sorghum per farm.

b/ Estimated using corrected data. Corresponding equation numbers are presented in Tables 3-6 and 4-6.

the year variables "captured" the significant effect of size of enterprise, it is more likely that when the year variables were omitted the acres per farm variable "captured" significant effects of other factors correlated with time.

The amount of weather detail included also affected the coefficient. The coefficient became negative when season totals or polynomial variables were substituted for the weekly weather variables.

Positive coefficients significant at the one-percent level were obtained (see Table 5-4 and equations 95, 137, 138, 229, and 238 Appendix B). Negative coefficients significant at the one-percent level were also obtained (see equations 12, 58, and 243 Appendix B). This indicates that any conclusion could have been reached concerning the effects of changes in the size of the enterprise, depending upon the model specified. There was a tendency for the coefficient to be negative and significant when year variables were included or when only M.C.I.V. were included. The coefficient tended to be positive and significant when year variables were not included, when only location variables were included (equation 95), when only the value of land variable was included (equation 299), or when no other variables were included (equation 238).

The significance of the coefficients in the nearly complete models (Table 5-4) suggest (1) there were no significant effects of changes in size of enterprise, or (2) there were significant effects but they were not "captured" by this variable. In the latter case, this could be due to (a) this variable was not the appropriate variable for determining this effect, (b) the variable was measured with error, or (c) other variables masked (captured) this effect. It is believed that the first two (a and b) are not true. Examination and comparison of equations containing this variable (see Appendix B) and of the simple correlation coefficients (see Table 5-2)1/ reveals no information to suggest that the third reason (c above) is true. Thus, it is concluded that changing the size of the enterprise does not significantly affect per acre yields of grain sorghum.

Dollars Spent on Gas and Oil

The variable dollars spent on gas and oil was included in 159 equations. Its coefficient was significant in one-third of the equations (see Table 5-3). For the "complete" or nearly complete equations estimated using the corrected data, the coefficient was not significant except when temperature, interaction, and precipitation or crop reporting districts were omitted (see Table 5-5).

1/ A table giving all the simple correlation coefficients can be obtained from the author.

Table 5-5.—Coefficients[a/] for dollars spent on gas and oil[b/]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial
None	-15.9	-22.1	-18.7
C.R.D.	-23.7[c]	-15.9	-25.8[b]
Years	-4.9	-15.0	-3.3
Precipitation	-12.4	-22.0	-20.8
Temperature	-27.2[b]	-23.9[c]	-20.3
Interaction	-12.0	-21.7	-20.1
Temperature and precipitation	-22.7[c]	-25.2[c]	-24.0[b]

a/ The coefficient indicates how many pounds per acre yield will change for an increase of one dollar spent on gas and oil.

b/ Estimated using corrected data. Corresponding equation numbers are presented in Tables 3-6 and 4-6.

Positive coefficients significant at the one-percent level were obtained in two equations containing only a few M.C.I.V. and no other variables (equations 234 and 235). The level of significance, sign, and magnitude of the coefficient were affected by model specification.

The results suggest a relationship between the fuel expense variable and weather and location variables. The highest simple correlation, however, is only .26.

It is concluded that changes in mechanization (as measured by fuel expense) did not significantly affect per acre yields. This variable is retained in the "complete" model because production theory suggests that increased mechanization does affect per acre yield and because its presence influences (and presumably improves) the coefficients of the other variables in the equation.

Acres of Cropland Harvested Per Tractor

The acres of cropland harvested per tractor (acres per tractor) variable was included in 139 equations. Its coefficient was significant in 57.4 percent of the equations.

This variable was included in only three equations estimated using the corrected data. The incorrect data affected both the magnitude and level of significance of the coefficients. In a model containing C, Y, M(L), P, R_i, T_i, and I_i, coefficients of .241 and -.001 were obtained for incorrect and correct data respectively. The incorrect data caused the coefficients to be larger and caused one to be significant. Although the coefficients estimated using incorrect data are wrong, it is reasonable to assume that the relative magnitudes do measure the effects of omitting sets of variables.

The sign, magnitude, and level of significance were affected by model specification. Significant negative coefficients were obtained in models containing only a few M.C.I.V. and no other variables (equations 241 and 242). Positive significant coefficients were obtained in many models (equations 1, 2, 34, 85, 205, and 222, for example).

Significant coefficients were never obtained when weekly weather variables were included. For this variable, the form of the weather variables substantially affected the coefficients. It can be concluded that mechanization as measured by the acres per tractor variable did not significantly affect per acre yields.

The inverse relationship of this variable to mechanization makes it difficult to interpret. Because of this, the variable "number of tractors per acre of cropland harvested" was included in most of the models estimated using the corrected data instead of "acres of cropland harvested per tractor."

Number of Tractors Per Acre of Cropland Harvested

The variable number of tractors per acre of cropland harvested (tractors per acre) was included in 21 equations. The coefficient was never significant.

The coefficient had its smallest value (210) in the "complete" equation and its largest value (3,786) in the model using the least weather detail (season totals) and omitting the years variables (see Table 5-6). The sign and magnitude of the coefficients were affected by model specification.

It is concluded that mechanization as measured by this variable had no significant effect on per acre yield.

Table 5-6.--Coefficients[a] for tractors per acre[b]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial of seventh degree
None	210	902	-661
C.R.D.	-1,573	1,813	-911
Years	1,947	3,786	1,333
Precipitation	852	861	1,642
Temperature	-192	260	-863
Interaction	731	690	1,333
Temperature and precipitation	2,251	386	1,471

a/ The coefficient indicates how many pounds per acre yield will increase for an increase of one tractor per acre.

b/ Estimated using corrected data. Corresponding equation numbers are presented in Tables 3-6 and 4-6.

Man-Hours of Labor

The variable man-hours of labor per acre of grain sorghum was considered in 139 equations. The coefficient was significant at $\alpha = .10$ or less in 94.9 percent of the cases (see Table 5-3).

On the surface, it would seem that this would be a very good variable to include in an equation. However, when the results of some of the equations were considered, it became apparent that a problem of multicollinearity existed between the set of variables representing years and the labor variable.

Some examples of how the coefficient for labor was affected by the inclusion of years in the equation are given in Table 5-7. It is interesting

Table 5-7.--Effects of multicollinearity of years with labor on the estimated labor coefficient[a/]

Equation number	Variables	Estimated coefficient[b/] for labor
109----------	M, P, R^i, T^i, I^i	-29.7[a]
97-----------	M, P, R^i, T^i, I^i, Y	-90.4[a]
86-----------	G, M, P, R^i, T^i	-35.2[a]
87-----------	G, M, P, R^i, T^i, Y	-93.4[a]
5------------	$C, M(A/T), P, R^i, T^i, I^i$	-23.3[a]
3------------	$C, M(A/T), P, R^i, T^i, I^i, Y$	-41.0
26-----------	G, M, R^i, T^i, I^{0-6}	-50.8[b]
25-----------	$G, M, R^i, T^i, I^{0-6}, Y$	-52.0[b]

a/ The equations are presented in pairs. The first equation does not include the dummy variables representing years. The second equation is exactly the same except it does include years. See Appendix B for complete equations. Estimated using the not corrected data.

b/ The coefficient indicates how many pounds per acre yield will change for an increase of one hour of labor per acre.

to note that the effect of years on the labor coefficient is markedly different depending on which of the other variables are included in the equation. When growing seasons, all technology variables, a seventh degree polynomial in precipitation and temperature, and a sixth degree polynomial in interaction are included in an equation (see equations 26 and 25 in Table 5-7) the addition of years had very little effect on the labor coefficients. This is surprising in that equations 86 and 97 were not much different but there the addition of years to the equation greatly affected the coefficient for labor.

In general, the addition of years to an equation which already included the labor variable greatly affected (increase in absolute value) the coefficient for labor.

The coefficients for the dummy variables representing years were also greatly affected by the inclusion of the labor variable in the equation (see Table 5-8). In all cases, the inclusion of the labor variable greatly affects the magnitude, sign, and level of significance of the coefficients for years.

The coefficients for years in those equations that include the labor variable were inconsistent in sign, magnitude, and level of significance. However, the coefficients for years in those equations that did not include the labor variable were consistent in sign and (in general) the level of significance and differ only in magnitude.

The labor variable is highly intercorrelated with the set of variables representing years. The simple correlations of the labor variable with the individual variables representing years were large in magnitude and monotonically decreasing in trend, i.e., .62, -.19, -.41, and -.56 for 1944, 1949, 1954, and 1959, respectively.

Table 5-8.--Effect of multicollinearity of years with labor on the estimated coefficients for years[a]

Equation number	Variables	Coefficients[b] 1959	1954	1949	1944
97	Te, P, R^i, T^i, I^i, Y	-147	-232	-167	326[a]
98	$Te(L), P, R^i, T^i, I^i, Y$	433[a]	297[a]	230[a]	246[a]
15	C, P, R^i, T^i, A/F, FT, VL, L, Y	168	-198	47	364[a]
14	C, P, R^i, T^i, A/F, FT, VL, Y	597[a]	178[a]	330[a]	323[a]
18	C, P, R^i, T^i, Te, Y	226	-144	85	372[a]
16	C, P, R^i, T^i, Te(L), Y	647[a]	227[a]	367[a]	332[a]
54	C, A/F, %, FT, VL, L, Y	566[a]	-25	359[a]	561[a]
55	C, A/F, %, FT, VL, Y	828[a]	199[a]	528[a]	543[a]
271	P, R_i, T_i, Y, L, VL	-76.5	-289	-176	328[a]
270	P, R_i, T_i, Y, VL	553[a]	263[a]	239[b]	308[a]
276	Te, P, R_i, T_i, Y	-276	-435[b]	-299[b]	247[a]
278	$Te(L), P, R_i, T_i, Y$	455[a]	210[a]	188[c]	230[a]

a/ The equations are presented in pairs. The first equation contains the labor variable, the second equation is identical except the labor variable has been omitted. See Appendix B for complete equations. Estimated using not corrected data.

b/ The coefficient indicates the pounds per acre yield differs from the 1939 yield.

All the data on labor used in the study are presented in Table 5-9.[1]

The problem of multicollinearity of years with labor was probably due in part to the aggregative nature of the labor variable. It is believed that if the value of the labor variable were determined for each county, the problem of multicollinearity with years would be reduced.

1/ For more detail see Appendix A, Table A-11.

Table 5-9.--Total man work units per acre of grain sorghum

Year	Farm production region		
	Nebraska, Kansas	Oklahoma, Texas	Colorado, New Mexico
1939----	12.2	11.6	12.0
1944----	13.4	11.6	12.2
1949----	6.7	7.0	9.3
1954----	5.0	5.7	7.9
1959----	3.4	5.2	6.7

Because of the poor measure of labor used and because there was great interest in the coefficients for years, it was decided that the labor variable should be omitted from the "complete" equation. Omitting the labor variable does not mean that the influence of labor on yields is ignored. The effects of changes in labor on yields was (partially at least) included in the coefficients for years. I fucked yo mama

In spite of the problem of high intercorrelation with years1/, the coefficient for labor was almost always significant. This is contrary to expectations and to the hypothesis stated in Chapter II, i.e., that the coefficient for this variable would be non-significant.

The negative coefficient is also unexpected. The significance and the sign can be explained in terms of the multicollinearity with years. That is, the "labor" variable explained a significant part of the effects of technology that were associated with years. Since the technology effects being "captured" cannot be related to any specific technology, it is better to let the effects be included in the coefficients for years.

1/ One of the effects of multicollinearity is to cause the standard errors of the coefficients to increase. Thus, if there was a problem of high intercorrelation among variables, it would be expected that the estimated coefficients would not be significant.

Percent Acres of Grain Sorghum Irrigated

It is well known that the irrigation of crops (particularly in the semi-arid parts of the country) will greatly increase yields. The variable percent irrigated did a good job of quantifying the effects of irrigation on yields of grain sorghum. This variable was included in 180 equations. The coefficients were significant at less than .01 level in all equations.

The coefficients from the nearly complete equations estimated using the corrected data are presented in Table 5-10. The magnitude of the coefficient was affected by the model specification, even though sign and level of significance were not. Within the context of "nearly complete" (omitting only one set of variables) equations, the maximum increase or decrease in the size of the coefficient was about 100 pounds per acre or about one-seventeenth of the magnitude in the "complete" equation (see Table 5-10).

Regardless of the form of the weather variables in the "nearly complete" equations (see Table 5-10), omitting the crop reporting district variables caused the coefficient for percent irrigated to increase. This is probably because there was great cross-sectional variation in percent irrigated.

The effect of omitting the year variables depends upon the form (detail) of the weather variables. When detailed weather variables (weekly and polynomial) were included, omitting years had no effect. However, when season totals were used to represent weather, omitting years caused the coefficient to <u>decrease</u> from 1810 to 1682. This may be due to the irrigation variable (positively correlated with time) having to "explain" some of the effects of bad weather in 1954 when weather is not included in detail and the year variables are removed.

Table 5-10.--Coefficients[a/] for percent irrigated[b/]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial of seventh degree
None	1,761[a]	1,810[a]	1,845[a]
C.R.D.	1,853[a]	1,866[a]	1,932[a]
Years	1,762[a]	1,682[a]	1,845[a]
Precipitation	1,757[a]	1,812[a]	1,796[a]
Temperature	1,753[a]	1,821[a]	1,867[a]
Interaction	1,757[a]	1,819[a]	1,798[a]
Temperature and precipitation	1,678[a]	1,808[a]	1,788[a]

a/ The coefficient indicates how many pounds yield per acre will change for a 100-percent increase in amount irrigated per acre.

b/ Estimated using corrected data. The corresponding equation numbers are given in Tables 3-6 or 4-6.

There was very little effect of omitting any single set of weather variables when weather is represented by either weekly or season total variables. However, the coefficient was affected when polynomial weather variables are included. Why this happened is not clear.

For models containing only M.C.I.V., the absence of the fertilizer or value of land variables greatly affect the coefficient for the percent irrigated variable. For example, in equation 233 (see Table 5-1 for variables included) a coefficient of 2,057 was obtained. When the fertilizer variable was added, the coefficient dropped to 1,619. In equation 244 (see Table 5-1 for variables included) a coefficient of 1,663 was obtained. When the value of land variable was added (equation 245), the coefficient decreased to 1,263. The effect of dropping these variables was reduced when a large number of other variables were included in the equation. For example, the 400-pound decrease caused by adding the value of land variable when only M.C.I.V. were included is reduced to 200 when the equation also contained location, years, and weather variables (equations 13 and 14).

Model specification did affect the coefficient for the percent irrigated variable, even though it was always positive and highly significant.

Value of Land

It was hypothesized in Chapter II that this variable reflected the interaction effects of land with the other M.C.I.V. It was further hypothesized that the coefficient would be positive and significant. These latter hypotheses were found to be true based on the results of this analysis. It is not possible on the basis of this study alone to determine the truth of the first hypothesis; but the results did not disprove it.

The problem of this variable not being completely exogenous with respect to the dependent variable was also discussed.

Six sets of equations were estimated where the only difference between the two equations in the set was the presence or absence of the value of land variable. By comparing the equations within each set it is possible to obtain some idea of how the presence of this variable affected the results. We can answer the question, Would the results or conclusions concerning the overall model or the other variables in the model have been greatly different if this variable were not included.

The most accurate estimate of the effect of dropping the value of land variable would be obtained from equations containing all the other variables included in the "complete" equation.

The nearest we can come to this is the set of equations 13 and 14 which contain the percent irrigated, acres per farm, and fertilizer variables, the year variables, the crop reporting district variables, pre-season precipitation, the seventh degree precipitation polynomial and the seventh degree temperature polynomial. They were estimated using the not corrected data.

Dropping the V of L variable from this equation caused the $\bar{R}^2$ to drop from .758 to .752. The irrigation coefficient changed from 1,708[a] to 1,963[a]. The fertilizer coefficient changed very little from 14.2[a] to 14.4[a]. The acres per farm coefficient changed from -.291 to -.408[c] and became significant at the 0.10 level. All the other coefficients exhibited little change (all the coefficients are listed in Appendix B, Table B, Part 2). Except for the acres per farm coefficient, all the other conclusions based on equation 14 (with the V of L variable) would have been essentially the same as if based on equation 13.

The other five pairs of equations differing only by the presence or absence of the V of L variable are: 55 and 56, 231 and 223, 137 and 138, 92 and 93, and 269 and 270. Since essentially the same conclusion is reached concerning these sets, they will not be discussed here. The coefficients for all of them are presented in Appendix B. Of course, as the equation becomes more incomplete, dropping the V of L variable has a greater effect upon the $\bar{R}^2$ and on the coefficients of other variables.

This variable was included in 189 equations and was significantly different from zero at the .01 level in all equations. The sign was always positive, but the magnitude varied.

The coefficients from the "nearly complete" equations estimated using the corrected data are presented in Table 5-11.

Table 5-11.--Coefficients[a] for value of land variable[b]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial of seventh degree
None	2.9[a]	2.1[a]	2.9[a]
C.R.D.	2.7[a]	2.2[a]	2.5[a]
Years	3.7[a]	3.9[a]	3.7[a]
Precipitation	2.6[a]	2.1[a]	2.3[a]
Temperature	3.3[a]	2.3[a]	3.0[a]
Interaction	2.6[a]	2.2[a]	2.3[a]
Temperature and precipitation	2.8[a]	2.4[a]	2.5[a]

a/ The coefficient indicates how many pounds per acre yield will change for a one-dollar increase in the value of land per acre.

b/ Estimated using corrected data. Corresponding equations listed in Tables 3-6 or 4-6.

The coefficient in equations containing weekly weather variables was not much different than the coefficient in the corresponding equations containing the seventh degree polynomial variables. However, the coefficient was consistently smaller (except when year variables were omitted) in equations containing the season total variables.

Only two sets of variables (years and temperature) greatly affected the coefficient. When the years variables were omitted the coefficient increased greatly. This was probably due to the value of land variable having "picked up" the effects of other variables also correlated with time. The coefficient also increased when the set of temperature variables was omitted (except for the season total variable). The reason for this is not clear.

In models containing only M.C.I.V., the coefficient was affected by three variables--man-hours of labor, fertilizer, and percent irrigated.

Acres Fallowed

This variable was included in 152 equations and was significantly different from zero in 56.4 percent of them.

The coefficient was obtained in only two equations estimated using the corrected data (equations 283 and 293). A coefficient of -.00013 was obtained in equation 283, which contained the weekly weather variable. Equation 293 contained the polynomial weather variable and a coefficient of .00011 was obtained. The form of the weather variables included affected the coefficient's magnitude and sign, but not its non-significance.

The coefficient was not significant in any equation containing crop reporting district variables. It tended to be significant and negative in those equations not containing district variables. This indicates that the variation in yield explained by differences in acres fallowed can also be explained as consistent differences between crop reporting districts. The results also indicate the effects of fallowing were confounded with the effects of temperature as the coefficient tended to be significant only when temperature variables were included.

Crop reporting district variables were not dropped from the "complete" equation even though they "cover up" the effect of fallowing. When the coefficients obtained for districts are discussed, it will have to be remembered that one of the effects they include is the effect of fallowing.

In future studies the effects of fallowing may be determined independent of the location effects if better input data are used. For example, if the proportion of grain sorghum actually planted on land fallowed the previous year were used, the effects of fallowing might be determined.

The variable acres fallowed is influenced by the size of the county. In an effort to remove this undesirable effect a new variable, "ratio: acres fallowed to acres of cropland harvested" was developed and used in most of the equations estimated using corrected data.

Ratio: Acres Fallowed to Acres of Cropland Harvested

The ratio of acres fallowed to acres of cropland harvested (percent fallowed) variable was included in 22 equations, all estimated using the corrected data. Its coefficient was significant in 18.1 percent of the equations. The coefficients obtained in the "nearly complete" models are presented in Table 5-12. The coefficients were consistent in sign (negative) but varied in magnitude and level of significance.

The effect of fallowing on yield was hypothesized to be positive and significant. Experiment station studies have in fact demonstrated that yield of sorghum on land previously fallowed is up to one-third greater than for sorghum grown on land cropped the previous year.

The negative coefficient can be explained. Percent acres fallowed is negatively correlated with the preseason precipitation variable and with 19 of the 23 weekly precipitation variables. That is, acres fallowed were high where precipitation was low and very little fallowing was practiced where precipitation was high. Because of the intercorrelation of these variables, <u>both</u> cross sectionally <u>and</u> over time, the effects of

Table 5-12.--Coefficients[a] for ratio: Acres fallowed to acres of cropland harvested[b]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial of seventh degree
None	-129	-126	-99
C.R.D.	-213[a]	-100	-142[b]
Years	-102	-64	-135
Precipitation	-171[b]	-127	-118
Temperature	-95	-108	-84
Interaction	-174[b]	-130	-117
Temperature and precipitation	-92	-98	-101

a/ The coefficient indicates how many pounds per acre yield will change for an increase of 100 percent in acres fallowed per acre of cropland.

b/ Estimated using corrected data. Corresponding equation numbers are presented in Tables 3-6 and 4-6.

precipitation and the effects of fallowing were confounded. This is unfortunate because one of the objectives was to separate the effects of the M.C.I.V. from the effects of weather.

The relationship of fallow to precipitation was also revealed by the coefficients obtained in the nearly complete equations (see Table 5-12). When the precipitation variables or the interaction variables which were highly correlated with the precipitation variables were omitted, the coefficient for fallow became significant. However, this only happened when the weekly weather variables were included in the model.

The only other set of variables that greatly affected the coefficient for the percent fallow variable was the crop reporting districts. When the set of district variables was omitted, the coefficient for percent fallow became significant. This was because there was a strong consistent cross-sectional pattern for percent fallow and when there were no location variables to pick up the location effects, they were "captured" by the percent fallow variable. Again the form of the weather variables affected the magnitude of this effect. When very detailed weather variables (weekly) were included, dropping the district variables caused the coefficient to increase (in absolute value) 84 pounds per acre and it became significant at the .01 level. When polynomial variables were included, dropping the district variables caused the coefficient to increase 43 pounds per acre and it became significant at the .05 level. When only season totals were included, the coefficient decreases 26 pounds and the coefficient was not significant. The reason why this happened as less detailed weather variables are included is not clear. However, it is clear that the conclusion reached concerning the level of significance and magnitude of the coefficient is greatly affected by model specification.

Fertilizer

The variable pounds of plant nutrients applied per acre of grain sorghum (fertilizer) was included in 188 equations. Its coefficient was significantly different from zero at the .01 level in all equations.

The coefficients from the "nearly complete" models estimated using the corrected data are presented in Table 5-13. The sign and level of significance were consistent, but the magnitude varied greatly.

Dropping the district variables from the equations caused the coefficient to increase in size. This indicates that in districts where fertilizer levels were high, there were other factors associated with the location that caused or allowed higher yields.

Table 5-13.--Coefficients[a/] for the fertilizer variable[b/]

Variables omitted	Season weather variables included		
	Weekly	Season total	Polynomial of seventh degree
None	11.2[a]	14.0[a]	12.4[a]
C.R.D.	13.1[a]	16.0[a]	15.5[a]
Years	13.4[a]	22.8[a]	15.0[a]
Precipitation	11.7[a]	14.0[a]	14.7[a]
Temperature	13.0[a]	14.0[a]	13.2[a]
Interaction	11.4[a]	13.9[a]	14.5[a]
Temperature and precipitation	13.1[a]	14.3[a]	15.1[a]

a/ The coefficient indicates how many pounds per acre yield will change for an increase of one pound of plant nutrient per acre of grain sorghum.

b/ Estimated using corrected data. The corresponding equation numbers are given in Tables 3-6 and 4-6.

Less detailed weather, whether by dropping sets of weather variables or by substituting in less detailed variables, caused the coefficient to increase. This indicates that where fertilizer levels were high, weather was conducive to higher yields.

Omitting the year variables also caused the coefficient to increase. This suggests that in years when fertilizer levels were high, yields were high. The combined effects of less detailed weather variables (season totals) and omitting the year variables caused the coefficient to increase to more than twice its size in the "complete" equation, i.e., from 11.2 to 22.8.

Even within the context of nearly complete equations, model specification greatly affected the coefficient for fertilizer.

Within the context of models containing only M.C.I. variables, the percent irrigated and value of land variables greatly affected the coefficient for fertilizer (compare coefficient for fertilizer in equations 227 with 228 and 228 with 239). The largest coefficient (47.1) was obtained in a model (equation 239) containing acres per farm and fertilizer as the only independent variables.

Conclusion

In this chapter man-controlled input variables and their coefficients were examined. It was determined that the $\bar{R}^2$'s for models that contained only M.C.I. variables did not compare favorable with the $\bar{R}^2$'s from models that contained M.C.I., weather, location, and time variables.

The simple correlation between the M.C.I. variables was discussed. The highest simple correlation between any two M.C.I. variables was less than .5. High intercorrelations among the M.C.I. variables was not a problem.

The effect of mis-specification (determined by specifying alternative models) on the regression coefficients was also examined. If the regression coefficient was significant in the "complete" model, it was also significant in all submodels. However, if the coefficient was not significant in the "complete" model, it may have been and often was significant in some submodels. In all cases, the magnitude of the coefficient was affected by changes in model specification.

CHAPTER VI

LOCATION AND YEARS

In this chapter, the coefficients estimated for the dummy variables included in the analysis to represent location and time are discussed. Principal concern is with the effects of alternative model specifications on their coefficients. In the first section of this chapter the sets of location variables (growing seasons and crop reporting districts) are discussed. The year variables are discussed in the second and final section.

Location Variables

Two sets of variables (crop reporting districts and growing seasons) were considered to take into account consistent differences in yield between locations. Such consistent differences between locations are expected primarily to measure the effect on yield of the difference in the physical inputs--soil, topography, climate, and cultural practices between the locations. The effect of consistent differences in levels of the M.C.I. and weather between locations may also have been captured by these variables.

The decision of which set of location variables to include in the "complete" equation was not made a priori. Rather, it was made after the results of some equations had been obtained. The decision was to include in the final equation that set which did the "best" job (in terms of $\bar{R}^2$) of explaining yield variation.

There were three pairs of equations which differed only by the set of location variables included. The $\bar{R}^2$ for these equations are presented in Table 6-1.

Table 6-1.--$\bar{R}^2$ for pairs of equations differing only by the presence of either growing seasons or crop reporting districts[a]

Other variables in equation	$\bar{R}^2$			
	Growing seasons		Crop reporting districts	
M(L), P, R^{07}, T^{07}, I^{07}	.720	(61)	.740	(6)
M, Y, P, R^{07}, T^{07}	.718	(87)	.740	(18)
None	.029	(96)	.182	(60)

a/ Estimated using the not corrected data. Numbers in parentheses are the equation numbers.

The set of dummy variables for crop reporting districts consistently did a better job of explaining yields. Although the difference in $\bar{R}^2$ was not great for the "more complete" models, the following discussion of location variables is limited to the set representing crop reporting districts.

The coefficients obtained in 21 equations estimated using the corrected data are presented in Tables 6-2-A, 6-2-B, and 6-2-C. The equations were grouped for the tables according to the form of the weather variables included in the equation. Table 6-2-A contains equations containing weekly weather variables; Table 6-2-B those containing season total weather variables; and Table 6-2-C those containing seventh degree polynomial weather variables. Within each table, the equations are those obtained by omitting selected sets of variables.

Table 6-2-A.--Coefficients[a]/ for crop reporting districts--equations containing weekly weather variables[b]/

Crop reporting districts	Set of variables omitted						
	None	M.C.I.	Years	Precipitation	Temperature	Interaction	Precipitation & temperature
	Pounds per acre						
1	384[a]	99	365[a]	354[a]	459[a]	351[a]	433[a]
2	239[a]	-7	196[c]	185[c]	322[a]	180[c]	295[a]
3	-1	-332[b]	10	-3	113	-5	113
4	-47	-712[a]	-22	-15	-71	-26	-66
5	-28	-664[a]	-32	-82	-68	-96	-157[b]
6	183	-341[b]	134	-25	93	-35	-119
7	-7	-619[a]	-24	30	-47	14	-31
8	-131	-533[a]	-177[b]	-142[c]	-207[a]	-159[b]	-258[a]
9	73	-375[b]	4	-7	-59	-23	-165
10	-89	-577[a]	-119	-47	-140[b]	-64	-113
11	-232[a]	-625[a]	-305[a]	-263[a]	-356[a]	-281[a]	-401[a]
12	-118	-592[a]	-221[b]	-164	-261[b]	-172	-346[a]
13	-242[a]	-828[a]	-183[b]	-228[a]	-286[a]	-240[a]	-274[a]
14	-20	-507[a]	-18	-38	-261[b]	-47	-272[b]
15	-345[a]	-836[a]	-379[a]	-331[b]	-570[a]	-335[a]	-558[a]
16	-451[a]	-1,012[a]	-433[a]	-470[a]	-201[b]	-468[a]	-201[b]
17	-390[a]	-698[a]	-333[a]	-438[a]	-159	-442[a]	-185[c]
18	-109	-677[a]	-51	-148[c]	-61	-135	-162[c]
19	---	---	---	---	---	---	---
20	-287[a]	-434[a]	-235[a]	-341[a]	-119[b]	-331[a]	-164[a]

-Continued

Crop :
reporting :
districts :

Table 6-2-A.--Continued

Crop reporting districts	Set of variables omitted						
	None	M.C.I.	Years	Precipitation	Temperature	Interaction	Precipitation & temperature
	Pounds per acre						
21	-263[a]	-635[a]	-215[b]	-361[a]	-171[b]	-352[a]	-276[a]
22	-227[c]	-650[a]	-78	-325[a]	-184[b]	-326[a]	-281[a]
23	-8	-345	49	-83	16	-66	41
24	-13	-73	-80	-167	-55	-158	-81
25	-282	-410	-271	-269	-195[c]	-238	-186[b]
26	116	-44	-42	42	169	105	221[b]
27	-197	-391	-250	-304	-90	-251	-59
28	-414[b]	-122[b]	-568[a]	-424[b]	-425[a]	-385[b]	-242[b]

a/ The coefficient indicates the pounds per acre yield difference relative to the yield in crop reporting district 19.

b/ Estimated using the corrected data. Corresponding equation numbers are listed in the first column of Tables 3-6 or 4-6.

Table 6-2-B.--Coefficients[a/] for crop reporting districts--equations containing season total weather variables[b/]

Crop reporting districts	Set of variables omitted: None	M.C.I.	Years	Precipitation	Temperature	Interaction	Precipitation & temperature
	Pounds per acre						
1	284[a]	-153	161	283[a]	341[a]	280[a]	370[a]
2	131	-345[a]	22	129	172[b]	121	207[b]
3	24	-535[a]	53	24	65	24	82
4	-26	-729[a]	43	-26	12	-21	18
5	-149[b]	-718[a]	-113	-150[b]	-121	-151[b]	-105
6	-176	-617[a]	-287[b]	-178	-155	-179	-134
7	59	-577[a]	91	59	76	57	87
8	-165[b]	-627[a]	-131	-166[b]	-172[b]	-167[b]	-168[b]
9	-115	-581[a]	-135	-117	-118	-119	-106
10	-4	-584[a]	-3	-5	-16	-10	-11
11	-313[a]	-763[a]	-305[a]	-314[a]	-333[a]	-319[a]	-327[a]
12	-215[c]	-703[a]	-215[c]	-218[c]	-246[b]	-225[b]	-236[b]
13	-164[c]	-819[a]	-39	-164[c]	-174[b]	-166[c]	-175[b]
14	-193	-634[a]	-49	-194	-266[c]	-198	-282[b]
15	-335[b]	-785[a]	-170	-337[b]	-428[a]	-344[b]	-443[a]
16	-276[a]	-1,070[a]	-186[c]	-275[a]	-219[b]	-270[a]	-208[b]
17	-215[b]	-721[a]	-104	-215[b]	-186[c]	-216[b]	-174[c]
18	-115	-672[a]	-21	-114	-89	-111	-87
19	---	---	---	---	---	---	---
20	-141[b]	-564[a]	-77	-142[b]	-168[a]	-147[b]	-169[a]

-Continued

Table 6-2-B.--Continued

Crop reporting districts	Set of variables omitted						
	None	M.C.I.	Years	Precipitation	Temperature	Interaction	Precipitation & temperature
	Pounds per acre						
21	-277[a]	-834[a]	-136	-278[a]	-304[a]	-282[a]	-304[a]
22	-214[a]	-731[a]	-25	-216[b]	-287[a]	-222[a]	-301[a]
23	55	-526[a]	213	54	40	48	43
24	-32	-453[a]	35	-35	-100	-45	-101
25	-72	-556[a]	-22	-73	-99	-77	-99
26	447[a]	-32	379[a]	446[a]	453[a]	445[a]	459[a]
27	92	-488[a]	208[c]	93	98	95	95
28	-112	-217	-125	-113	-148	-117	-153

a/ The coefficient indicates the pounds per acre yield difference relative to the yield in crop reporting district 19.

b/ Estimated using the corrected data. Corresponding equation numbers are listed in the second column of Table 3-6 or 4-6.

Table 6-2-C.--Coefficients[a] for crop reporting districts--equations containing seventh degree polynomial weather variables[b]

Crop reporting districts	Set of variables omitted						
	None	M.C.I.	Years	Precipitation	Temperature	Interaction	Precipitation & temperature
	Pounds per acre						
1	412[a]	-76	344[a]	337[a]	455[a]	332[a]	431[a]
2	287[a]	-220[c]	218[b]	184[b]	307[a]	181[c]	273[a]
3	93	-492[a]	111	48	117	48	118
4	-39	-800[a]	-8	-55	-40	-56	-1
5	-52	-740[a]	-68	-155[b]	-50	-160[c]	-107
6	44	-595[a]	-31	-134	62	-131	-73
7	-19	-680[a]	-2	9	-14	-1	48
8	-130[c]	-614[a]	-142[c]	-191[b]	-166[b]	-194[b]	-193[b]
9	14	-554[a]	-36	-128	-13	-131	-109
10	-99	-670[a]	-94	-49	-115[c]	-57	-44
11	-283[a]	-739[a]	-317[a]	-337[a]	-344[a]	-343[a]	-357[a]
12	-171	-705[a]	-232[b]	-245[b]	-229[b]	-250[b]	-270[b]
13	-184[b]	-825[a]	-105	-178[b]	-207[b]	-182[b]	-190[b]
14	-99	-613[a]	7	-170	-174	-169	-257[c]
15	-327[b]	-817[a]	-240[c]	-344[b]	-408[a]	-348[b]	-441[a]
16	-226[b]	-1,000[a]	-132	-262[b]	-212[b]	-256[b]	-202[b]
17	-157	-658[a]	-35	-192[c]	-181[c]	-193[c]	-171
18	-84	-658[a]	-17	-128	-30	-127	-92
19	---	---	---	---	---	---	---
20	-96	-420[a]	-8	-117[c]	-114[b]	-116[c]	-155[a]

-Continued

Table 6-2-C.--Continued

Crop reporting districts	Set of variables omitted						
	None	M.C.I.	Years	Precipitation	Temperature	Interaction	Precipitation & temperature
	Pounds per acre						
21	-156^{c}	-657^{a}	-34	-223^{b}	-202^{a}	-223^{b}	-269^{a}
22	12	-446^{a}	230^{c}	-47	-171^{b}	-42	-241^{a}
23	330^{c}	146	501^{a}	302	78	312^{c}	94
24	262	14	343^{b}	209	-29	223	-16
25	159	-199	219	113	-53	137	-106
26	615^{a}	303	570^{a}	604^{a}	414^{a}	618^{a}	423^{a}
27	294^{a}	-82	349^{c}	261	63	279	73
28	-89	18	-81	30	-316^{a}	38	-216

a/ The coefficient indicates the pounds per acre yield difference relative to the yield in crop reporting district 19.

b/ Estimated using the corrected data. Corresponding equation numbers are listed in third column of Tables 3-6 or 4-6.

It would be difficult and nearly meaningless to discuss and compare the nearly 600 coefficients presented in these three tables. Thus, the discussion is restricted to general comments. The levels of significance, although presented in Tables 6-2, were of no particular interest in this study. This is because the level of significance refers to the significance of the difference relative to district 19. District 19 was arbitrarily omitted and no hypothesis was suggested concerning the significance of these locational differences. The only hypothesis concerned the significance of the set, and this was discussed in Chapter IV.

Regardless of how the "complete" equation was modified, i.e., by form of weather variables or dropping sets of variables, the magnitude of the coefficients was affected and in many cases the sign and level of significance were also affected.

The largest change in the coefficients due to modifying the "complete" equation was when the M.C.I.V. were omitted. This was true regardless of the form of the weather variables. This suggests that the set of M.C.I.V. is highly correlated with the set of location variables.

Dropping any of the four sets of weather variables did not greatly affect the coefficients of the location variables.

Omitting the year variables did affect the coefficients. This is interesting because the year variables are independent of the location variables. This is evidenced by the fact that when year variables were added to an equation containing only crop reporting district variables, the estimated value of the cross sectional constants (coefficients for location variables) were not affected (see equations 59 and 60). Also, the simple correlation between any crop reporting district variable and any year variable was zero.

Although the presence of the year variables did not affect the estimated cross section constants when only the two sets were in the equation, they did affect them if there were other variables in the equation (note results presented in Tables 6-2). This would be expected if the other variables in the equation were not independent of either the district or year variables.

The magnitude of this indirect or second order effect was surprising. It is second order in the sense that the presence of the year variables affects the coefficients of the weather and/or man-controlled input variables and they in turn affect the coefficients for the district variables. The magnitude of these indirect effects indicates that the simple correlation coefficients tell little concerning interrelationships or interdependencies of the independent variables in a multiple regression model.

Year Variables

Time was taken into account in this analysis by a set of four dummy variables: One variable for each year except 1939 which was omitted to avoid a singular matrix. The coefficient obtained for these variables measured the consistent difference in yields over all counties between the year in question and 1939.

Time, of course, cannot directly affect yields. These variables were used to estimate the effect on yields of physical factors affecting yields, changing with time and not otherwise included in the analysis. The change in varieties was the major factor so related, but changes in management ability, changes in cultural practices, insecticides, herbicides, and labor used were also related to time.

The multicollinearity problem of the year variables with the man-hours of labor per acre variable was discussed in Chapter V. The relationship of the year variables with the location variables was discussed above. These discussions will not be repeated here.

The coefficients for the year variables obtained in some equations estimated using the corrected data are presented in Table 6-3. The coefficients presented in Table 6-3 are all positive and significantly different from zero at the .01 level. Altering the model by omitting a single set of variables or substituting different weather variables did not affect the sign or level of significance of the coefficients.

When the M.C.I.V. were omitted the coefficients for the year variables increased. The coefficients for all years were not affected the same. The coefficient for 1959 increased much more (as expected) than did other coefficients. The form of weather variables did not greatly affect the change in the 1959 coefficient. However, it did affect the coefficients for the earlier years. When detailed weather variables were included, the coefficients for 1944, 1949, and 1954 increased much more than when season total weather variables were included.

Omitting the crop reporting district variables caused the coefficient to decrease in size. This means that when the effects of cross sectional variation were taken into account (district variables included) more effects consistent over time were measured. This in spite of the independence of the year and district variables as discussed above. The effect of omitting the district variables was not greatly affected by the alternate sets of weather variables.

Table 6-3.--Coefficient[a] for year variables[b]

Variables omitted	Year	Weather variables included		
		Weekly	Season total	Polynomial of seventh degree
		Pounds per acre		
None	1959	528[a]	676[a]	537[a]
	1954	346[a]	231[a]	313[a]
	1949	419[a]	271[a]	428[a]
	1944	368[a]	301[a]	376[a]
M.C.I.V.	1959	968[a]	982[a]	994[a]
	1954	609[a]	409[a]	656[a]
	1949	532[a]	341[a]	624[a]
	1944	377[a]	308[a]	395[a]
Crop reporting districts	1959	458[a]	510[a]	415[a]
	1954	340[a]	144[a]	280[a]
	1949	259[a]	107[a]	243[a]
	1944	259[a]	179[a]	255[a]
Precipitation	1959	555[a]	672[a]	617[a]
	1954	225[a]	228[a]	210[a]
	1949	345[a]	270[a]	330[a]
	1944	342[a]	300[a]	314[a]
Temperature	1959	528[a]	700[a]	541[a]
	1954	233[a]	215[a]	217[a]
	1949	370[a]	331[a]	432[a]
	1944	341[a]	337[a]	358[a]
Interaction	1959	553[a]	657[a]	609[a]
	1954	223[a]	216[a]	211[a]
	1949	364[a]	264[a]	341[a]
	1944	342[a]	297[a]	316[a]
Precipitation and temperature	1959	623[a]	743[a]	682[a]
	1954	208[a]	233[a]	180[a]
	1949	348[a]	367[a]	395[a]
	1944	300[a]	361[a]	331[a]

a/ Estimated using corrected data. Corresponding equation numbers are listed in Tables 3-6 and 4-6.

b/ The coefficient indicates the pounds per acre difference in yield relative to 1939.

Omitting any set of weather variables did not affect the coefficient for years greatly. Although, in almost all cases less detailed weather variables (either omitting a set of substituting a less detailed set) caused the 1959 coefficient to increase and the other coefficients to decrease.

CHAPTER VII

WEATHER VARIABLES

This chapter is composed of three major sections. In the first section the coefficients for the preseason, weekly, polynomial, and season total variables and how they are affected by model specification are discussed. In the second section the estimated effects of weather in each week of the growing season as obtained from the three sets of weather variables are compared. It was not possible to determine the "correct" or "best" degree of polynomial for the weather factors a priori. The third section contains a discussion of why the seventh degree polynomial was selected for all three weather factors.

Weather Coefficients in Alternative Models

Preseason Precipitation

The preseason precipitation variable was included because it was believed a priori to be an important factor affecting yields. The estimated coefficient obtained in the "nearly complete" equations are presented in Table 7-1.

In all cases the coefficient is positive and significantly different from zero at the .01 level. The form of the weather variables greatly affects the coefficient. When less detailed weather variables are included, the coefficient is smaller. Omitting the M.C.I.V. when the weekly weather variables were included caused the coefficient to decrease a little (20.3 to 20.1). It decreased more (19.1 to 15.2) if the form of the weather

Table 7-1.--Coefficients for preseason precipitation variables for "nearly complete" equations[a/]

Set of variables omitted	Weather variables included		
	Weekly	Season total	Polynomial of seventh degree
	Pounds per acre per inch		
None	20.3[a]	11.6[a]	19.1[a]
M.C.I.V.	20.1[a]	6.9[a]	15.2[a]
C.R.D.	22.7[a]	21.4[a]	21.3[a]
Years	27.2[a]	13.3[a]	25.9[a]
Precipitation	17.3[a]	11.7[a]	15.1[a]
Temperature	24.6[a]	14.1[a]	18.9[a]
Interaction	17.8[a]	12.1[a]	16.0[a]
Temperature and precipitation	22.1[a]	14.1[a]	15.6[a]

a/ Corresponding equation numbers are presented in Tables 3-6 and 4-6. Estimated using the corrected data.

variables included was the polynomial. It decreased much more (11.6 to 6.9) if only the season total variables were included. The coefficient was increased when crop reporting district variables were omitted. The magnitude of the increase was affected by the form of the weather variables present. It increased a little when weekly weather variables were included, more when the polynomial variables were included, and almost doubled when season totals were included. It is interesting to note that when district variables were omitted the coefficient for preseason precipitation was nearly the same regardless of the form of the weather variables.

The coefficient for preseason precipitation was increased when the year variables were omitted. The magnitude of the increase was greater, the greater the weather detail included.

Omitting the season precipitation and interaction variables had about the same effect. It caused the coefficient to decrease when weekly or polynomial variables were included but had almost no effect when season totals were included.

When the temperature variables were omitted the coefficient increased for equations containing the weekly and season total variable, but remained nearly the same in the equations containing the polynomial variables. If the season precipitation variables are omitted in addition to omitting the temperature variables, the effect is nearly the net effect of omitting each set separately.

Weekly Weather Variables

When the weekly weather variables were included, coefficients were obtained for each week of the growing season for each weather factor. Coefficients for precipitation from the "nearly complete" equations are presented in Table 7-2; coefficients for temperature in Table 7-3; and coefficients for interaction in Table 7-4.

When discussing the effects of alternative model specification on the estimated effects of increasing precipitation (or temperature), it is necessary to consider more than the coefficient for the precipitation (or temperature) variable. This is because of the presence of an interaction variable which also measures the effect of increasing precipitation (or temperature). To obtain a true picture of the effects of increasing precipitation, it is necessary to consider the joint (or net) effect of the precipitation (or temperature) variable and the interaction variable.

Table 7-2.--Coefficients for weekly precipitation variables from the "nearly complete" equations

Week of growing season	Set of variables omitted[a/]					
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	T(291)	I(292)
	Pounds per acre per inch					
1	-486[b]	-686[b]	-634[a]	-397[c]	-550[a]	0.6
2	390[c]	207	472[b]	250	410[b]	14.4
3	301[c]	-073	529[a]	335[b]	577[a]	63.9[a]
4	-138	147	-148	-311[c]	-327[b]	9.5
5	192	006	205	274[c]	-272[b]	-21.3
6	-057	-35	-048	-004	-101	-30.6[b]
7	-505[b]	-829[a]	-550[b]	-359	-408[b]	22.5
8	212	666[b]	217	177	367[b]	-13.0
9	-327	-523[c]	-495[b]	-052	270	19.6
10	292	305	551	578[c]	123	22.7
11	254	130	203	153	212	50.7[a]
12	-238	-541	-237	-398	076	72.8[a]
13	-150	076	226	-073	251	9.8
14	-796[a]	-489	-829[a]	-910[a]	-410[c]	40.1[a]
15	-693[a]	-339	-260	-831[a]	-479[c]	29.8
16	-812[a]	-910[a]	-496[b]	-717[a]	-827[a]	73.4[a]
17	-815[a]	-291	-642[b]	-818[a]	-780[a]	-33.6
18	-193	092	174	-233	018	22.4
19	-080	-163	083	-176	-263	-19.1
20	105	001	-039	135	217[a]	77.9[a]
21	-027	-307	-090	198	204	-20.5
22	-223	-379	-072	-181	099	16.6
23	026	166	-258	123	-185	-73.0[b]

a/ Number in parentheses is equation number. M.C.I. = man-controlled inputs; C.R.D. = crop reporting district; Y = years; T = temperature; and I = interaction. Estimated using the corrected data.

Table 7-3.--Coefficients for weekly temperature variables from the "nearly complete" equations

Week of growing season	Set of variables omitted[a]					
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	P(289)	I(292)
	Pounds per acre per degree					
1	-0.10	-1.28	0.34	-0.32	0.18	0.13
2	1.46[b]	2.98[a]	0.73	0.72	0.19	0.18
3	-1.35[b]	-2.21[a]	-0.64	-1.20[b]	-2.27[a]	-2.12[a]
4	0.72	0.71	0.38	-0.17	0.93	0.83
5	1.19[b]	2.46[a]	1.30[b]	1.12[b]	1.12[b]	1.12[b]
6	-0.88	-2.24[b]	-1.64[b]	0.06	0.13	0.09
7	1.17[c]	0.44	0.83	1.26[c]	1.62[b]	1.57[b]
8	-1.79[a]	-0.37	-2.41[a]	-1.86[a]	-1.97[a]	-1.86[a]
9	-2.33[a]	-2.02[c]	-2.43[a]	-3.59[a]	-2.19[a]	-1.93[b]
10	-1.34[c]	0.15	-0.17	-0.93	-1.55[b]	-1.56[b]
11	-0.22	-0.44	-0.28	-0.44[c]	-0.48[b]	-0.45[c]
12	2.60[b]	-0.11	0.54	3.50[a]	2.42[a]	2.61[a]
13	-3.08[a]	-2.86[b]	-2.40[a]	-2.28[a]	-3.50[a]	-3.40[a]
14	-0.81	-1.38	-0.73	-0.85	0.30	0.25
15	-0.85	-0.06	-0.25	-0.93	0.08	0.21
16	2.53[a]	0.64	2.51[a]	3.51[a]	3.00[a]	3.00[a]
17	0.30	-1.62	0.40	-0.60	0.83	0.77
18	-0.82	0.43	-0.12	-0.89	-0.60	-0.48
19	1.87[a]	3.22[a]	1.99[a]	1.61[a]	1.78[a]	1.66[a]
20	0.25	-0.75	-0.99[b]	-0.07	0.42	0.53
21	-0.79	-2.17[a]	-0.44	-0.58	-0.45	-0.50
22	-1.53[b]	-2.48[b]	-1.34[c]	-1.04	-0.90	-1.01
23	-0.02	1.80[a]	-0.92[c]	-0.49	-0.53	-0.54

a/ Number in parentheses is equation number. Estimated using the corrected data.

Table 7-4.--Coefficients for weekly interaction variables[a/]

Week of growing season	Set of variables omitted						
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	P(289)	T(291)	P & T (290)
	Pounds per acre per unit						
1	0.89[b]	1.30[b]	1.13[a]	0.72[c]	.013	1.00[a]	.033
2	-0.67[c]	-0.29	-0.77[c]	-0.44	.019	-0.71[b]	.038
3	-0.44	0.30	-0.81[a]	-0.48	.114[a]	-0.92[a]	.122[a]
4	0.24	-0.21	0.26	0.53[c]	.016	0.52[b]	-.037
5	-0.36	-0.06	-0.36	-0.49[c]	-.040	-0.41[c]	-.047[c]
6	0.07	-0.08	0.08	-0.04	-.047[c]	0.15	-.030
7	0.85[b]	1.35[a]	0.95[a]	0.63[c]	.040	0.74[b]	.081[a]
8	-0.37	-1.14[a]	-0.38	-0.31	-.025	-0.60[b]	.004
9	0.54	0.98[c]	0.82[b]	0.09	.031	-0.40	.072[a]
10	-0.42	-0.46	-0.83	-0.84	.037	-0.16	.039
11	-0.33	-0.20	-0.24	-0.17	.078[a]	-0.28	.075[b]
12	0.46	0.91	0.43	0.73	.109[a]	-0.01	.123[a]
13	0.26	-0.14	-0.31	0.14	.019	-0.37	.042[b]
14	1.35[a]	0.87	1.41[a]	1.54[a]	.070[a]	0.73[b]	.058[a]
15	1.20[a]	0.53	0.53	1.46[a]	.057[b]	0.84[b]	.027
16	1.51[a]	1.61[a]	0.99[a]	1.36[a]	.127[a]	1.49[a]	.012
17	1.27[a]	0.40	1.04[b]	1.30[a]	-.045	1.19[a]	-.042
18	0.38	-0.10	-0.25	0.45	.040	0.04	.073[b]
19	0.07	0.22	-0.21	0.27	-.030	0.41	-.022
20	-0.08	0.09	0.21	-0.10	.150[a]	-0.24	.183[a]
21	0.01	0.46	0.11	-0.38	-.031	-0.40	-.014
22	0.39	0.64	0.13	0.31	.027	-0.17	.020
23	-0.22	-0.48	0.28	-0.36	-.132[b]	0.18	-.087[c]

a/ Estimated using corrected data. Corresponding equation numbers presented in first column of Tables 3-6 or 4-6.

The following procedure was used to estimate the net effect of one inch of precipitation: Net effect = (precipitation coefficient) + (interaction coefficient) X (average temperature).[1/] If the precipitation variables were omitted, the first part of the equation would be zero and the effect would be measured simply by taking the interaction coefficient multiplied by average temperature. If the interaction variables were omitted, the effect is simply the coefficient for precipitation. Similar statements hold for the net temperature effects.

The average total maximum temperature and the average precipitation for each week in the growing season, needed to estimate the net effects, are presented in Table 7-5.

The net effects for precipitation for some equations are presented in Table 7-6. The great change in the magnitude of the precipitation coefficients between the equation (292) not containing the interaction variable and equations containing the interaction variables apparent in Table 7-2 are not present in Table 7-6. Table 7-6 also contains estimates of the effect of precipitation for some equations not containing the precipitation variables. Although the estimated net effects of precipitation differ between the alternative equations, there is great consistency in direction (sign) and relative magnitude. In all cases, omitting a set of variables caused some net effects to change greatly and others to change very little. Also, the net effect for some weeks was greatly affected when some sets of variables were omitted, but affected very little when other sets were omitted. Except for this, very little of a general nature can be said concerning the effect of omitting sets of variables on the estimated net effect of precipitation.

1/ Note that this is simply the **partial deviation of yield** with respect to precipitation evaluated at the mean of temperature.

Table 7-5.--Average temperature and precipitation for each week in growing season

Week in growing season	Average total maximum temperature	Average precipitation
	Degrees F°	Inches
1	549	.787
2	577	.797
3	577	.815
4	600	.838
5	623	.706
6	633	.695
7	645	.560
8	638	.867
9	649	.672
10	644	.625
11	630	.510
12	648	.539
13	648	.808
14	639	.696
15	641	.579
16	642	.474
17	618	.355
18	617	.344
19	593	.448
20	566	.724
21	551	.499
22	546	.316
23	534	.173

The same general statement applies to the net effects of temperature. They are presented in Table 7-7. The major exception is that when the temperature and precipitation variables were omitted (equation 290), the sign and magnitude of the coefficients were greatly affected. This is due to the interaction variable having to explain with a single coefficient the effects of both temperature and precipitation. The precipitation effects dominate the determination of the sign and magnitude of the interaction coefficients (the signs are the same as for the net precipitation effects).

Table 7-6.--Net effects of one additional inch of precipitation--by weeks for several alternative equations[a]

Week in growing season	Set of variables omitted and equation number							
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	P_i(289)	T_i(291)	I_i(292)	T_i & P_i (290)
	Pounds per acre							
1	2.6	27.7	-13.6	-1.7	7.1	-1.0	0.6	18.1
2	3.4	39.7	27.7	-3.9	-11.0	0.3	14.4	21.9
3	47.1	100.1	61.6	58.0	65.8	46.2	63.9	70.4
4	6.0	21.0	8.0	7.0	9.6	-15.0	9.6	-22.2
5	-32.3	-31.4	-19.3	-31.3	-24.9	-16.6	-21.3	-29.3
6	-12.7	-15.6	2.6	-29.3	-29.8	-6.1	-30.6	-19.0
7	43.3	41.8	62.8	47.4	25.8	75.8	22.5	52.2
8	-24.1	-61.3	-25.4	-20.8	-16.0	-15.8	-13.0	2.6
9	23.5	113.0	37.2	6.4	20.1	10.4	19.6	46.7
10	21.5	8.8	16.5	37.0	23.8	20.0	22.7	25.1
11	46.1	4.0	51.8	45.9	49.1	35.6	50.7	47.3
12	60.1	48.7	41.6	75.0	70.6	69.5	72.8	79.7
13	18.5	-14.7	25.1	17.7	12.3	11.2	9.8	27.2
14	66.7	66.9	72.0	74.1	44.7	56.5	40.1	37.1
15	76.2	0.7	79.7	104.9	36.5	59.4	29.8	17.3

-Continued

Table 7-6.--Continued

Week in growing season	Set of variables omitted and equation number							
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	P_i(289)	T_i(291)	I_i(292)	T_i & P_i (290)
	Pounds per acre							
16	157.4	123.6	139.6	156.1	81.5	129.6	73.4	7.7
17	-30.1	-43.8	0.7	-14.6	-27.8	-44.6	-33.6	-26.0
18	41.5	30.3	19.8	44.7	24.7	42.7	22.4	45.0
19	-38.5	-32.5	-41.5	-15.9	-17.8	-19.9	-19.1	-13.0
20	59.7	52.9	79.9	78.4	84.9	81.2	77.9	103.6
21	-21.5	-53.5	-29.4	-11.4	-17.1	-16.4	-20.5	-7.7
22	-10.1	-29.6	-1.0	-11.7	14.7	6.2	16.6	10.9
23	-91.5	-90.3	-108.5	-69.2	-70.5	-88.9	-73.0	-46.5

a/ All equations estimated using corrected data. Number in parentheses is equation number. Net effect = $(b_{ip}) + (b_{iI}) \times (\overline{T}_i)$; where i refers to the week, b_{ip} is coefficient for precipitation variable in ith week, b_{iI} is coefficient for interaction variable in ith week and $\overline{T}_i$ is average of total weekly maximum temperature for ith week.

Table 7-7.--Net effects of one additional degree of temperature--by weeks for several alternative equations[a]

Week of growing season	Set of variables omitted and equation number							
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	P_i(289)	T_i(291)	I_i(292)	T_i & P_i (290)
	Pounds per acre							
1	0.60	-0.26	1.23	0.25	0.19	0.79	0.13	0.03
2	0.93	2.75	0.12	0.37	0.17	-.56	0.18	0.03
3	-1.71	-1.97	-1.30	-1.59	-2.18	-.75	-2.12	0.10
4	0.92	0.53	0.60	0.27	0.94	0.44	0.83	-0.03
5	0.94	2.42	1.05	0.77	1.09	0.29	1.12	-0.03
6	-0.83	-2.30	-1.60	0.32	0.10	0.10	0.09	-0.02
7	1.65	1.20	1.36	1.61	1.64	0.42	1.57	0.05
8	-2.11	-1.36	-2.74	-2.13	-1.99	-0.52	-1.86	0.01
9	-1.97	-1.36	-1.88	-3.53	-2.17	-0.27	-1.93	0.05
10	-1.60	-0.14	-0.69	-1.46	-1.53	-0.10	-1.56	0.02
11	-0.39	-0.54	-0.40	-0.53	-0.44	-0.14	-0.45	0.04
12	2.85	0.38	0.77	3.89	2.48	-0.01	2.61	0.07
13	-2.87	-2.97	-2.65	-2.17	-3.48	-0.30	-3.40	0.03
14	0.13	-0.77	0.25	0.22	0.35	0.51	0.25	0.04
15	-0.15	0.25	0.06	-0.08	0.11	0.49	0.21	0.16

-Continued

Table 7-7.--Continued

Week of growing season	Set of variables omitted and equation number							
	None (285)	M.C.I. (286)	C.R.D. (288)	Y(287)	P_i(289)	T_i(291)	I_i(292)	T_i & P_i (290)
	Pounds per acre							
16	3.25	1.40	2.98	4.15	3.06	0.71	3.00	0.01
17	0.75	-1.48	0.77	-0.14	0.81	0.42	0.77	-0.01
18	-0.69	0.40	-0.21	-0.74	-0.59	0.01	-0.48	0.03
19	1.90	3.32	1.90	1.73	1.77	0.18	1.66	-0.01
20	0.19	-0.68	-0.84	-0.14	0.53	-0.17	0.53	0.13
21	-0.79	-1.94	-0.39	-0.77	-0.47	-0.20	-0.50	-0.01
22	-1.41	-2.30	-1.30	-0.94	-0.89	-0.05	-1.01	0.01
23	-0.06	1.72	-0.87	-0.55	-0.55	0.03	-0.54	-0.02

a/ All equations estimated using corrected data. Number in parentheses is equation number. Net effect = $(b_{iT}) + (b_{iI}) \times (\bar{P}_i)$; where i is the week, b_{iT} is coefficient for temperature variable in ith week, b_{iI} is coefficient for interaction variable in ith week, and $\bar{P}_i$ is average precipitation in ith week.

Polynomial Weather Variables

Only polynomials of seventh degree will be considered in this section. Thus, eight coefficients were estimated for each weather factor. Because the coefficients were for transofrmed variables, they have no direct interpretation. The following discussion would have been more meaningful if the polynomial had been evaluated to obtain the weekly estimates. The weekly estimates then could have been used to obtain the net effects as was done in the previous section.

However, this was not done because the rounding error, particularly for weeks late in the season, was so large that it made meaningless the resulting estimates. This was because enough significant digits were not obtained for the coefficients for the higher order polynomial variables.[1/] Even though coefficients containing eight places after the decimal point were obtained, in many cases there were only two or three significant digits (for example, see Appendix B, Part 22). It was discovered, after the bulk of the analysis was done, that this was not sufficient to give meaningful weekly estimates. The discussion will necessarily be limited to the coefficients obtained for the polynomial variables.

Polynomial Precipitation Variables

Six equations were estimated using the corrected data and containing the polynomial precipitation variables. The coefficients obtained are presented in Table 7-8.

In all equations the coefficients are consistent in sign. Except for the equation omitting the interaction variables, the coefficients are

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1/ The coefficients for the "complete" polynomial were re-estimated to obtain additional significant digits. The results are discussed on pages 151 and 153.

Table 7-8.--Coefficients for polynomial precipitation variables a/

Set of variables omitted	Polynomial precipitation variables							
	R^0	R^1	R^2	R^3	R^4	R^5	R^6	R^7
None (294)	-3974[a]	5455[a]	-2326[a]	451[a]	-45.5[a]	2.47[a]	-.068[a]	.00075[a]
M.C.I.V.(295)	-4672[a]	6022[a]	-2565[a]	504[a]	-51.7[a]	2.86[a]	-.081[a]	.00092[a]
C.R.D.(296)	-4733[a]	6250[a]	-26.4[a]	500[a]	-49.9[a]	2.69[a]	-.074[a]	.00081[a]
Y(297)	-3559[a]	4811[a]	-2017[a]	387[a]	-38.7[a]	2.08[a]	-.057[a]	.00061[a]
T(300)	-3762[a]	4885[a]	-2065[a]	402[a]	-40.7[a]	2.22[a]	-.061[a]	.00068[a]
I(301)	-117[c]	227[a]	-106[a]	20.7[a]	-2.01[a]	.103[b]	-.0026[b]	.00003

a/ Estimated using corrected data.

consistent in level of significance (all being significant at the .01 level) and quite consistent in magnitude.

When the interaction variables were omitted, the magnitude and level of significance of the coefficients were affected. This was probably due to the high intercorrelation between precipitation and interaction variables (never less than .97). Adding the interaction variables to the equation containing the precipitation variables (obtaining the "complete" polynomial equation, 294) caused the coefficients for the precipitation variables to become larger (in absolute value) and to become significant at a higher level. This result is interesting because one of the "problems" generally associated with multicollinearity is that it is more difficult to show the significance of the coefficients of variables that are highly correlated.

With respect to the significance of the set of precipitation variables in the "complete polynomial" equation, it seems intuitively clear that if all the coefficients in a set are significant, the set would be significant.1/

1/ That is, the hypothesis: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$ would be rejected.

This was checked using the test discussed in Chapter IV, and an F value of 10.42 with 8 and 581 degrees of freedom was obtained. This set was significantly different from zero at .01 level.

Polynomial Temperature Variables

Coefficients were obtained in six equations estimated using the corrected data. The coefficients obtained are presented in Table 7-9.

In the "complete polynomial"1/ equation, all coefficients are significantly different from zero at the .05 or less level. Omitting the M.C.I.V. caused all the coefficients to increase (in absolute value) and all became significant at .01 level.

Omitting the crop reporting district variables resulted in coefficients only a little larger (in absolute value) than the coefficients obtained in the "complete polynomial" equation. The level of significance of the two highest order terms was reduced.

Only one of the coefficients was significant in the equation omitting the year variables. This means that if the effects of factors correlated with years were not taken into account, it was not possible to pick up (measure) the significant effects of temperature.

If the polynomial for either precipitation or interaction was omitted, the coefficients for the temperature polynomials were not significant.

In the "complete polynomial," the set of variables explained a significant amount of the variation in yield. Using the test discussed earlier, an F value of 3.16 was obtained. With 8 and 581 degrees of freedom, this is significant at the .05 level.

1/ Contains polynomial weather variables and with no set of variables omitted.

Table 7-9.--Coefficients for polynomial temperatures[a]

Set of variables omitted	Polynomial temperature variables							
	T^0	T^1	T^2	T^3	T^4	T^5	T^6	T^7
None(294)---------	-4.36[b]	7.17[a]	-3.20[a]	.636[a]	-.066[a]	.0037[a]	-.00011[a]	.0000001[a]
M.C.I.V.(295)----	-10.19[a]	15.04[a]	-6.83[a]	1.410[a]	-.152[a]	.0089[a]	-.00026[a]	.0000003[a]
C.R.D.(296)------	- 5.12[a]	7.70[a]	-3.39[a]	.659[a]	-.067[a]	.0037[a]	-.00011[b]	.0000001[b]
Y(297)-----------	-2.81	4.18[c]	-1.63	.276	-.024	.0011	-.00003	.00000003
P(298)-----------	1.01	-1.01	.43	-.090	.009	-.0005	.00001	-.00000001
I(301)-----------	.79	-.55	.19	-.037	.003	-.0001	.0000002	-.000000001

a/ Estimated using corrected data.

Polynomial Interaction Variables

Coefficients were obtained for the interaction polynomials in seven equations estimated using the corrected data. The coefficients obtained are presented in Table 7-10.

The coefficients were significantly different from zero at the .01 level in all equations containing polynomials for all three weather factors. When the precipitation polynomial variables were omitted, either alone or with the temperature polynomial variables, some coefficients were not significant and the magnitude of the coefficients was greatly reduced (in absolute value).

Omitting only the temperature polynomials did not greatly affect the magnitude or level of significance of the coefficients.

The set of interaction polynomial variables in the "complete polynomial" equation was significant at the .01 level. An F value of 9.61 was obtained with 8 and 581 degrees of freedom.

Temperature and Precipitation Polynomial Variables

A test was made to determine if the set of variables composed of the temperature and precipitation variables explained a significant amount of variation. Omitting these sets of variables from the "complete polynomial" equation significantly reduced variance explained. An F value of 6.43 with 16 and 581 degrees of freedom was obtained. Any F value greater than 2.75 is significant at the .01 level.

Season Total Weather Variables

Season Total Precipitation Variables

This variable is the sum total of precipitation that fell during the growing season and corresponds to the zero degree term in the

Table 7-10.--Coefficients for polynomial interaction variables[a]

Set of variables omitted	Polynomial interaction variables							
	I^0	I^1	I^2	I^3	I^4	I^5	I^6	I^7
None(294)	6.84[a]	-9.24[a]	3.91[a]	-.754[a]	.076[a]	.004[a]	.00011[a]	-.0000001[a]
M.C.I.V.(295)	7.97[a]	-10.00[a]	4.22[a]	-.823[a]	.084[a]	-.005[a]	.00013[a]	-.0000001[a]
C.R.D.(296)	8.11[a]	-10.60[a]	4.41[a]	-.842[a]	.084[a]	-.005[a]	.00012[a]	-.0000001[a]
Y(297)	6.07[a]	-8.04[a]	3.33[a]	-.636[a]	.063[a]	-.003[a]	.00009[a]	-.0000001[a]
P(298)	-.13	.30[b]	-.14[b]	.029[b]	-.003[b]	.0001[c]	-.0000003	.000000003
T(300)	6.46[a]	-8.28[a]	3.47[a]	-.672[a]	.068[a]	-.004[a]	.00001[a]	-.0000001[a]
T & P(299)	-.14	.29[b]	-.15[b]	.030[b]	-.003[b]	.0002[b]	-.0000004[b]	.000000005

a/ Estimated using corrected data.

precipitation polynomial. The coefficient gives the average effect on yield of one additional inch of precipitation regardless of when it falls during the growing season.

A coefficient was estimated in six equations using the corrected data. The coefficients obtained are presented in the first column of Table 7-11.

The coefficient is only significant when the interaction variable or the year variables are omitted. The interaction variable and the precipitation variable have a simple correlation of .992, which explains why its presence caused the precipitation coefficient to become insignificant. However, the <u>net</u> effect of one inch of precipitation based on the "complete season total" equation (equation 302) and assuming average temperature, was 25.43 pounds per acre or nearly the same as the 24.82 obtained when the interaction term was omitted (see Table 7-11). In fact, omitting any of the sets of weather variables had very little effect on the net effect of one inch of precipitation.

Omitting the M.C.I.V. or the crop reporting district variables caused the net effect to decrease about 20 percent. The season total precipitation variables explained a large amount of the variation in yield between years unless that variation was explained by year variables.

Season Total Temperature Variables

This variable is the sum over all the days in the growing season of the daily maximum temperature. Its coefficient indicates how much yield would increase as a result of a one-degree increase in the season total maximum temperature. The coefficient is significant in all equations presented in Table 7-11. The sign is always negative, indicating that on the average, higher temperatures decrease yields.

Table 7-11.--Coefficients for season total weather variables[a]

Set of variables omitted	Coefficients for season total weather variables			Net effects of a one-unit increase in--	
	Precipitation	Temperature	Interaction	Precipitation[b]	Temperature[c]
	Pounds per acre[d]				
None (302)	-5.74	-.1367[b]	.05118	25.43	-.1059
M.C.I.V. (307)	-52.19	-.2424[a]	.11794[c]	19.40	-.1715
C.R.D. (300)	-5.03	-.2629[a]	.04215	20.57	-.2377
Years (309)	99.45[a]	-.1934[a]	-.10819[b]	33.78	-.2584
Precipitation (305)		-.1310[a]	.0417[a]	25.32	-.1059
Temperature (304)	35.68		-.01509	26.52	-.0907
Interaction (303)	24.82[a]	-.1072[b]		24.82	-.1072
Temperature and precipitation (306)			.04457[a]	27.05	.2679

a/ Estimated using corrected data. Corresponding equation numbers are listed in Tables 3-6 or 4-6.

b/ Based on average weekly total temperature of 609 degrees.

c/ Based on average weekly precipitation of .601 inches.

d/ Pounds per acre per unit of the independent variable.

The net effect is also negative except when both the precipitation and temperature variables were omitted. This is probably due to the fact that a single coefficient (for the interaction variable) had to measure the effect of a one-unit increase in precipitation and temperature. The effect of precipitation clearly dominated.

The net effect of temperature relative to the "complete season total" equation (equation 302) was not greatly affected by omitting any single weather variable. However, omitting the M.C.I.V., the district variables or the years variables caused the net effect to increase (in absolute value) greatly. Thus, the importance of temperature differentials in "explaining" yield differences was greater when the effects of location, years, or M.C.I.V. were not taken into account.

Weekly Estimates from Alternative Sets of Weather Variables

It was possible, regardless of the form of the weather variables, to obtain estimates of the effect of changes in a weather factor in any week on yields. When the weekly variables were included, their coefficients were the estimated effects. When season total variables were included, their estimated effect was their coefficient and was constant for the entire growing season. When polynomial weather variables were included, it was necessary to evaluate the resulting polynomial for each week of the growing season.

It is of interest to compare these alternative estimates. The results discussed here are limited to three equations (equations 292, 303, and 301) estimated using the corrected data and differing only by the form of the weather variables. Equations were selected which did not contain the interaction terms to simplify the comparisons. All equations selected contained the seven M.C.I.V., the crop reporting district variables, the time variables, and the preseason precipitation variable.

The effects from the weekly and season total variables were the coefficients and are presented in Table 7-12. The weekly estimates from the polynomial variables are also presented in Table 7-12.

It was discovered when trying to evaluate the temperature polynomial for the weekly effects that the eight digits after the decimal obtained for each polynomial variable <u>were</u> <u>not</u> sufficiently accurate.[1/] The basic temperature data was transformed (inputed as thousands of degrees instead of degrees) and the equation re-estimated. The resulting temperature and precipitation coefficients are presented in Table 7-13.

To obtain the weekly precipitation estimates, the first column vector was multiplied successively with the rows in the matrix presented in Appendix C. In effect, it is taking the number of the week raised to the degree of the variable and then multiplied by the corresponding coefficient. For example, to obtain the weekly precipitation estimate for the third week we have: $(-117.04644798)\ (3^0) + (227.15416386)\ (3^1) + (-105.09337465)\ (3^2) + \ldots + (0.00002617)\ (3^7) = 63.9$ (see Table 7-12). The same procedure is used for the temperature estimates.

To facilitate the comparisons, the coefficients from the three techniques (and presented in Table 7-12) are presented in Figure 7-1 and 7-2.

Let's consider precipitation first. The season total estimate is not a function of time (within the growing season). There is no direct relationship between the 23 within-season estimates from either the weekly or polynomial techniques and the season total technique. It is worth noting, however, the average effect of one additional inch of precipitation

1/ None of the coefficients presented in Appendix B for the higher order polynomial terms are accurate enough to derive meaningful weekly estimates.

Table 7-12.--Weekly estimates of effects of a unit increase in precipitation or temperature from models including weekly or seventh degree polynomial variables[a]

Week of growing season	Yield increase for a one-inch increase in precipitation			Yield increase for a one-degree increase in temperature		
	Weekly	Polynomial	Season	Weekly	Polynomial	Season
	Pounds per acre					
1	0.6	23.0	24.8	0.13	0.40	-0.11
2	14.4	50.3	24.8	0.19	0.23	-0.11
3	63.9	30.6	24.8	-2.13	0.15	-0.11
4	9.5	2.2	24.8	0.83	0.09	-0.11
5	-21.3	-16.2	24.8	1.12	0.01	-0.11
6	-30.6	-18.9	24.8	0.09	-0.07	-0.11
7	22.5	-7.8	24.8	1.57	-0.17	-0.11
8	-13.0	11.2	24.8	-1.86	-0.26	-0.11
9	19.6	31.5	24.8	-1.93	-0.32	-0.11
10	22.7	47.4	24.8	-1.56	-0.34	-0.11
11	50.7	55.4	24.8	-0.45	-0.31	-0.11
12	72.8	54.5	24.8	2.61	-0.23	-0.11
13	9.8	46.2	24.8	-3.40	-0.11	-0.11
14	40.1	33.8	24.8	0.25	0.02	-0.11
15	29.8	21.4	24.8	0.21	0.15	-0.11
16	73.4	12.9	24.8	3.00	0.24	-0.11
17	-33.6	11.4	24.8	0.77	0.26	-0.11
18	22.4	17.2	24.8	-0.48	0.18	-0.11
19	-19.1	28.0	24.8	1.66	0.03	-0.11
20	77.9	38.0	24.8	0.53	-0.20	-0.11
21	-20.5	38.0	24.8	-0.50	-0.46	-0.11
22	16.6	16.4	24.8	-1.01	-0.63	-0.11
23	-73.0	-39.8	24.8	-0.54	-0.57	-0.11

a/ Estimated using corrected data.

Table 7-13.--Coefficients for precipitation and temperature polynomial variables, equation 301

Degree of variable	Coefficients	
	Precipitation polynomial	Temperature polynomial
0	-117.04644798	0.78974512655
1st	227.15416386	-0.54797708289
2nd	-105.90337465	0.19485726587
3rd	20.71714078	-0.03674830948
4th	-2.01418461	0.00335175379
5th	0.10260923	-0.00014217109
6th	-0.00261471	0.00000236237
7th	0.00002617	-0.00000000509

is 24.8 pounds per acre for the season total estimate, 21.16 pounds per acre (simple average of the 23 polynomial estimates) for the polynomial estimates, and 14.59 pounds per acre (simple average of the 23 weekly estimates) for the weekly estimates.

The estimates from the weekly and polynomial techniques make a similar pattern (see Figure 7-1). They show that additional precipitation (above average) during the time the plants are seedlings and during the harvesting season decreased yields. Additional precipitation during the planting season[1] and during most of the growing season increased yields. The maximum effect was obtained by additional precipitation about the time the plant was in bloom.

Although the estimates "tend" to make the same pattern, there are some major discrepancies. As expected, the estimates from the weekly

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1/ Of course, this may decrease acres planted.

Figure 7-1.--Estimated effects of precipitation--for a one-inch increase in weekly total--alternative techniques

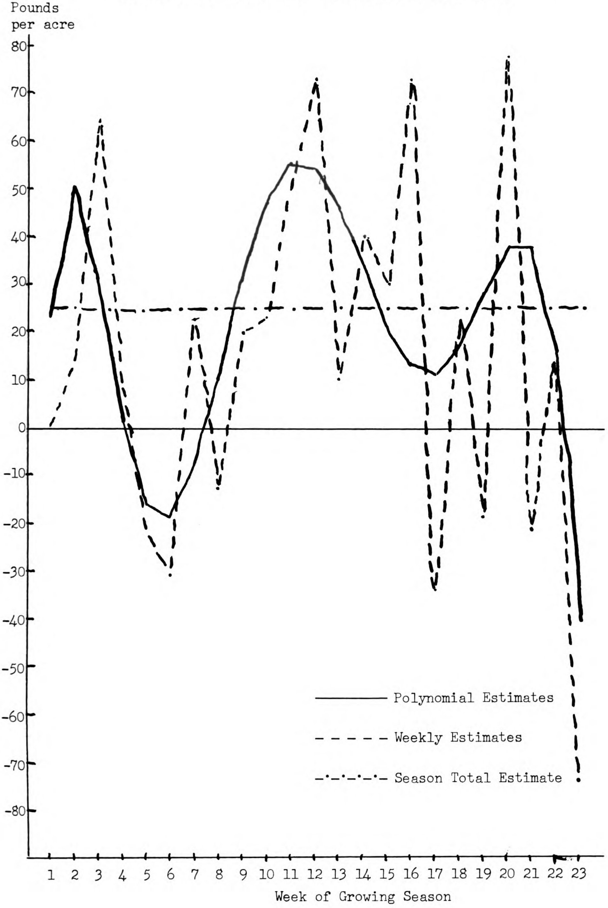
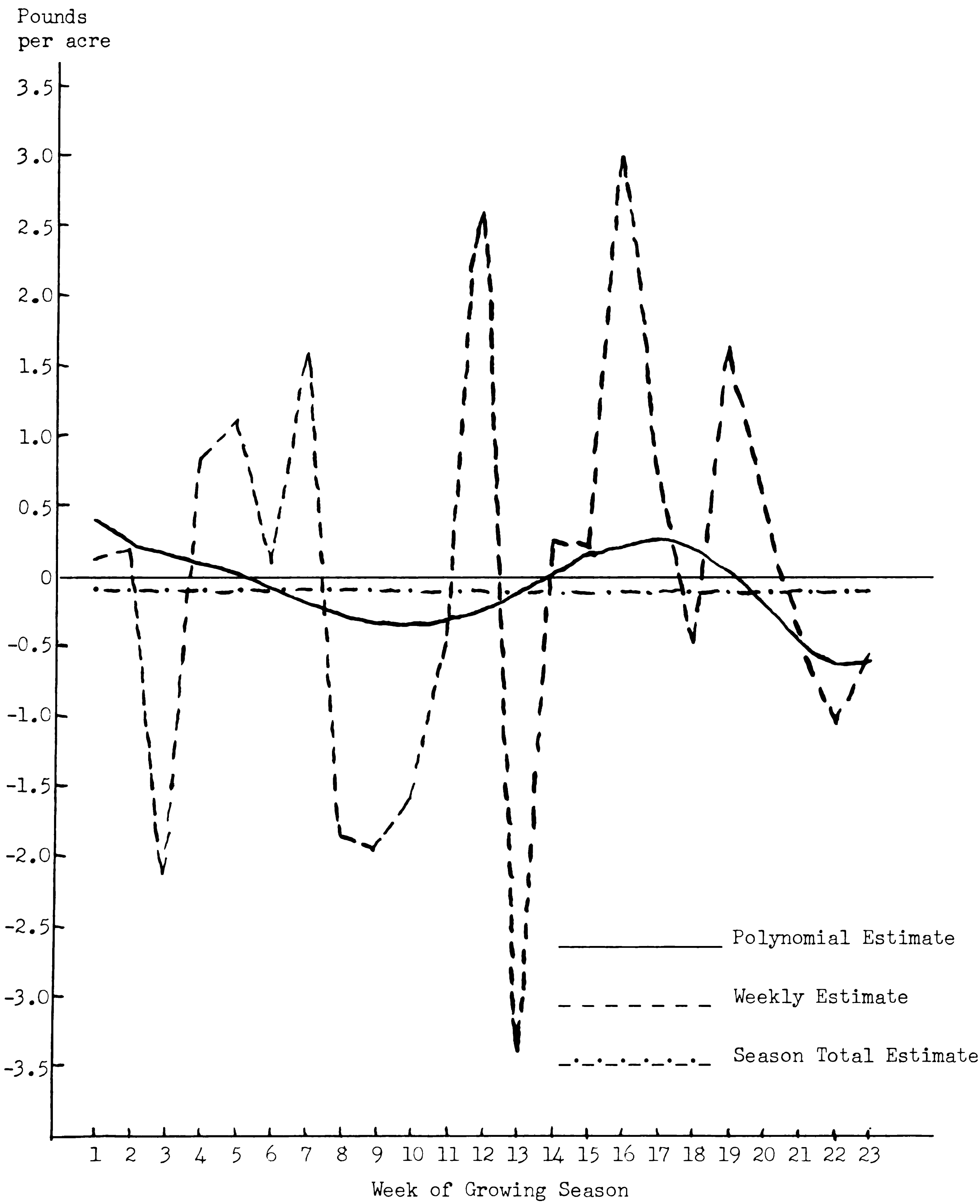


Figure 7-2.--Estimated effects of temperature--for a one-degree increase in weekly total--alternative techniques



techniques were more extreme and changed (difference in estimates for consecutive weeks) more rapidly than those from the polynomial technique.

The same general conclusions can be made about the temperature estimates (see Figure 7-2). However, the pattern made by the weekly estimates is only vaguely related to the pattern made by the polynomial estimates. The patterns indicate that above average temperatures during the planting season and during grain development caused yields to increase. Above average temperature during plant growth from seedling until after blooming and during the harvesting season decreased yields. These results agree with our a priori knowledge concerning the effects of temperature on yields.

The reasons why the weekly estimates deviate from the polynomial estimates and why the deviations are so much greater for the temperature estimates than the precipitation estimates need further consideration. The principal reason for the discrepancies was intercorrelation among the weather variables.

Consider the precipitation variables. Most of the simple correlations of a precipitation variable in one week and the precipitation variable in either the preceding or following week were very low, less than 0.01. However, the correlation between the 12th and 13th week (where a major shift in the size of the coefficient occurred) is .209. Similarly, for the 15th and 16th weeks the simple correlation was .206; 16th and 17th weeks, .186; 19th and 20th weeks, .501. These higher intercorrelations correspond to the major discrepancies between the weekly and polynomial estimates (see Figure 7-1). There is a very positive relationship between the size of the simple correlation coefficient and the extent of the discrepancies between the polynomial and weekly estimate. It is surprising that such low intercorrelations would have this effect.

When it is realized that the simple correlations of a temperature variable with the temperature variables in the preceding or following period were high (as high as .857), it is not difficult to understand the discrepancies between the temperature polynomial estimates and the weekly estimates.

The intercorrelations among the weekly precipitation variables or the weekly temperature variables do not affect the coefficients estimated for the polynomials. One of the principal advantages of the polynomial technique is that it does take into account the preceding and following weather values in "estimating"1/ the effect for a particular week.

Conclusions

There are several advantages of using a polynomial to estimate the effects of weather during the growing season, as compared to the weekly variable technique.

(a) It uses fewer degrees of freedom, in this case using only 24, while the weekly variable techniques used 69.

(b) It takes into account the preceding and following weather values in "estimating" the effects for a particular week.

(c) The resulting estimates are more meaningful and are consistent with a priori knowledge that the effects of a weather factor should change slowly from one week to the next.

There are also disadvantages of the polynomial technique (advantages in using the weekly variable technique).

1/ The technique does not estimate the effect for a particular week directly, rather the weekly effect must be derived from the estimated coefficients for the polynomial.

(a) The weekly variable technique results in a higher $\bar{R}^2$. If the weather coefficients are of no particular interest, it may be more valuable to obtain a higher $\bar{R}^2$.

(b) There are additional data transformations required for the polynomial technique. Of course, these can be done within the computer as was done in this study.

(c) More likely to accurately measure particularly critical week (no smoothing) if degrees of freedom are large.

The advantages of the season total technique are: (1) It has simple data requirements, and (2) it uses very few degrees of freedom. The disadvantages are: (1) It produces a lower $\bar{R}^2$, and (2) its coefficient ignores the timeliness or distribution of the weather factors.

The Polynomial Models

No information existed on which to base an a priori hypothesis concerning the "best" degree of polynomial to include. Many trial equations were estimated in an attempt to resolve this. How $\bar{R}^2$ changes as the degree of the polynomial was varied is discussed. The discussion is necessarily limited to equations estimated using the incorrect data.

Precipitation Polynomials

Five sets of precipitation polynomials were estimated. A set contains a polynomial for each degree, zero through seven. Each set was estimated with different "other" variables included. The resulting $\bar{R}^2$'s are presented in Table 7-14. In all cases, the seventh degree precipitation polynomial did "better" than polynomials of lower degrees. Here "better" simply refers to magnitude of $\bar{R}^2$. The fact that $\bar{R}^2$ increases as degree terms are added indicates that the gain in increased variation explained is greater than the loss due to decreasing degrees of freedom.

Table 7-14.--$\bar{R}^2$ for models containing precipitation polynomials of varying degrees[a]

Other variables included	Degree of precipitation polynomials[b]							
	0	1	2	3	4	5	6	7
	$\bar{R}^2$							
P	.112 (213)	.134 (214)	.133 (215)	.134 (216)	.139 (217)	.149 (218)	.161 (219)	.172 (220)
M,P	.613 (212)	.622 (211)	.626 (210)	.626 (209)	.627 (208)	.628 (207)	.632 (206)	.638 (205)
C,Y,P	.555 (36)	.558 (37)	.559 (38)	.561 (39)	.561 (40)	.562 (41)	.569 (42)	.571 (43)
M,C,Y,P	.725 (33)	.725 (32)	.727 (31)	.728 (30)	.729 (29)	.730 (28)	.737 (27)	.738 (26)
M,T^{07}	.660 (178)	.662 (177)	.668 (176)	.670 (175)	.671 (174)	.670 (173)	.678 (172)	.684 (171)

a/ Symbols used are listed in Chapter III. Estimated using the incorrect data.

b/ Number in parentheses is equation number.

It is interesting to observe the pattern presented by the coefficients in equations 213-220 (Table 7-15). With the only other variable in the model being the preseason precipitation variable, consecutive terms of the precipitation polynomial were added. In the first two equations, the highest degree term (zero degree and first degree respectively) were significantly different from zero at .01 level. In the next two equations, no coefficients were significant. Beginning with the fifth and the sixth equations, some of the higher order terms became significant. In the seventh and eighth equations all coefficients are significant. All were significant at $\alpha < .01$ in the last equation.

The above investigation considered the coefficients for the precipitation polynomial without taking into account the effect of temperature and

Table 7-12.--Precipitation polynomial coefficients from selected counties

Table 7-15.--Precipitation polynomial, coefficients from selected equations

Equation number	Other variables	R^0	R^1	R^2	R^3	R^4	R^5	R^6	R^7
213	P	33.6[a]							
214	P	-10.1	3.88[a]						
215	P	-5.05	2.58	.058					
216	P	21.0	-9.50	1.35	-.038				
217	P	-41.3	34.3	-6.69[c]	.490[b]	-.011[b]			
218	P	62.2	-59	18.1[c]	-2.17[b]	.112[b]	-.002[a]		
219	P	135[c]	174[b]	-67.2[b]	11.4[a]	-.939[a]	.037[a]	-.0005[a]	
220	P	-390[a]	537[a]	-235[a]	47[a]	-4.87[a]	.27[a]	-.008[a]	.00009[a]
141	P, T^0, I^0	134[a]							
144	P, T^{0-1}, I^{0-1}	-289[a]	29.3[a]						
147	P, T^{0-2}, I^{0-2}	97	-7917[c]	4.6[c]					
150	P, T^{0-3}, I^{0-3}	297	-148	9.8	-.117				
153	P, T^{0-4}, I^{0-4}	-1042[b]	677[a]	-130[a]	8.5[a]	-.178[a]			
156	P, T^{0-5}, I^{0-5}	-292	46.8	37.8	-9.2	.613	-.013		
159	P, T^{0-6}, I^{0-6}	-2789[a]	2864[a]	-1018[a]	164[a]	-13[a]	.491[a]	-.007[a]	

interaction variables. Every third equation beginning with equation 141 and extending through equation 162 (see Table 7-15) gives the coefficient for the precipitation polynomial when polynomials of the same degree for temperature and interaction are present. Considering the levels of significance of the coefficients, the pattern is much different than when temperature and interactions effects were not considered.

None of the coefficients in the polynomial of third or fifth degree are significant. The coefficients for the last two terms of the seventh degree polynomial are not significant. On the other hand, all the coefficients in the fourth and sixth degree polynomials are significant and all but one at the $\alpha < .01$ level.

The fact that this pattern exists raises some interesting problems. For example, if we drew our conclusions about the effect of introducing polynomials of equal degree in temperature and interaction on the coefficients of the precipitation variables, based on the fifth degree polynomial, we would conclude that the effect was to make the coefficients insignificant. If based on the sixth degree polynomial, the effect was to make the coefficients more significant. If based on the seventh degree, the effect was to make some coefficients less significant and some insignificant. In all cases the magnitude of coefficients was greatly affected.

Because the $\bar{R}^2$ in all equations containing the seventh degree polynomial was higher than in any comparable equation containing a polynomial of lower degree, it was decided to include a polynomial for precipitation of seventh degree in the "nearly complete" equation.

Temperature Polynomials

Five sets of temperature polynomials were estimated. The resulting $\bar{R}^2$'s are presented in Table 7-16.

Table 7-16.--$\bar{R}^2$ for models containing temperature polynomials of varying degrees[a]

Other variables included	Degree of temperature polynomials[b]							
	0	1	2	3	4	5	6	7
	$\bar{R}^2$							
P,R^{07}	.244 (202)	.257 (201)	.255 (200)	.266 (199)	.266 (198)	.295 (197)	.316 (196)	.315 (195)
M, P,R^{07}	.669 (194)	.674 (193)	.674 (192)	.687 (191)	.688 (190)	.691 (189)	.691 (188)	.691 (187)
C,Y,P,R^{07}	.573 (44)	.574 (45)	.575 (46)	.575 (47)	.575 (48)	.575 (49)	.575 (50)	.583 (11)
M,C,Y,P,R^{07}	.738 (25)	.738 (24)	.738 (23)	.740 (22)	.740 (21)	.740 (20)	.739 (19)	.740 (18)
M	.613 (186)	.618 (185)	.618 (184)	.620 (183)	.632 (182)	.635 (181)	.635 (180)	.635 (179)

a/ Symbols used are listed in Chapter III.

b/ Number in parentheses is equation number.

The results for the temperature polynomials were quite different from the results of the precipitation polynomial. There is no consistent pattern. The $\bar{R}^2$ for equations containing the seventh degree temperature polynomial in one case is higher, in one case lower, and in three cases the same as the $\bar{R}^2$ for equations with lower degree polynomials.

The pattern made by the coefficients in equations 195-202 is interesting (see Table 7-17). When only the zero degree term or the zero and first degree term are included, all coefficients are significant. However, where the second degree term is added, only the coefficient of the zero degree term is significant. The addition of the third degree term makes all coefficients significant again. The fourth degree term causes the coefficient for the two highest degree terms to become insignificant.

Table 7-17.--Temperature polynomial, coefficients from selected equations

Equation number	Other variables	T^0	T^1	T^2	T^3	T^4	T^5	T^6	T^7
202	P,R^i	-.377[a]							
201	P,R^i	-.70[a]	.022[a]						
200	P,R^i	-.773[a]	.037	-.0006					
199	P,R^i	1.24[c]	-.846[a]	.089[a]	-.002[a]				
198	P,R^i	1.34[c]	-.919[b]	.102[c]	-.003	.00002			
197	P,R^i	-3.35[a]	3.37[a]	-.976[a]	.108[a]	-.005[a]	.00008[a]		
196	P,R^i	-8.82[a]	10.1[a]	-3.42[a]	.483[a]	-.003[a]	.001[a]	-.00001[a]	
195	P,R^i	-10.6[a]	12.5[a]	-4.48[a]	.703[b]	-.057	.002	-.00006	.0000005
141	P,R^0,I^0	-.309[a]							
144	P,R^{0-1},I^{0-1}	-.893[a]	.037[a]						
147	P,R^{0-2},I^{0-2}	-.796[b]	-.004	.002					
150	P,R^{0-3},I^{0-3}	1.2	-.879[a]	.090[a]	-.002[a]				
153	P,R^{0-4},I^{0-4}	.05	-.215	-.013	.003	-.0001			
156	P,R^{0-5},I^{0-5}	-2.7[a]	2.4[a]	-.677[b]	.073[a]	-.003[a]	.0001[a]		
159	P,R^{0-6},I^{0-6}	-10.3[a]	11.7[a]	-4.0[a]	.579[a]	-.041[a]	.001[a]	-.00002[a]	
161	P,R^i,I^i	-13.5[a]	16.5[a]	-6.29[a]	1.07[a]	-.094[b]	.005[b]	-.0001[c]	.000001
2	$C,Y,Te(L),P,R^i,I^i$	-5.9[b]	9.4[a]	-4.2[a]	.832[a]	-.086[a]	.005[a]	-.0001[a]	.0000002[a]
11	C,Y,P,R^i	-7.6[a]	11.4[a]	-5.2[a]	1.1[a]	-.117[a]	.007[a]	-.0003[a]	.0000002[a]
16	$C,Y,Te(L),P,R^i$	-1.5	2.8	-1.3	.254	-.027	.002	-.00004	.0000001

Adding the fifth degree term makes them all significant again. The sixth degree term affects the magnitude, but not the levels of significance. The coefficients for the four highest degree terms are significant when the seventh degree term is added. One can only wonder if an eighth degree term were added.

The above results are from a submodel which has other than the temperature variable only the precipitation polynomial (of seventh degree) and preseason precipitation variables. When the remaining variables are added, the coefficients of all terms in the temperature polynomial are significant (see equation 2, Table 7-17).

The second set of equations presented in Table 7-17 shows how the coefficients for the temperature polynomials are affected by adding the next highest degree term to each of the weather polynomials. It is interesting to note that none of the coefficients of the fourth degree temperature polynomial are significant. All are significant in the fifth and sixth degree polynomial and all but the highest order term in the seventh.

It is interesting to note that when the M.C.I.V. and the interaction polynomial variables were omitted (equation 11, Table 7-17), all the temperature polynomial coefficients were significant at the .01 level. When the M.C.I.V. were added all the coefficients were not significant. Adding, in turn, the interaction polynomial variable (equation 2) caused all the coefficients to again be significant.

In any case, all coefficients were significant in equation 2 and on this basis it was decided to include the seventh degree polynomial for temperature in the "nearly complete" equation.

Interaction Polynomials

Only one set of interaction polynomials was estimated. The $\bar{R}^2$'s are presented in Table 7-18, and the coefficients in Table 7-19.

Table 7-18.--$\bar{R}^2$ for equations containing interaction polynomials of varying degrees[a]

Other variables included	Degree of interaction polynomial[b]							
	I^0	I^1	I^2	I^3	I^4	I^5	I^6	I^7
	$\bar{R}^2$							
P,R^i,T^i	.315 (168)	.315 (167)	.317 (166)	.318 (165)	.319 (164)	.321 (163)	.339 (162)	.339 (161)

a/ Symbols used are listed in Chapter III.

b/ Number in parentheses is equation number.

The $\bar{R}^2$ increased or stayed the same as additional terms were added.

The pattern of coefficients when only other weather variables were included is interesting. With two exceptions, all the coefficients in the fifth or lower degree polynomials were not significant. Most of the coefficients in the sixth and seventh degree polynomials were significant.

However, if instead of seventh degree precipitation and temperature polynomials, polynomials of the same degree for all three weather factors were included (equations 141-161, Table 7-19), more interaction coefficients were significant. In the zero and first degree polynomials, all the coefficients were significant. Two of the three coefficients in the second degree polynomial were significant. In the third and fifth degree polynomials, none of the coefficients were significant. All the coefficients in the fourth and sixth equations were significant. Seven of the eight coefficients in the seventh degree polynomial were significant.

Table 7-19.--Interaction polynomial, coefficients from selected equations

Equation number	Other variables	I^0	I^1	I^2	I^3	I^4	I^5	I^6	I^7
168	P,R^i,T^i	.083							
167	P,R^i,T^i	.277	-.015						
166	P,R^i,T^i	-.354	.128	-.006[c]					
165	P,R^i,T^i	.191	-.122	.020	-.001				
164	P,R^i,T^i	1.1	-.666	.112[c]	-.006	.001			
163	P,R^i,T^i	-.372	.679	-.240	.031	-.002	-.00003		
162	P,R^i,T^i	5.7[b]	-6.4[b]	2.5[b]	-.460[b]	.043[c]	-.002	.0001	
161	P,R^i,T^i	4.1[b]	-4.3[a]	1.56[a]	-.258[a]	.021[a]	-.0008[a]	.00002[a]	-.00000005
141	P,R^0,T^0	-.205[b]							
144	P,R^{0-1},T^{0-1}	.479[a]	-.047[a]						
147	P,R^{0-2},T^{0-2}	-.182	.136[c]	-.008[a]					
150	P,R^{0-3},T^{0-3}	-.462	.22	-.013	.001				
153	P,R^{0-4},T^{0-4}	1.9[b]	-1.2[a]	.225[a]	-.015[a]	.0003[a]			
156	P,R^{0-5},T^{0-5}	.557	-.077	-.071	.017	-.001	.00002		
159	P,R^{0-6},T^{0-6}	4.8[a]	-4.7[a]	1.7[a]	-.265[a]	.021[a]	-.001[a]	.00001[a]	
131	$Te(L),P,R^i,T^i$	6.6[a]	-8.5[a]	3.5[a]	-.649[a]	.064[a]	-.003[a]	.0001[a]	-.0000001[a]
8	C,P,R^i,T^i	6.7[a]	-7.5[a]	2.9[a]	-.538[b]	.053[b]	-.003[b]	.0001[c]	-.0000001[c]
99	Y,P,R^i,T^i	8.0[a]	-10.1[a]	4.3[a]	-.855[a]	.087[a]	-.005[a]	.0001[a]	-.0000001[a]
2	$C,Y,Te(L),P,R^i,T^i$	7.0[a]	-9.4[a]	4.0[a]	-.785[a]	.080[a]	-.004[a]	.0001[a]	-.0000001[a]

When non-weather variables were included in the equation, all coefficients in the seventh degree polynomial were significant (see equations 2, 8, 99, and 131, Table 7-19). On this basis, it was decided to include a seventh degree polynomial for the interaction variables in the "nearly complete" equation.

Conclusion

Many combinations of weather polynomials were considered. It was concluded that a polynomial of the seventh degree in each of the weather factors (temperature, precipitation, and interaction) would be included in the "nearly complete" equations. Polynomials of degree higher than seven were not considered.

The coefficients for polynomial variables changed as the power of the polynomial was increased. However, the net effect of such changes may have been very small.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

There were two principal objectives in this study. The first was to estimate how changes in inputs have affected yield, and the second was to determine the effect of specifying alternative models.

A single equation model was developed. The parameters were estimated by least squares regression analysis. The dependent variable was yield of grain sorghum per acre. There were 645 observations--observations on 129 counties in each of the agricultural census years, 1939-1959. Three kinds of independent variable were included--man-controlled input variables, dummy (0, 1) variables, and weather variables.

The seven man-controlled input variables were: (1) Percent of grain sorghum acreage irrigated, (2) dollars spent on gas and oil per acre of cropland harvested, (3) pounds of fertilizer nutrients applied per acre of grain sorghum, (4) ratio of acres fallowed to acres of cropland harvested, (5) average acres of grain sorghum per farm harvesting grain sorghum, (6) number of tractors per acre of cropland harvested, and (7) per acre value of land (to measure the interaction effects of land with technology).

Two sets of dummy (0, 1) variables were included--27 variables to represent the crop reporting districts and four variables to represent years.

Four sets of weather variables were included: (1) Preseason precipitation, (2) season precipitation, (3) season temperature, and (4) season interaction (temperature times precipitation). Three forms of the season weather variables were considered in detail: (a) A weather variable for each week of the 23-week growing season for each weather factor, (b) a polynomial of seventh degree (8 variables) for each weather factor, and (c) a season total variable for each weather factor.

Also considered but in less detail were: (1) Man-hours of labor per acre of grain sorghum, (2) a set of seven dummy variables to represent different climatic regions (based on average planting date), and (3) season weather polynomials of degrees two through six.

Results

Estimates of the effect on unweighted average yield of changes in the level of inputs were obtained from the "complete" equation. This equation as specified a priori contained the seven man-controlled input variables, the 27 dummy variables for crop reporting districts, the 4 dummy variables for years, the preseason precipitation variable, the 23 season precipitation variables (one for each week), the 23 season temperature variables, and the 23 season interaction variables.

On the basis of this equation it was estimated that of the 1,146-pound[1/] per acre increase in yield between 1939 and 1959, 27.4 percent was explained by changes in the level of the explicit man-controlled inputs, 46.1 percent by changes in the level of implicit man-controlled inputs, and 26.5 percent by changes in weather.

1/ This is unweighted average yield. The other effects were also estimated using unweighted averages of the explanatory variables for each year.

Of the increase due to changes in explicit man-controlled inputs, almost all is due to changes in two inputs, fertilizer and irrigation and their interaction with land (value of land). Changes in weather <u>during</u> the growing season accounted for 85.4 percent of the total weather effects. It is important to note that the implicit (unquantified) man-controlled inputs (as measured by the dummy year variables) were 60 percent more important in explaining yield changes than the explicit man-controlled inputs. Shifts in the location of production, 1939 to 1959, caused average yield to increase 50 pounds.

The second objective can be broken down into these four sub-objectives: (1) What is the effect on $\bar{R}^2$ of omitting sets of variables from the "complete" model, (2) what is the effect on $\bar{R}^2$ of representing factors in alternative ways, (3) what is the effect on the coefficients of variables in the model when sets of variables are omitted, and (4) what is the effect on the coefficients of representing some factors in alternative ways.

A set of 24 equations was used for the most part to meet these objectives. This set of "nearly complete" equations includes the "complete" equation described above. Seven equations were obtained from the "complete" equation by omitting respectively the following sets of variables: (1) Man-controlled input variables, (2) crop reporting district (dummy) variables, (3) year (dummy) variables, (4) weekly season precipitation variables, (5) weekly season temperature variables, (6) weekly season interaction variables, and (7) weekly season precipitation and temperature variables.

The "complete" equation was then modified by substituting the polynomial weather variables for the weekly weather variable. The seven sets of variables listed above were omitted in turn from this modified equation. This gave eight additional equations. Season total weather variables were then substituted for the weekly weather variables. The seven sets of variables were again deleted in turn.

With respect to the first sub-objective, omitting any set caused the $\bar{R}^2$ to decrease significantly. The largest effect was obtained by omitting the man-controlled input variables which caused $\bar{R}^2$ to decrease from .8548 to .7094 (17 percent). The effect on $\bar{R}^2$ of substituting a polynomial of seventh degree in each weather factor for the weekly variables was to reduce $\bar{R}^2$ from .8548 to .8213 (4 percent). Substituting in the season total variables caused $\bar{R}^2$ to decrease from .8548 to .7861 (29 percent). The largest effect of omitting a set of variables <u>and</u> substituting in a set of weather variables was obtained by omitting the man-controlled input variables <u>and</u> substituting in the season total variables and resulted in an $\bar{R}^2$ of .609.

With respect to the third and fourth sub-objective, the results were too diversified and extensive to allow a simple summary. As expected, the magnitude of the coefficients was affected in almost all cases. In many cases the sign and level of significance were also affected. For some variables, it would have been possible, under different model specification to have the coefficient test (1) not significantly different from zero, (2) significantly less than zero, and (3) significantly greater than zero. The effect of omitting a set of variables on the coefficients of variables remaining in the model was reduced as the number of other variables remaining in the model was increased.

Other Conclusions

Although not the principal objectives, there are several aspects of the study that warrent attention.

These results demonstrate that a crop yield model containing several explicit man-controlled input (technology) variables <u>and</u> several explicit weather variables can do a good job ($\bar{R}^2$ of .85) of explaining yield variation. It also demonstrated that it is feasible to use real world (aggregate) data by counties.

It is also demonstrated that combined time series and cross section data break up the multicollinearity problem often faced when using only time series data. By using combined time series and cross section data it is also possible to include dummy (0, 1) variables for years and locations. The advantage of using a set of dummy variables for years instead of the usual trend variable is that no particular functional form for time is forced. The advantage of using dummy variables for locations is that the coefficients "pick up" consistent difference between locations. These differences can then be used to determine the effect of shifts in the location of production, net of the effects of weather and man-controlled inputs.

Comparing the estimated effects of each weather factor in each week of the growing season from the weather polynomial technique with the weekly weather variable technique revealed these advantages and disadvantages. The polynomial technique: (1) Uses fewer degrees of freedom, (2) results in a lower $\bar{R}^2$, (3) requires more data manipulation, and (4) results in more meaningful estimates.

Model Flexibility

Although this model was set up for a particular crop, with particular objectives, and for particular data, the basic ideas of including several weather and technology variables and using time series, cross section data admit a wide variety of models. Some of the characteristics that can vary are discussed below.

Functional Form

The principle of fitting a physical production function using several explicit technology and weather variables does not specify any particular function form. A linear, Cobb-Douglas, quadratic, or other form could be used.

Time Series-Cross Section Data

Although there are advantages in using combined time series and cross section data, this method may be used with either time series or cross section data. If the combined data are used it is not necessary that the same number of units be used in each time period.

Aggregation of Data

The basic unit of analysis in this study was the county. Data from firms, plots, States, etc., could be used instead. The counties were selected to represent the major area producing grain sorghum. Units could be selected to represent the Nation or selected to represent a very small (local) area.

Type of Crop Considered

The crop considered is one of the major feed grains. Fruits, vegetables, forage, etc., could also be analyzed by a model similar to this.

Number and Kind of Weather Variables

The relevant growing season was assumed to be 23 weeks for grain sorghum. Clearly the model can be adapted to any length of growing season. The model could be fitted for time periods other than one week in length.

Precipitation, temperature, and temperature multiplied by precipitation (interaction) were considered. Other weather variables (including a different form for the interaction term) could be employed. The weekly weather variables were considered in a linear form and in a polynomial (of degrees zero through seven) form in this study; other forms could be used.

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APPENDIX A

THE DATA: PROBLEMS, SOURCES AND METHODS OF ESTIMATION

The Dependent Variable

Yield per Acre. This value was obtained by taking the ratio of total pounds of grain sorghum produced in a county by the total acres of sorghum harvested for grain or seed in that county.

The data for the latter two variables were obtained from the U. S. Census of Agriculture. The specific source is shown in Table A-1.

Table A-1.--Sources of data on acres of grain sorghum harvested and production of grain sorghum

Year	Volume	Parts	County table number
1959	I	20,21,36,37,41,42	11
1954	I	12,13,25,26,29,30	9
1949	I	12,13,25,26,29,30	5
1944	I	12,13,25,26,29,30	2/1

The Independent Variables

Acres of Grain Sorghum Harvested per Farm Harvesting Grain Sorghum. These values were obtained by taking the ratio of total number of acres of sorghum harvested for grain or seed in a county to the total number of farms harvesting sorghums for grain or seed in that county.

The data for the latter two variables are found in the sources indicated in Table A-1.

Acres of Sorghum Harvested for Grain or Seed. These values were used as published. The specific sources are listed in Table A-1.

<u>Acres of Cropland Harvested per Tractor</u>. These values were obtained by taking the ratio of total acres of cropland harvested in a county to the total number of tractors in that county.

The data for these variables were obtained from the U. S. Census of Agriculture. The specific source is given in Table A-2.

Table A-2.--Sources of data on cropland harvested and tractor numbers

Year	Volume	Parts	County table number: Harvested cropland	County table number: Tractor numbers
1959----	I	20,21,36,37,41,42	1	6
1954----	I	12,13,25,26,29,30	1	5
1949----	I	12,13,25,26,29,30	1	3
1944----	I	12,13,25,26,29,30	1/1	1/2

<u>Proportion of Sorghum Acreage Irrigated</u>. These values for the years 1959, 1955, 1949, and 1939 were obtained by taking the ratio of acres of grain sorghum irrigated to the total acres of grain sorghum harvested.

The data for total acres of grain sorghum harvested were obtained from the sources listed in Table A-1. The data for acres irrigated were obtained from the sources listed in Table A-3.

Table A-3.--Sources of data on acres of grain sorghum harvested that had been irrigated

Year	Volume	Parts	County table number
1959----	I	20,21,36,37,41,42	11-A
1954----	I	12,13,25,26,29,30	9-A
1949----	I	12,13,25,26,29,30	5-A
1939----	I	2,5,6	15

No census data on irrigation by counties were available for 1944. However, State totals of irrigated land in farms were available. They were obtained from the 1949 U. S. Census of Agriculture, Vol. I, Parts 12,13,25,26,29, and 30, State Table 1, and are reported in Table A-4.

Table A-4.--Data on acres irrigated by States, and values used to estimate acres of grain sorghum irrigated in 1944

State	Irrigated land in farms			A = 1949 acreage - 1939 acreage	B = 1944 acreage - 1939 acreage	C = B/A
	1949	1944	1939			
Nebraska---	904,492	631,762	473,775	430,717	157,987	.36680
Kansas-----	145,334	96,248	82,872	62,462	13,376	.02142
Oklahoma---	34,857	2,237	4,437	30,420	-2,200	-.07232
Colorado---	2,902,118	2,698,519	2,467,548	434,570	230,971	.53149
New Mexico-	663,195	534,640	436,402	226,793	98,238	.39789
Texas------	3,167,536	1,320,216	894,638	2,272,898	425,578	.18724

From the State total it was possible to determine (for the State) what proportion of the total change from 1939 to 1949 had occurred by 1944. The assumption was made that the change in acres of grain sorghum irrigated in each county had changed in the same proportion as the change in the total acres irrigated in the State.

The estimated acres of grain sorghum irrigated in 1944 for a county was set equal to the 1939 acres of grain sorghum irrigated in that county plus C (selected from Table A-4) times the total change in acres of grain sorghum irrigated in that county between 1939 and 1949.

<u>Dollars Spent on Gas and Oil per Acre</u>. These values were obtained as the ratio of total dollars spent on gas and oil (in constant dollars) to acres of cropland harvested.

The sources of data for cropland harvested is given in Table A-2. The data on dollars spent on gas and oil for the years 1959, 1954, 1949, and 1939 were obtained from the U. S. Census of Agriculture. Specific sources are given in Table A-5.

Table A-5.--Sources of data on dollars spent on gas and oil

Year	Volume	Parts	County table number
1959-----	I	20,21,36,37,41,42	7
1954-----	I	12,13,25,26,29,30	6
1939-----	I	2,5,6	10

As all census figures were in current dollars, it was necessary to deflate them. The values were deflated by the Index of Average Prices Paid by Farmers for Motor Supplies. These data were obtained from USDA Statistical Bulletin No. 319, 1962, and are listed in Table A-6.

Table A-6.--Index of average prices paid by farmers for motor supplies for years used in study

Year	Index of average prices paid by farmers for motor supplies, 1910-14 = 100
1939---------------	102
1944---------------	115
1949---------------	146
1954---------------	162
1959---------------	173

There are no data by counties or States for 1944. However, there are some U. S. values and they are presented in Table A-7. They are obtained from the Farm Income Situation, July 1964, Table 53-H, page 53.

Of the total change in dollars (deflated) spent on gas and oil between 1939 and 1949, 27.37 percent had occurred by 1944. By assuming that the change in dollars (deflated) spent on gas and oil in each county changed in proportion to the change at the national level, it was possible to

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to estimate values for each county for 1944. The 1944 estimated value for a county was set equal to the 1939 dollars (deflated) spent on gas and oil in that county plus .2737 times the change in dollars (deflated) spent on gas and oil between 1939 and 1949 in that county.

Table A-7.--Data for U. S. on dollars spent on gas and oil, 1939, 1944, and 1949

Year	Dollars spent on gas and oil	
	Current	Constant[a]
1939	323,000,000	316,700,000
1944	509,000,000	442,600,000
1949	1,134,000,000	776,700,000

a/ Deflated by the index given in Table A-6.

Value of Land per Acre. The values for this variable were derived from the statistic, value of land and buildings per acre, which is reported in the U. S. Census of Agriculture. Specific sources are given in Table A-8.

Table A-8.--Sources of data for value of land and buildings per acre

Year	Volume	Parts	County table number
1959	I	20,21,36,37,41,42	1
1954	I	12,13,25,26,29,30	1
1949	I	12,13,25,26,29,30	1
1944	I	12,13,25,26,29,30	1/1

The value of land and buildings per acre is reported in current dollars. To make the data more meaningful they were deflated by the Consumer Price Index. These data were obtained from Business Statistics, 1961 Biennial Edition of the U. S. Department of Labor, Bureau of Labor Statistics, and reported in Table A-9.

Table A-9.--Consumer price index for years used in study

Year	Consumer price index (1947-49 = 100)
1939	59.4
1944	75.2
1949	101.8
1954	114.8
1959	124.6

Estimates of the proportion of value of land and buildings that was buildings were obtained from photostats of USDA worksheets on farm real estate, selected statistics. These photostats were made available by William H. Scofield, Agricultural Economist, Farm Production Economics Division, Economic Research Service, USDA. The data for the States and years included in the study are presented in Table A-10.

Table A-10.--Percent buildings are of land and buildings, for years and States used in study

State	Percent buildings are of land and buildings[a]				
	1939	1944	1949	1954	1959
Oklahoma	17.1 (82.9)	17.2 (82.8)	13.5 (86.5)	14.1 (85.9)	8.0 (92.0)
Texas	16.3 (83.7)	17.5 (82.5)	16.9 (83.1)	14.3 (85.7)	11.9 (88.1)
Nebraska	22.4 (77.6)	17.8 (82.2)	16.4 (83.6)	17.5 (82.5)	12.5 (87.5)
Kansas	18.4 (81.6)	15.3 (84.7)	15.7 (84.3)	13.3 (86.7)	14.6 (85.4)
Colorado	21.8 (78.2)	20.1 (79.9)	19.5 (80.5)	18.3 (81.7)	15.6 (84.4)
New Mexico	15.1 (84.9)	13.1 (86.9)	12.5 (87.5)	10.9 (89.1)	8.0 (92.0)

a/ Numbers in parentheses are the percent land is of land and buildings.

The values of land and buildings per acre for counties were adjusted by the appropriate State value to give value of land per acre.

Man-hours per Acre. The values used for this variable are the sum of preharvest and harvest man work units used per acre of grain sorghum. The data were obtained from personal correspondence with Reuben W. Hecht, Agricultural Economist, Farm Production Economics Division, Economic Research Service, USDA.

The data were available only for selected farm production regions.[1/] The data used in the study are presented in Table A-11.

Table A-11.--Data on total man work units per acre of grain sorghum, farm production regions and years used in study

Year	Farm production regions: Northern Plains Nebraska, Kansas	Southern Plains Oklahoma, Texas	Mountain Colorado, New Mexico
	Man work units		
1939	12.2	11.6	12.0
1944	13.4	11.6	12.2
1949	6.7	7.0	9.3
1954	5.0	5.7	7.9
1959	3.4	5.2	6.7

Acres Cultivated Summer Fallow. The values used for this variable are as published in the Census of Agriculture for the years 1959, 1954, and 1949. For the years 1944 and 1939, the value used is derived from the variable, acres idle and fallow, appearing in the Census of Agriculture for those years. The specific sources are shown in Table A-12.

Acres cultivated summer fallow was not obtained as a separate entity in the agricultural census of 1944 and 1939. However, an estimate of the total number of acres in summer fallow for 10 Great Plains States was available for these years. It was published by Sherman E. Johnson in USDA Bureau of Agricultural Economics Bulletin F.M. 58, revised June 1948.

1/ A map delineating the farm production regions and showing the States therein is shown on the inside front cover of USDA Statistical Bulletin No. 233, September 1959 revision.

Table A-12.--Sources of data on acres fallow and acres idle and fallow

Year	Volume	Parts	Table number: Acres summer fallow	Table number: Acres fallow and idle
1959----:	I	20,21,36,37,41,42	County Table 1	
1954----:	I	12,13,25,26,29,30	County Table 1	
1944----:	I	12,13,25,26,29,30		County Table 1
1944[a]--:	I	11,12,13,25,26,28,29,30		State Table 1

a/ State totals only.

All six of the States included in this study were included in the 10 Great Plains States used for these estimates. The total number of acres in idle and fallow for these same 10 States was obtained from the 1944 Census of Agriculture. The specific sources are shown in Table A-12 for the year 1944, footnote a/. Using these data, the proportions that fallow acres were of total acres fallow and idle was obtained for each year. The results are given in Table A-13.

Table A-13.--Data on acres fallow and acres fallow and idle for 10 Great Plains States, 1939 and 1944

Item	1939	1944
Acres fallow----------------:	17,400,000	10,800,000
Acres fallow and idle-------:	29,237,205	16,602,644
Percent land fallow is of land idle and fallow-------:	59.51	65.05

The county estimates for these years were obtained by multiplying the acres fallow and idle in the county by the appropriate percent from Table A-13.

It should be noted that the above data are not what is really desired. The most appropriate data would be proportion of total grain

sorghum acreage planted on fallowed land. Such data are not available. Given that total acres summer fallowed have to be used it would be desirable to have this data for the year previous to the one being studied as these are the acres that will influence yields in the current year.

The data used will lead to meaningful results only if the following two assumptions hold: That the proportion of acres fallowed in the current year to acres fallowed in the previous year is nearly the same for all counties included in the study, and that the proportion of total acres fallowed used for grain sorghum is the same for all counties included in the study.

Pounds of Fertilizer Nutrients per Acre of Grain Sorghum. The values used for each county are as published for the aggregates which contain the county. For 1959 the aggregate is the State part of U. S. agricultural subregions. The data for this were obtained from USDA Statistical Bulletin 348, "Commercial Fertilizer Used on Crops and Pasture in the United States, 1959 Estimates." These estimates are based on 1959 Census of Agriculture data. The data used in this study from this source are presented in Table A-14.

Data for 1954 were available only at the State level. The data are obtained from USDA Statistical Bulletin 216, "Fertilizer Used on Crops and Pasture in the United States, 1954 Estimates." The data from this source used in this study are presented in Table A-15.

Data for 1949 was not available. However, estimates for 1950 were available in USDA Agricultural Handbook No. 68, "Fertilizer Use and Crop Yields in the U. S., 1950 Estimates." The 1950 estimates are used as good approximations of 1949 values. They are believed to be close estimates

Table A-14.--Fertilizer data for 1959, for economic subregions and State parts used in study

Economic sub-region	State part	Acres harvested of grain sorghum	Tons of fertilizer applied to grain sorghum				Average pounds of nutrients per acre
			N	P_2O_5	K_2O	Total	
68------	Kansas	425,117	898	1,429	340	2,667	12.55
69------	Kansas	193,699	670	879	130	1,679	17.34
70------	Kansas	203,700	1,362	1,008	114	2,484	24.39
	Nebraska	266,091	940	260	19	1,219	9.16
76------	Kansas	418,419	757	281	0	1,038	4.96
	Nebraska	1,143,593	6,679	859	77	7,615	13.32
77------	Kansas	876,414	1,655	1,336	0	2,991	6.83
80------	Texas	787,588	1,294	1,147	229	2,670	6.78
81------	Texas	1,246,995	1,698	1,291	129	3,121	5.01
82------	Texas	177,200	335	0	0	335	3.78
83------	Oklahoma	319,167	180	617	44	841	5.27
	Texas	1,031,770	269	228	23	520	1.01
84------	Texas	2,135,831	6,893	893	0	7,786	7.29
85------	Kansas	2,678,212	6,770	1,012	0	7,782	5.81
	New Mexico	233,795	1,035	3	0	1,038	8.88
	Texas	1,684,691	33,720	1,605	0	35,325	41.94
	Oklahoma	438,777	278	88	10	376	1.71
	Colorado	576,921	606	98	0	704	2.44

Table A-15.--Fertilizer data for 1954 for States used in study

State	Acres harvested	Fertilizer in tons				Pounds of nutrients per acre
		N	P_2O_5	K_2O	Total	
Nebraska----	540,000	841	97	15	953	3.53
Kansas------	3,567,000	2,381	3,004	138	5,523	3.10
Oklahoma----	614,000	577	866	247	1,690	5.50
Colorado----	396,000	---	---	---	---	a/
New Mexico--	281,000	278	945	5	528	3.76
Texas-------	5,782,000	15,472	7,167	1,725	24,364	8.43

a/ Used Kansas average.

because (1) the 1950 values are quite low, and (2) the values are for a farm production region and changes in averages for a whole region would be very small. The data used for this study are presented in Table A-16.

Table A-16.--Fertilizer data for 1949 by farm production regions

Farm production region	States included	Acreage of sorghum harvested	Pounds of plant nutrients per acre: N	P_2O_5	K_2O	Total
Southern States--------	Oklahoma, Texas	8,185,000	0.5	0.6	0.3	1.4
North Central States--	Nebraska, Kansas	3,190,000	.5	.6	.2	1.3

New Mexico and Colorado belong to the Mountain States. Estimates for the Mountain States were dominated by sorghum production in California and Arizona where most of the crop is irrigated and heavily fertilized. Thus these estimates were rejected as being unreasonably high for New Mexico and Colorado. The values used for New Mexico were set equal to those of Texas, whose production practices are similar and the values used for Colorado were set equal to those for Kansas, whose production practices are similar.

The total pounds of nutrients applied per acre of grain sorghum for all counties for 1944 and 1939 was estimated to be zero. Not a single source of data about fertilizer applied to sorghum prior to the 1950 estimates was found. The value zero was used because it was believed to be a very close approximation to the true value. This belief is substantiated for 1939 by the fact that of the 129 counties included in the study, 82 used no fertilizer on any crops in 1939. It is also substantiated by the fact that for dryland farming the recommended fertilizer practice was to use no fertilizer.

The assumption that no fertilizer was applied to grain sorghum in 1939 was extended to 1944 because: (1) Nitrogen which was the principal nutrient applied in latter years was scarce during the war years; (2) the low values for 1950 indicate that fertilizer use, which has increased over time, must have been very near zero for 1944; and (3) the fact that no fertilizer data were obtained for this crop while they were obtained for other crops[1] indicates that fertilizing sorghum was not an important practice.

1/ "The Third National Fertilizer Practice Survey," The Fertilizer Review, National Fertilizer Association, Inc., Jan., Feb., and March 1946: 7-10.

Table A-17.--List of counties included in the study with data related to each county, observation number, and county number key

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Adams	Nebraska	3	1	76	1	130	259	388	517
Clay	Nebraska	2	1	76	2	131	260	389	518
Fillmore	Nebraska	2	1	76	3	132	261	390	519
Franklin	Nebraska	3	1	76	4	133	262	391	520
Furnas	Nebraska	3	1	76	5	134	263	392	521
Gage	Nebraska	2	1	70	6	135	264	393	522
Hamilton	Nebraska	1	1	76	7	136	265	394	523
Lancaster	Nebraska	1	1	70	8	137	266	395	524
Nukolls	Nebraska	2	1	76	9	138	267	396	525
Thayer	Nebraska	2	1	76	10	139	268	397	526
Webster	Nebraska	3	1	76	11	140	269	398	527
Barton	Kansas	8	2	85	12	141	270	399	528
Butler	Kansas	12	2	68	13	142	271	400	529
Cloud	Kansas	5	2	77	14	143	272	401	530

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Table A-17.--Continued

Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Cowley	Kansas	12	2	68	15	144	273	402	531
Edwards	Kansas	11	2	85	16	145	274	403	532
Ellis	Kansas	8	2	85	17	146	275	404	533
Finney	Kansas	10	2	85	18	147	276	405	534
Ford	Kansas	10	2	85	19	148	277	406	535
Gove	Kansas	7	2	85	20	149	278	407	536
Graham	Kansas	4	2	85	21	150	279	408	537
Grant	Kansas	10	2	85	22	151	280	409	538
Gray	Kansas	10	2	85	23	152	281	410	539
Greeley	Kansas	7	2	85	24	153	282	411	540
Hamilton	Kansas	10	2	85	25	154	283	412	541
Harper	Kansas	11	2	77	26	155	284	413	542
Harvey	Kansas	11	2	77	27	156	285	414	543
Jewell	Kansas	5	2	76	28	157	286	415	544

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Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Kearney	Kansas	10	2	85	29	158	287	416	545
Kingman	Kansas	11	2	77	30	159	288	417	546
Lane	Kansas	7	2	85	31	160	289	418	547
Logan	Kansas	7	2	85	32	161	290	419	548
McPherson	Kansas	8	2	77	33	162	291	420	549
Marion	Kansas	8	2	77	34	163	292	421	550
Marshall	Kansas	6	2	76	35	164	293	422	551
Mitchell	Kansas	5	2	85	36	165	294	423	552
Morton	Kansas	10	2	85	37	166	295	424	553
Nemaha	Kansas	6	2	70	38	167	296	425	554
Ness	Kansas	7	2	85	39	168	297	426	555
Osage	Kansas	9	2	69	40	169	298	427	556
Osborne	Kansas	5	2	85	41	170	299	428	557
Pawnee	Kansas	11	2	85	42	171	300	429	558

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Table A-17.—Continued

Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Phillips	Kansas	5	2	76	43	172	301	430	559
Pratt	Kansas	11	2	85	44	173	302	431	560
Reno	Kansas	11	2	77	45	174	303	432	561
Republic	Kansas	5	2	76	46	175	304	433	562
Rice	Kansas	8	2	77	47	176	305	434	563
Rush	Kansas	8	2	85	48	177	306	435	564
Scott	Kansas	7	2	85	49	178	307	436	565
Sedgewick	Kansas	11	2	77	50	179	308	437	566
Seward	Kansas	10	2	85	51	180	309	438	567
Sheridan	Kansas	4	2	85	52	181	310	439	568
Sherman	Kansas	4	2	85	53	182	311	440	569
Smith	Kansas	5	2	76	54	183	312	441	570
Stafford	Kansas	11	2	85	55	184	313	442	571
Stanton	Kansas	10	2	85	56	185	314	443	572

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Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Stevens	Kansas	10	2	85	57	186	315	444	573
Summer	Kansas	11	2	77	58	187	316	445	574
Thomas	Kansas	4	2	85	59	188	317	446	575
Trego	Kansas	7	2	85	60	189	318	447	576
Washington	Kansas	5	2	76	61	190	319	448	577
Wichita	Kansas	7	2	85	62	191	320	449	578
Beaver	Oklahoma	13	2	85	63	192	321	450	579
Caddo	Oklahoma	15	2	83	64	193	322	451	580
Cimarrion	Oklahoma	13	2	85	65	194	323	452	581
Texas	Oklahoma	13	2	85	66	195	324	453	582
Washita	Oklahoma	14	2	83	67	196	325	454	583
Baca	Colorado	17	1	85	68	197	326	455	584
Kiowa	Colorado	16	1	85	69	198	327	456	585
Kit Carson	Colorado	16	1	85	70	199	328	457	586

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Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Powers---------:	Colorado	17	1	85	71	200	329	458	587
Yuma-----------:	Colorado	16	1	85	72	201	330	459	588
Curry----------:	New Mexico	18	2	85	73	202	331	460	589
Roosevelt------:	New Mexico	18	2	85	74	203	332	461	590
Bailey---------:	Texas	20	1	84	75	204	333	462	591
Bee------------:	Texas	25	5	81	76	205	334	463	592
Bell-----------:	Texas	24	4	80	77	206	335	464	593
Bexar----------:	Texas	25	5	81	78	207	336	465	594
Briscoe--------:	Texas	19	2	85	79	208	337	466	595
Carson---------:	Texas	19	2	85	80	209	338	467	596
Castro---------:	Texas	19	2	85	81	210	339	468	597
Cochran--------:	Texas	20	1	84	82	211	340	469	598
Collingsworth-:	Texas	21	1	83	83	212	341	470	599
Crosby---------:	Texas	20	1	84	84	213	342	471	600

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Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Dallam	Texas	19	2	85	85	214	343	472	601
Dawson	Texas	20	1	84	86	215	344	473	602
Deaf Smith	Texas	19	2	85	87	216	345	474	603
Ellis	Texas	24	4	80	88	217	346	475	604
Floyd	Texas	19	2	85	89	218	347	476	605
Gaines	Texas	20	1	84	90	219	348	477	606
Garza	Texas	21	1	83	91	220	349	478	607
Guadalupe	Texas	25	5	80	92	221	350	479	608
Hale	Texas	19	2	85	93	222	351	480	609
Hall	Texas	21	1	83	94	223	352	481	610
Hartley	Texas	19	2	85	95	224	353	482	611
Haskell	Texas	22	3	83	96	225	354	483	612
Hidalgo	Texas	28	8	82	97	226	355	484	613
Hill	Texas	24	4	80	98	227	356	485	614

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Table A-17.--Continued

Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Hockley	Texas	20	1	84	99	228	357	486	615
Howard	Texas	20	1	84	100	229	358	487	616
Jim Wells	Texas	27	6	81	101	230	359	488	617
Jones	Texas	22	3	83	102	231	360	489	618
Knox	Texas	22	3	83	103	232	361	490	619
Lamb	Texas	20	1	84	104	233	362	491	620
Live Oak	Texas	27	6	81	105	234	363	492	621
Lubbock	Texas	20	1	84	106	235	364	493	622
Lynn	Texas	20	1	84	107	236	365	494	623
McLennon	Texas	24	4	80	108	237	366	495	624
Martin	Texas	20	1	84	109	238	367	496	625
Medina	Texas	25	5	81	110	239	368	497	626
Milam	Texas	24	4	80	111	240	369	498	627
Moore	Texas	19	2	85	112	241	370	499	628

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Table A-17.--Continued

County	State	Crop reporting district[a]	Growing season[b]	Economic subregion[c]	Observation number[d]				
					County number: 1959	1954	1949	1944	1939
Nolan----------	Texas	22	3	83	113	242	371	500	629
Nueces---------	Texas	26	6	81	114	243	372	501	630
Parmer---------	Texas	19	2	85	115	244	373	502	631
Randall--------	Texas	19	2	85	116	245	374	503	632
Refugio--------	Texas	26	6	81	117	246	375	504	633
Runnels--------	Texas	22	3	83	118	247	376	505	634
San Patricio--	Texas	26	6	81	119	248	377	506	635
Surry----------	Texas	22	3	83	120	249	378	507	636
Swisher--------	Texas	19	2	85	121	250	379	508	637
Taylor---------	Texas	22	3	83	122	251	380	509	638
Terry----------	Texas	20	1	84	123	252	381	510	639
Tom Green------	Texas	23	4	81	124	253	382	511	640
Travis---------	Texas	25	5	80	125	254	383	512	641

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Table A

Table A-17.--Continued

County	State	Crop reporting district a/	Growing season b/	Economic subregion c/	Observation number d/				
					County number: 1959	1954	1949	1944	1939
Wheeler	Texas	21	1	83	126	255	384	513	642
Willary	Texas	28	8	82	127	256	385	514	643
Williamson	Texas	24	4	80	128	257	386	515	644
Yoakum	Texas	20	1	84	129	258	387	516	645

a/ See Table A-18.

b/ See Table A-19.

c/ Map delineating economic subregions can be found on page 2 of "Commercial Fertilizer Used on Crops and Pasture in the United States, 1959 Estimates," USDA Statistical Bulletin No. 348.

d/ Observation numbers for 1959 are also county numbers.

The Dummy Variables. Three sets of dummy variables were considered in this study. The data on these variables is presented by counties in Table A-17. The last part of Table A-17 contains the county numbers and observation numbers which are keyed to other tables to be presented later

The year variables need no explaining.

Table A-18.--Key to crop reporting districts used in study

Crop reporting district number used in study	State	Crop reporting district, State number or name
1	Nebraska	East
2	Nebraska	South East
3	Nebraska	South
4	Kansas	North West
5	Kansas	North Central
6	Kansas	North East
7	Kansas	West Central
8	Kansas	Central
9	Kansas	East Central
10	Kansas	South West
11	Kansas	South Central
12	Kansas	South East
13	Oklahoma	No. 1
14	Oklahoma	No. 4
15	Oklahoma	No. 7
16	Colorado	District No. 6
17	Colorado	District No. 9
18	New Mexico	North East
19	Texas	1-N
20	Texas	1-S
21	Texas	2-N
22	Texas	2-S
23	Texas	7
24	Texas	4
25	Texas	8-N
26	Texas	8-S
27	Texas	10-N
28	Texas	10-S

Since the counties included in the study came from different States and different climatic regions, it was decided that a single growing season representing all counties was not appropriate. Data as to the average planting date are not available on a county basis. Data as to the average planting date are available for crop reporting districts in Texas.

There were seven different growing seasons considered in the study but because two seasons were affected by leap year (1944) two extra growing seasons were included. The growing seasons considered are shown in Table A-19 and are keyed to the numbers given in Table A-17.

Table A-19.--Key for growing seasons

Growing season number	Begins	Ends
1	May 11	October 18
2	May 20	October 27
3	April 19	September 26
4	March 25	September 1
5	March 11	August 18
6 a/	February 27	August 6
7 b/	February 17	July 27

a/ For 1944 February 28 to August 6.

b/ For 1944 February 18 to July 27.

Temperature. A weather station reporting daily maximum temperatures was selected from each county, if there was at least one in the county. If there were no weather stations in the county reporting maximum temperatures, then the nearest weather station that did report temperatures was used. A list of the weather stations used to obtain the weather data for each county is presented in Table A-20.

If maximum temperature was not reported for (1) one day or for two consecutive days, the missing values were estimated by simple interpolation, and (2) three or more consecutive days, the missing values were estimated by using the actual reported maximum temperatures of the nearest reporting station.

Precipitation. If there were four or more weather stations in a county reporting precipitation, then three were selected for use in this study. If there were at least one, but less than four reporting weather stations in a county, then all were used.

If there were no reporting weather stations in a county, up to three nearby stations were used. A list of the weather stations used is presented in Table A-20.

If there were any days for which precipitation was not reported, the missing value(s) was (were) approximated by using precipitation occurring on that day (those days) at the nearest weather station.

Table A-20.--List of weather stations from which weather data were obtained, by county and kind of weather data

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Adams	1	Neb.	T	Red Cloud	Hastings	Hastings	Hastings	Hastings
			R	Hastings	Hastings	Hastings	Hastings	Hastings
Clay	2	Neb.	T	Red Cloud	Red Cloud	Clay Center	Clay Center	Clay Center
			R	Clay Center	Clay Center	Clay Center	Clay Center	Clay Center
Fillmore	3	Neb.	T	Geneva	Geneva	Geneva	Geneva	Geneva
			R	Geneva	Geneva	Geneva	Geneva	Geneva
			R	Fairmont	Fairmont	Fairmont	Fairmont	Fairmont
Franklin	4	Neb.	T	Red Cloud	Red Cloud	Franklin	Franklin	Franklin
			R	Upland	Naponee	Franklin	Franklin	Franklin
			R	Franklin	Franklin	Naponee	Naponee	Naponee
			R		Upland	Upland	Upland	Upland
Furnas	5	Neb.	T	Beaver City	Beaver City	Beaver City	Beaver City	Beaver City
			R	Beaver City	Beaver City	Beaver City	Beaver City	Beaver City
			R	Cambridge	Cambridge	Cambridge	Cambridge	Cambridge
			R	Sappa Valley	Sappa Valley		Edison	Wilsonville
Gage	6	Neb.	T	Beatrice No. 1	Beatrice No. 1	Beatrice No. 1	Beatrice No. 1	Beatrice No. 1
			R	Beatrice No. 1	Beatrice No. 1	Beatrice No. 1	Beatrice No. 1	Beatrice No. 1
			R	Virginia	Virginia	Wymore	Barnston	Barnston
			R				Wymore	Wymore
Hamilton	7	Neb.	T	Red Cloud	Red Cloud	Red Cloud	Grand Island	Grand Island
			R	Aurora	Aurora	Aurora	Grand Island	Grand Island
			R				Aurora	Aurora

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations				
				1939	1944	1949	1954	1959
Lancaster	8	Neb.	T	Lincoln	Lincoln	Lincoln	Lincoln	Lincoln
			R	Lincoln	Lincoln	Lincoln	Lincoln	Lincoln
			R			Agnew	Agnew	Bennet
			R			Bennet	Bennet	Malcolm
Nukalls	9	Neb.	T	Geneva	Geneva	Nelson	Nelson	Nelson
			R	Nelson	Nelson	Nelson	Nelson	Nelson
			R	Superior	Sedan	Sedan	Sedan	Hardy
			R		Superior	Superior	Superior	Superior
Thayer	10	Neb.	T	Geneva	Geneva	Hebron	Hebron	Hebron
			R	Hebron	Burning	Hebron	Hebron	Hebron
			R	Burning	Hebron	Burning	Burning	Burning
			R					Hubble
Webster	11	Neb.	T	Red Cloud	Red Cloud	Red Cloud	Red Cloud	Red Cloud
			R	Red Cloud	Red Cloud	Red Cloud	Red Cloud	Red Cloud
			R	Guide Rock	Guide Rock	Guide Rock	Guide Rock	Guide Rock
			R			Rosemont	Rosemont	Rosemont
Barton	12	Kan.	T	Larned	Larned	Great Bend	Great Bend	Great Bend
			R	Claflin	Hoisington	Great Bend	Great Bend	Great Bend
			R	Great Bend		Beaver	Claflin	Claflin
			R	Hoisington		Claflin		
Buller	13	Kan.	T	El Dorado	El Dorado	El Dorado	El Dorado	El Dorado
			R	El Dorado	El Dorado	El Dorado	El Dorado	El Dorado
			R	Agusta		Agusta	Agusta	Agusta
			R			Beaumont	Beaumont	De Groff

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Table A-20.—Continued

Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations				
				1939	1944	1949	1954	1959
Cloud	14	Kan.	T	Concordia	Concordia	Burr Oak	Concordia	Concordia
			R	Concordia	Concordia	Concordia	Concordia	Concordia
			R			Miltonvale	Miltonvale	Miltonvale
Cowley	15	Kan.	T	Winfield	Winfield	Winfield	Winfield	Winfield
			R	Winfield	Winfield	Winfield	Winfield	Winfield
			R	Arkansas City		Arkansas City	Arkansas City	Arkansas City
			R			Dexter	Atlanta	Atlanta
Edwards	16	Kan.	T	Larned	Larned	Larned	Kinsley	Kinsley
			R	Kinsley	Trousdale	Trousdale	Kinsley	Kinsley
			R	Trousdale		Kinsley	Trousdale	Trousdale
Ellis	17	Kan.	T	Hays	Hays	Hays	Hays	Hays
			R	Hays	Hays	Hays	Hays	Hays
			R	Ellis	Ellis		Ellis	Ellis
Finney	18	Kan.	T	Garden City	Garden City	Garden City	Garden City	Garden City
			R	Garden City	Garden City	Garden City	Garden City	Garden City, E.S.
			R	Kalvesto		Imperial	Imperial	Imperial
Ford	19	Kan.	T	Dodge City	Dodge City	Dodge City	Dodge City	Dodge City
			R	Dodge City	Dodge City	Dodge City	Dodge City	Dodge City
			R	Bucklin	Bucklin	Bucklin	Bucklin	Bucklin
Gove	20	Kan.	T	Quinter	Quinter	Quinter	Quinter	Quinter
			R	Quinter	Quinter	Quinter	Quinter	Quinter
			R			Jerome	Gove	Gove
			R				Jerome	Jerome

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Grahm	21	Kan.	T	Hill City	Hill City	Hill City	Hill City	Hill City
			R	Hill City	Hill City	Hill City	Hill City	Hill City
			R				Wakeeney 9N	St. Peter
			R					Wakeeney 9N
Grant	22	Kan.	T	Ulysses	Ulysses	Ulysses	Ulysses	Ulysses
			R	Ulysses	Ulysses	Ulysses	Ulysses	Ulysses
Gray	23	Kan.	T	Cimarron	Cimarron	Cimarron	Cimarron	Cimarron
			R	Cimarron	Cimarron	Cimarron	Cimarron	Cimarron
Greeley	24	Kan.	T	Tribune	Tribune	Tribune	Tribune	Tribune
			R	Tribune	Tribune	Tribune	Tribune	Tribune
Hamilton	25	Kan.	T	Syracuse	Syracuse	Syracuse	Syracuse	Syracuse
			R	Syracuse	Syracuse	Syracuse	Syracuse	Syracuse
Harper	26	Kan.	T	Anthony	Anthony	Anthony	Anthony	Anthony
			R	Anthony	Anthony	Anthony	Anthony	Anthony
			R			Attica	Attica	Attica
Harvey	27	Kan.	T	Newton	Newton	Newton	Newton	Newton
			R	Newton	Newton	Newton	Newton	Newton
			R	Sedgewick		Burrton	Sedgewick	Sedgewick
			R			Sedgewick		
Jewell	28	Kan.	T	Burr Oak	Burr Oak	Burr Oak	Burr Oak	Lovewell Dam
			R	Burr Oak	Burr Oak	Burr Oak	Burr Oak	Lovewell Dam
			R			Ionia	Ionia	Esbon
			R			Jewell	Jewell	Jewell

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Kearney	29	Kan.	T	Lakin	Lakin	Lakin	Lakin	Lakin
			R	Lakin	Lakin	Lakin	Lakin	Lakin
			R	Deerfield	Deerfield	Deerfield	Deerfield	Deerfield
Kingman	30	Kan.	T	Norwich	Norwich	Norwich	Kingman	Kingman
			R	Norwich	Norwich	Norwich	Kingman	Kingman
			R	Kingman				Norwich
Lane	31	Kan.	T	Healy	Healy	Healy	Healy	Healy
			R	Healy	Healy	Healy	Healy	Healy
Logan	32	Kan.	T	Oakley	Oakley	Oakley	Oakley	Oakley
			R	Oakley	Oakley	Oakley	Oakley	Oakley
			R			Winona	Elkader	Elkader
			R				Winona	Winona
McPherson	33	Kan.	T	McPherson	McPherson	McPherson	McPherson	McPherson
			R	McPherson	McPherson	McPherson	McPherson	McPherson
			R	Lindsborg	Lindsborg	Inman	Inman	Inman
			R			Lindsborg	Lindsborg	Lindsborg
Marion	34	Kan.	T	McPherson	McPherson	McPherson	Florence	Florence
			R	Florence	Florence	Florence	Florence	Florence
			R	Marion	Marion	Marion	Hillsboro	Hillsboro
			R				Marion	Marion
Marshall	35	Kan.	T	Hanover	Oketo	Oketo	Maryville	Maryville
			R	Oketo	Oketo	Oketo	Maryville	Maryville
			R	Blue Rapids	Blue Rapids	Blue Rapids	Blue Rapids	Blue Rapids
			R			Breman	Breman	Breman

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Mitchell	36	Kan.	T	Concordia	Concordia	Burr Oak	Concordia	Concordia
			R	Beloit	Beloit	Beloit	Beloit	Beloit
			R	Cawker City	Cawker City	Cawker City	Cawker City	Cawker City
			R					Hunter
Morton	37	Kan.	T	Elkhart	Elkhart	Elkhart	Elkhart	Elkhart
			R	Elkhart	Elkhart	Elkhart	Elkhart	Elkhart
			R	Richfield	Richfield	Richfield	Richfield	Richfield
			R			Richfield SWSW	Richfield SWSW	Richfield SWSW
Nemaha	38	Kan.	T	Centralia	Centralia	Centralia	Centralia	Centralia
			R	Centralia	Centralia	Centralia	Centralia	Centralia
			R				Sabetha Lake	Sebetha Lake
Ness	39	Kan.	T	Wakeeney	Wakeeney	Ness City	Ness City	Ness City
			R	Ness City	Ness City	Ness City	Ness City	Ness City
			R			Bazine	Bazine	Ransom
			R			Utica	Utica	Utica
Osage	40	Kan.	T	Osage City	Osage City	Osage City	Osage City	Osage City
			R	Osage City	Osage City	Osage City	Osage City	Osage City
			R	Carbondale	Lyndon	Burlingame	Burlingame	Burlingame
			R	Lyndon		Lyndon	Lyndon	Lyndon
Osborne	41	Kan.	T	Burr Oak	Alton	Alton	Alton	Alton
			R	Alton	Alton	Alton	Alton	Alton
			R			Covert	Covert	Covert
			R			Natoma	Natoma	Natoma

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Pawnee	42	Kan.	T	Larned	Larned	Larned	Larned	Larned
			R	Larned	Larned	Larned	Larned	Larned
			R			Burdett	Burdett	Burdett
			R			Zook	Zook	Zook
Phillips	43	Kan.	T	Phillipsburg	Phillipsburg	Phillipsburg	Phillipsburg	Phillipsburg
			R	Phillipsburg	Phillipsburg	Phillipsburg	Phillipsburg	Phillipsburg
			R			Long Island	Kirwin	Kirwin
			R				Long Island	Long Island
Pratt	44	Kan.	T	Pratt	Pratt	Pratt	Pratt	Pratt
			R	Pratt	Pratt	Pratt	Pratt	Pratt
			R				Preston	Preston
Reno	45	Kan.	T	Hutchinson	Hutchinson	Hutchinson	Hutchinson	Hutchinson
			R	Hutchinson	Hutchinson	Hutchinson	Hutchinson	Hutchinson E.S.
			R	Medora		Nickerson	Nickerson	
			R			Plevna	Plevna	
Republic	46	Kan.	T	Belleville	Belleville	Belleville	Belleville	Belleville
			R	Belleville	Belleville	Belleville	Belleville	Belleville
			R			Scanda	Scanda	Scanda
Rice	47	Kan.	T	Alden	Alden	Alden	Sterling	Sterling
			R	Alden	Alden	Alden	Sterling	Sterling
			R	Lyons		Geneseo	Geneseo	Geneseo
			R			Lyons	Lyons	Lyons

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Table A-20.—Continued

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Rush	48	Kan.	T	Bison	Bison	Bison	Bison	Bison
			R	Bison	Bison	Bison	Bison	Bison
			R			Alexander	Alexander	Alexander
			R				Loretta	Loretta
Scott	49	Kan.	T	Scott City	Scott City	Scott City	Scott City	Scott City
			R	Scott City	Scott City	Scott City	Scott City	Scott City
			R				Scott City 13NE	Scott City 13NE
Sedgewick	50	Kan.	T	Wichita	Wichita	Wichita	Wichita	Wichita
			R	Wichita	Wichita	Wichita	Wichita	Wichita
			R	Mt. Hope	Mt. Hope	Mt. Hope	Mt. Hope	Mt. Hope
			R			Ripley	Ripley	Ripley
Seward	51	Kan.	T	Liberal	Liberal	Liberal	Liberal	Liberal
			R	Liberal	Liberal	Liberal	Liberal	Liberal
			R		Kismet	Old Springfield		
Sheridan	52	Kan.	T	Hoxie	Hoxie	Hoxie	Hoxie	Hoxie
			R	Hoxie	Hoxie	Hoxie	Hoxie	Hoxie
			R			Morland	Lucerne	Lucerne
			R				Morland	Rexford
Sherman	53	Kan.	T	Goodland	Goodland	Goodland	Goodland	Goodland
			R	Goodland	Goodland	Goodland	Goodland	Goodland
Smith	54	Kan.	T	Burr Oak	Burr Oak	Burr Oak	Phillipsburg	Phillipsburg
			R	Smith Center	Smith Center	Smith Center	Smith Center	Belaire
			R			Harlan	Belaire	Harlan
			R				Harlan	Smith Center

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather stations 1939	1944	1949	1954	1959
Stafford	55	Kan.	T	Larned	Larned	Larned	Hudson	Hudson
			R	Hudson	Hudson	Hudson	Hudson	Hudson
Stanton	56	Kan.	T	Johnson	Johnson	Johnson	Johnson	Johnson
			R	Johnson	Johnson	Big Bow	Johnson	Johnson
Stevens	57	Kan.	T	Elkhart	Elkhart	Elkhart	Hugoton	Hugoton
			R	Hugoton	Hugoton	Hugoton	Hugoton	Hugoton
Summer	58	Kan.	T	Wellington	Wellington	Wellington	Wellington	Wellington
			R	Wellington	Wellington	Wellington	Wellington	Wellington
			R			Caldwell	Caldwell	Caldwell
			R			Conway Springs	Conway Springs	Conway Springs
Thomas	59	Kan.	T	Colby	Colby	Colby	Colby	Colby
			R	Colby	Colby	Colby	Colby	Colby
			R			Brewster	Brewster	Brewster
			R			Levant	Levant	Mingo
Trego	60	Kan.	T	Wakeeney	Wakeeney	Wakeeney	Wakeeney	Wakeeney
			R	Wakeeney	Wakeeney	Wakeeney	Wakeeney	Wakeeney
			R			Collyer	Cedar Buff D.	Cedar Buff D.
			R				Collyer	Collyer
Washington	61	Kan.	T	Hanover	Hanover	Hanover 1	Washington	Washington
			R	Hanover	Hanover	Hanover 1	Hanover	Washington
			R	Clifton	Clifton	Clifton	Clifton	Haddam
			R			Haddam	Haddam	

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Wichita	62	Kan.	T	Leoti	Leoti	Leoti	Leoti	Leoti
			R	Leoti	Leoti	Leoti	Leoti	Leoti
			R				Leoti 12N	Leoti 12N
Beaver	63	Okla.	T	Beaver	Beaver	Beaver	Beaver	Beaver
			R	Beaver	Beaver	Beaver	Beaver	Beaver
			R			Tarpin		
Caddo	64	Okla.	T	Carnegie	Carnegie	Carnegie	Carnegie	Carnegie
			R	Carnegie	Carnegie	Carnegie	Carnegie	Carnegie
			R	Apache	Apache	Apache	Apache	Apache
			R		Lookeba	Lookeba	Lookeba	Lookeba
Cimmarrion	65	Okla.	T	Kenton	Kenton	Kenton	Boise City	Boise City
			R	Kenton	Kenton	Kenton	Boise City	Boise City
			R	Boise City	Boise City	Boise City	Kenton	Kenton
			R		Regnier	Regnier	Regnier	Regnier
Texas	66	Okla.	T	Hooker	Kenton	Hooker	Guyman	Guyman
			R	Hooker	Hooker	Hooker	Guyman	Guyman
			R	Goodwell	Goodwell	Goodwell	Goodwell	Goodwell
			R		Guyman	Guyman	Hooker	Hooker
Washita	67	Okla.	T	Carnegie	Carnegie	Cloud Chief	Cordell	Cordell
			R	Cloud Chief	Cloud Chief	Cloud Chief	Cordell	Cordell
			R	Cordell	Cordell	Cordell	Cloud Chief	Cloud Chief

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Table A-20.—Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Baca	68	Col.	T	Two Buttes	Two Buttes	Springfield 8S	Springfield 8S	Springfield 8S
			R	Two Buttes	Utheyville	Utheyville	Springfield 8S	Springfield 8S
			R	Springfield	Mitchell	Eversoll Ranch	Eversoll Ranch	Eversoll Ranch
			R			Mitchell	Two Buttes	Two Buttes
Kiowa	69	Col.	T	Holly	Eads	Eads	Eads	Eads
			R	Eads	Eads	Eads	Eads	Eads
			R	Haswell	Haswell	Haswell	Chivington	Brandon
			R				Haswell	
Kit Carson	70	Col.	T	Burlington	Statton	Statton	Statton	Statton
			R	Burlington	Statton	Statton	Statton	Statton
			R	Statton	Burlington	Burlington	Burlington	Burlington
			R		Vona	Vona	Flagler	Flagler
Powers	71	Col.	T	Holly	Holly	Holly	Holly	Holly
			R	Holly	Holly	Holly	Holly	Holly
			R	Lamar	Lamar	Granda	Lamar	Lamar
			R			Lamar		
Yuma	72	Col.	T	Wray	Wray	Statton	Wray	Bonney Dam
			R	Wray	Wray	Wray	Wray	Bonney Dam
			R	Yuma	Idialia	Idialia	Idialia	Idialia
			R		Yuma	Yuma	Yuma	Yuma
Curry	73	N. M.	T	Clovis	Clovis	Clovis	Clovis	Clovis
			R	Clovis	Clovis	Clovis	Clovis	Clovis
			R		Bellview	Melrose	Clovis 13N	Clovis 13N
			R		Melrose		Melrose	Melrose

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Roosevelt	74	N. M.	T	Richland	Elida	Elida	Elida	Elida
			R	Portales	Elida	Elida	Elida	Elida
			R		Arch	Arch	Arch	Floyd
			R		Portales	Portales	Portales	Portales
Bailey	75	Texas	T	Lubbock	Lubbock	Muleshoe 1	Muleshoe	Muleshoe
			R	Muleshoe	Muleshoe	Muleshoe	Muleshoe	Muleshoe
Bee	76	Texas	T	Beeville	Beeville	Beeville	Beeville	Beeville
			R	Beeville	Beeville	Beeville	Beeville	Beeville
			R			Cadiz		
Bell	77	Texas	T	Taylor	Taylor	Temple	Temple	Temple
			R	Temple	Temple	Temple	Temple	Temple
			R			Troy	Killeen	Belton Dam
			R				Troy	Killeen
Bexar	78	Texas	T	San Antonio	San Antonio	San Antonio	San Antonio	San Antonio
			R	San Antonio	San Antonio	San Antonio	San Antonio	San Antonio
			R			Classens R.	San Antonio Nursez	Classens R
			R			Randolph F.	Classens R.	Clodine
Briscoe	79	Texas	T	Plainview	Plainview	Plainview	Tulia	Tulia
			R	Memphis	Floydada	Quitaque	Silverton	Ouitague
			R	Tulia	Tulia	Silverton	Ouitague	Silverton

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Carson	80	Texas	T	Dalhart	Dalhart	Dumas	Amarillo	Amarillo
			R	Canyon	Panhandle	Panhandle	Panhandle	Panhandle
			R	Dumas				
			R	Shamrock				
Castro	81	Texas	T	Plainview	Plainview	Herford 1	Tulia	Tulia
			R	Dimmit	Dimmit	Dimmit	Dimmit	Dimmit
			R					Hart
Cochran	82	Texas	T	Lubbock	Lubbock	Muleshoe 1	Levelland	Levelland
			R	Levelland	Muleshoe	Morton	Morton	Morton
			R	Muleshoe				
Collingsworth	83	Texas	T	Clarendon	Clarendon	Memphis	Memphis	Memphis
			R	Memphis	Memphis	Memphis	Memphis	Memphis
			R	Shamrock	Shamrock	Shamrock	Wellington	Wellington
Crosby	84	Texas	T	Lubbock	Lubbock	Crosbyton	Crosbyton	Crosbyton
			R	Crosbyton	Crosbyton	Crosbyton	Crosbyton	Crosbyton
Dallam	85	Texas	T	Dalhart	Dalhart	Dalhart	Dalhart	Dalhart
			R	Dalhart	Dalhart	Dalhart	Dalhart	Dalhart
			R			Bunker Hill	Coldwater	Coldwater
			R				Conlen	Conlen
Dawson	86	Texas	T	Seminole	Seminole	Lamesa	Lamesa	Lamesa
			R	Lamesa	Lamesa	Lamesa	Lamesa	Lamesa

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Table A-[illegible]2.—Continued

Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Deaf Smith	87	Texas	T	Plainview	Plainview	Herford 1	Herford 1	Herford 1
			R	Herford	Friona	Herford 1	Herford 1	Herford 1
Ellis	88	Texas	T	Hillsboro	Hillsboro	Waxahachie	Waxahachie	Waxahachie
			R	Waxahachie	Waxahachie	Waxahachie	Waxahachie	Waxahachie
			R			May Pearl	May Pearl	Ennis
			R			Midlothian	Midlothian	Midlothian
Floyd	89	Texas	T	Plainview	Plainview	Plainview	Plainview	Plainview
			R	Plainview	Floydada	Sterley	Floydada	Floydada
			R	Crosbyton			Floydada 9ESE	Floydada 9ESE
			R				Sterley	
Gaines	90	Texas	T	Seminole	Seminole	Seminole	Seminole	Seminole
			R	Seminole	Seminole	Seminole	Seminole	Seminole
			R				Loop	Loop
Garza	91	Texas	T	Lubbock	Lubbock	Crosbyton	Crosbyton	Crosbyton
			R	Post	Post	Post	Post	Post
Guadalupe	92	Texas	T	San Antonio	San Antonio	San Antonio	Seguin	Seguin
			R	Seguin	Seguin	Seguin	Seguin	Seguin
			R			LaVernia		
Hale	93	Texas	T	Plainview	Plainview	Plainview	Plainview	Plainview
			R	Plainview	Plainview	Plainview	Plainview	Plainview
			R			Abernathy	Hale Center	Abernathy
			R			Tuco Station	Tuco Station	

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Table A-[illegible]0.—Continued

Table A-20.—Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Hall	94	Texas	T	Clarendon	Clarendon	Memphis	Memphis	Memphis
			R	Memphis	Memphis	Memphis	Memphis	Memphis
			R			Brice	Tampico	Tampico
			R			Tampico	Turkey	
Hartley	95	Texas	T	Dalhart	Dalhart	Dalhart Exp.Sta.	Dalhart	Dalhart
			R	Dalhart	Dalhart	Dalhart Exp.Sta.	Channing	Bravo
			R	Dumas		Bravo	Bravo	
			R			Channing		
Haskell	96	Texas	T	Abilene	Abilene	Haskell	Knox City	Knox City
			R	Haskell	Haskell	Haskell	Haskell 6NW	Haskell 6NW
			R			Haskell 6NW	Haskell	Haskell
Hidalgo	97	Texas	T	Mercedes	Mercedes	McAllen	McAllen	McAllen
			T	Mercedes	Mercedes	McAllen	McAllen	McAllen
			R	Hidalgo	Hidalgo	Mission	Engleman G.	Engleman G.
			R	Mission	Mission	Engleman G.	Mission	Mission
Hill	98	Texas	T	Hillsboro	Hillsboro	Waco	Hillsboro	Hillsboro
			R	Hillsboro	Hillsboro	Waco	Hillsboro	Hillsboro
			R			Waxahachie		
Hockley	99	Texas	T	Lubbock	Lubbock	Levelland	Levelland	Levelland
			R	Levelland	Lubbock	Levelland	Levelland	Levelland

-Continued

Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Howard	100	Texas	T	Seminole	Big Spring	Big Spring	Big Spring	Big Spring
			R	Big Spring	Big Spring	Big Spring	Big Spring	Big Spring
			R				Ackerly	Ackerly
			R				Forsan	Forsan
Jim Wells	101	Texas	T	Corpus Christi	Corpus Christi	Alice	Alice	Alice
			R	Alice	Alice	Alice	Alice	Alice
Jones	102	Texas	T	Abilene	Abilene	Abilene	Abilene	Abilene
			R	Stamford	Stamford	Hamlin	Hamlin	Hamlin
			R			Stamford	Stamford	Stamford
			R				Truby	Truby
Knox	103	Texas	T	Abilene	Abilene	Knox City	Knox City	Knox City
			R	Knox City	Knox City	Knox City	Knox City	Knox City
			R	Munday	Munday	Benjamin	Benjamin	Benjamin
			R			Munday	Munday	Munday
Lamb	104	Texas	T	Lubbock	Lubbock	Muleshoe 1	Muleshoe 1	Muleshoe 1
			R	Littlefield	Muleshoe	Littlefield	Littlefield	Littlefield
Live Oak	105	Texas	T	Beeville	Beeville	Alice	Beeville	Beeville
			R	George West	George West	George West	George West	George West
			R	Three Rivers	Three Rivers	Three Rivers	Three Rivers	Three Rivers
			R	Whitsett	Whitsett	Whitsett	Whitsett	Whitsett
Lubbock	106	Texas	T	Lubbock	Lubbock	Lubbock	Lubbock	Lubbock
			R	Lubbock	Lubbock	Lubbock	Lubbock	Lubbock
			R					Lubbock W.B.

-Continued

Table A-20.—Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Lynn	107	Texas	T	Seminole	Seminole	Tahoka	Tahoka	Tahoka
			R	Tahoka	Tahoka	Tahoka	Tahoka	Tahoka
			R				Elaton	Elaton
McLennon	108	Texas	T	Waco	Waco	Waco	Waco	Waco
			R	Waco	Waco	Waco	Waco	Waco
			R	Hewitt	Hewitt	Hewitt	Hewitt	Hewitt
			R	McGregor	McGregor	McGregor	McGregor	McGregor
Martin	109	Texas	T	Seminole	Big Spring	Big Spring	Big Spring	Big Spring
			R	Big Spring	Big Spring	Big Spring	Big Spring	Big Spring
			R	Lamesa	Lamesa	Lamesa	Lenorah	Lenorah
Medina	110	Texas	T	San Antonio	San Antonio	San Antonio	Hondo	Hondo
			R	Hondo	Hondo	Hondo	Hondo	Hondo
			R	Riomedina	Riomedina	Riomedina	Revine	Riomedina
			R	Tarpley	Tarpley	Tarpley	Riomedina	
Milan	111	Texas	T	Taylor	Taylor	Cameron	Cameron	Cameron
			R	Cameron	Cameron	Cameron	Cameron	Cameron
			R			Burlington	Burlington	Burlington
			R				Davilla	Davilla
Moore	112	Texas	T	Dalhart	Dalhart	Dumas	Dumas	Dumas
			R	Dumas	Dalhart	Dumas	Dumas	Dumas
			R			Dumas 7NE		
			R			Middlewell		

-Continued

Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Nolan	113	Texas	T	Abilene	Abilene	Roscoe	Roscoe	Roscoe
			R	Roscoe	Roscoe	Roscoe	Roscoe	Roscoe
			R			Tesco	Tesco	Tesco
Nueces	114	Texas	T	Corpus Christi	Corpus Christi	Corpus Christi	Corpus Christi	Corpus Christi
			R	Corpus Christi	Corpus Christi	Corpus Christi	Corpus Christi	Corpus Christi
			R	Bishop	Bishop	Bishop	Bishop	Bishop W.B.
			R			Robstown	Robstown	Robstown
Parmer	115	Texas	T	Plainview	Plainview	Herford 1	Muleshoe	Muleshoe
			R	Friona	Friona	Herford 1	Friona	Hart
			R			Hart Jones R.		Herford 1
Randall	116	Texas	T	Plainview	Plainview	Herford 1	Amarillo	Amarillo
			R	Canyon	Canyon	Canyon	Canyon	Canyon
			R			Bushland	Umbarger	Umbarger
Refugio	117	Texas	T	Beeville	Beeville	Corpus Christi	Austwell W.L.	Austwell W.L.
			R	Austwell	Austwell	Austwell	Austwell W.L.	Woodsboro
			R	Woodsboro	Woodsboro	Refugio	Refugio	Refugio
			R			Woodsboro	Woodsboro	
Runnels	118	Texas	T	Abilene	Abilene	Ballinger	Ballinger	Ballinger
			R	Ballinger	Ballinger	Ballinger	Ballinger	Ballinger
			R			Winters	Winters	Winters
San Patricio	119	Texas	T	Beeville	Beeville	Corpus Christi	Corpus Christi	Corpus Christi
			R	Sinton	Sinton	Araness Pass	Aranass Pass	Sinton
			R				Sinton	

-Continued

Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Surry	120	Texas	T	Abilene	Abilene	Snyder	Snyder	Snyder
			R	Snyder	Snyder	Snyder	Snyder	Snyder
Swisher	121	Texas	T	Plainview	Plainview	Plainview	Tulia	Tulia
			R	Tulia	Happy	Kress	Tulia	Tulia
			R		Tulia	Tulia		
Taylor	122	Texas	T	Abilene	Abilene	Abilene	Abilene	Abilene
			R	Abilene	Abilene	Abilene	Abilene	Abilene
			R				Lawn	Lawn
			R				Trent	Trent
Terry	123	Texas	T	Seminole	Seminole	Levelland	Levelland	Levelland
			R	Brownfield	Brownfield	Brownfield	Brownfield	Brownfield
Tom Green	124	Texas	T	San Angelo	Abilene	San Angelo	San Angelo	San Angelo
			R	San Angelo	Ballinger	San Angelo	San Angelo	San Angelo
			R			Christoval	Christoval	Christoval
			R				Water Valley	Water Valley
Travis	125	Texas	T	Austin	Austin	Austin	Austin	Austin
			R	Austin	Austin	Austin	Austin	Austin
			R			Manchaca	Manchaca	Manchaca
			R			Phlugerville	Phlugerville	Phlugerville

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Table A-20.--Continued

County	County number	State	Weather factor a/	Weather Stations 1939	1944	1949	1954	1959
Wheeler	126	Texas	T	Clarendon	Clarendon	Memphis	Memphis	Miami
			R	Shamrock	Shamrock	Shamrock	Miami	Miami
			R				Mobeetie	Mobeetie
			R				Shamrock	Shamrock
Willacy	127	Texas	T	Mercedes	Mercedes	Raymondville	Raymondville	Raymondville
			R	Raymondville	Raymondville	Raymondville	Raymondville	Raymondville
			R					Port Mansfield
Williamson	128	Texas	T	Taylor	Taylor	Taylor	Taylor	Taylor
			R	Taylor	Taylor	Taylor	Taylor	Taylor
			R			Janell	Janell	Janell
			R			Liberty Hill	Liberty Hill	Liberty Hill
Yoakum	129	Texas	T	Seminole	Seminole	Seminole	Plains	Plains
			R	Seminole	Seminole	Plains	Plains	Plains
			R	Brownfield	Brownfield			

a/ Weather factors, T = temperature, R = rainfall.

The Basic Data

Tables containing the following data by year and by county have been prepared and are available from the author. Data included are: Acres of grain sorghum harvested for grain or seed; production of grain sorghum in hundredweight; yield per acre; number of farms harvesting grain sorghum; number of tractors; acres of grain sorghum irrigated; acres of cropland harvested; value of land per acre; acres fallowed; total expense for gas, oil and lubricants; acres of grain sorghum harvested per farm harvesting sorghum for grain or seed; acres of cropland harvested per tractor; percent of grain sorghum acreage irrigated; and dollars spent on gas, oil and lubricants per acre.

APPENDIX B

The results of the regression analysis are presented in the following table.

The equations are presented in numerical order. The variables in the equation are also presented in numerical order. However, if some variables are not considered in any equations presented on a particular page, they were dropped from the list.

The smallest degree of freedom available for the test of significance (t test) of the estimated coefficient was 536. Thus, the values listed for infinite degrees of freedom in the table of percentiles of the t distribution, as presented in Table A-5 (page 384) of "Introduction to Statistical Analysis," 2d ed., by Dixon and Massey, were used.

In order to conserve space, the following symbols (appearing as superscripts to the coefficients in the table) were used to indicate the levels of significance of the estimated coefficients. In all cases the hypothesis tested is:

$$H_0 : b_i = 0$$

$$H_A : b_i \neq 0$$

and the level at which the null hypothesis was rejected is indicated by:

$$a = t_b \geq 2.576 = \alpha \leq .01$$

$$b = 1.960 \leq t_b \leq 2.575 = .01 < \alpha \leq .05$$

$$c = 1.645 \leq t_b \leq 1.959 = .05 < \alpha \leq .10$$

where α is the probability of rejecting the null hypothesis when it is true.

Also to conserve space, the variables are identified by numbers rather than by names. The numbers are keyed to the list of variables as follows.

It should be noted that the coefficients for variables 84-110 have a different meaning in some equations than in others. The reason for this is that crop reporting district 9 is omitted in some equations and crop reporting district 19 is omitted in others. When district 9 was omitted, the space following variable number 92 (see list below) would be blank and the space following number 101-A would be occupied. If district 19 was omitted, the space following variable number 92 would be occupied and that following 101-A would be blank. The coefficients for crop reporting districts from equations with district 9 omitted can be compared to those with district 19 omitted by subtracting a constant equal to the coefficient for district 19 from the overall constant term and from the coefficients for all other districts (including district 9 which has a value of zero) in the equation in which district 9 had been omitted. This was not done here because statements of significance cannot be made after the coefficients are transformed.

Variable No.	Variable
0	Constant term
1	Pounds of grain sorghum per acre of grain sorghum harvested
2	Percent of grain sorghum acreage irrigated
3	Average acres of grain sorghum harvested per farm harvesting grain sorghum
4	Number of acres of cropland harvested per tractor
4-A	Number of tractors per acre of cropland harvested
5	Dollars spent on gas and oil per acre of cropland harvested

Variable No.	Variable
6	Per acre value of land
7	Man-hours of labor per acre of grain sorghum
8	Acres cultivated summer fallow
8-A	Ratio acres cultivated summer fallow to acres of cropland harvested
9	Pounds of fertilizer nutrients applied per acre of grain sorghum
10	1959
11	1954
12	1949
13	1944
14	Preseason precipitation
15	Precipitation, 1st period week
16	Precipitation, 2d period week
17	Precipitation, 3d period week
18	Precipitation, 4th period week
19	Precipitation, 5th period week
20	Precipitation, 6th period week
21	Precipitation, 7th period week
22	Precipitation, 8th period week
23	Precipitation, 9th period week
24	Precipitation, 10th period week
25	Precipitation, 11th period week
26	Precipitation, 12th period week
27	Precipitation, 13th period week
28	Precipitation, 14th period week
29	Precipitation, 15th period week

Variable No.	Variable
30	Precipitation 16th period week
31	Precipitation, 17th period week
32	Precipitation, 18th period week
33	Precipitation, 19th period week
34	Precipitation, 20th period week
35	Precipitation, 21st period week
36	Precipitation, 22d period week
37	Precipitation, 23d period week
38	Total temperature, 1st period week
39	Total temperature, 2d period week
40	Total temperature, 3d period week
41	Total temperature, 4th period week
42	Total temperature, 5th period week
43	Total temperature, 6th period week
44	Total temperature, 7th period week
45	Total temperature, 8th period week
46	Total temperature, 9th period week
47	Total temperature, 10th period week
48	Total temperature, 11th period week
49	Total temperature, 12th period week
50	Total temperature, 13th period week
51	Total temperature, 14th period week
52	Total temperature, 15th period week
53	Total temperature, 16th period week
54	Total temperature, 17th period week

Variable No.	Variable
55	Total temperature, 18th period week
56	Total temperature, 19th period week
57	Total temperature, 20th period week
58	Total temperature, 21st period week
59	Total temperature, 22d period week
60	Total temperature, 23d period week
61	Interaction, 1st period week
62	Interaction, 2d period week
63	Interaction, 3d period week
64	Interaction, 4th period week
65	Interaction, 5th period week
66	Interaction, 6th period week
67	Interaction, 7th period week
68	Interaction, 8th period week
69	Interaction, 9th period week
70	Interaction, 10th period week
71	Interaction, 11th period week
72	Interaction, 12th period week
73	Interaction, 13th period week
74	Interaction, 14th period week
75	Interaction, 15th period week
76	Interaction, 16th period week
77	Interaction, 17th period week
78	Interaction, 18th period week
79	Interaction, 19th period week
80	Interaction, 20th period week

Variable No.	Variable
81	Interaction, 21st period week
82	Interaction, 22d period week
83	Interaction, 23d period week
84	Crop reporting district 1
85	Crop reporting district 2
86	Crop reporting district 3
87	Crop reporting district 4
88	Crop reporting district 5
89	Crop reporting district 6
90	Crop reporting district 7
91	Crop reporting district 8
92	Crop reporting district 9
93	Crop reporting district 10
94	Crop reporting district 11
95	Crop reporting district 12
96	Crop reporting district 13
97	Crop reporting district 14
98	Crop reporting district 15
99	Crop reporting district 16
100	Crop reporting district 17
101	Crop reporting district 18
101-A	Crop reporting district 19
102	Crop reporting district 20
103	Crop reporting district 21
104	Crop reporting district 22

Variable No.	Variable
105	Crop reporting district 23
106	Crop reporting district 24
107	Crop reporting district 25
108	Crop reporting district 26
109	Crop reporting district 27
110	Crop reporting district 28
111	Growing season 1
112	Growing season 3
113	Growing season 4
114	Growing season 5
115	Growing season 6
116	Growing season 7
117	0th degree term, precipitation polynomial
118	1st degree term, precipitation polynomial
119	2d degree term, precipitation polynomial
120	3d degree term, precipitation polynomial
121	4th degree term, precipitation polynomial
122	5th degree term, precipitation polynomial
123	6th degree term, precipitation polynomial
124	7th degree term, precipitation polynomial
125	0th degree term, temperature polynomial
126	1st degree term, temperature polynomial
127	2d degree term, temperature polynomial
128	3d degree term, temperature polynomial
129	4th degree term, temperature polynomial
130	5th degree term, temperature polynomial

Variable No.	Variable
131	6th degree term, temperature polynomial
132	7th degree term, temperature polynomial
133	0th degree term, interaction polynomial
134	1st degree term, interaction polynomial
135	2d degree term, interaction polynomial
136	3d degree term, interaction polynomial
137	4th degree term, interaction polynomial
138	5th degree term, interaction polynomial
139	6th degree term, interaction polynomial
140	7th degree term, interaction polynomial

Table B, Part 1

Variable number	Equation number 1	2	3	4	5	6	7	8
R^2------:	.783	.782	.781	.768	.767	.764	.626	.531
$\bar{R}^2$------:	.759	.758	.758	.745	.743	.740	.590	.489
D.F.----:	580	581	581	584	585	585	588	592
0-------:	2935[a]	2234[b]	3101[a]	3833[a]	4005[a]	3555[a]	5085[a]	7778[a]
2-------:	1855[a]	1862[a]	1814[a]	1872[a]	1832[a]	1843[a]		
3-------:	-.368	-.340	-.216	.019	.151	.276		
4-------:	.341[c]	.357[b]		.342[c]		.176		
5-------:	-20.1	-20.7	-21.8	-11.4	-13.3	-.54		
6-------:	3.0[a]	3.1[a]	3.1[a]	3.3[a]	3.3[a]	3.9[a]		
7-------:	-39.6		-41.0	-27.8[a]	-23.3[a]			
8-------:	.0002	.0001	.0003	.0002	.0002	.0004		
9-------:	13.3[a]	13.3[a]	13.3[a]	13.5[a]	13.4[a]	15.7[a]		
10------:	297	561[a]	252				981[a]	
11------:	91.9	327[a]	47.6				631[a]	
12------:	242	432[a]	222				609[a]	
13------:	400[a]	383[a]	403				389[a]	
14------:	.211[a]	18.8[a]	.204[a]	.291[a]	.282[a]	26.9[a]	13.1[b]	17.6[a]
84------:	479[a]	502[a]	487[a]	440[b]	449[a]	430[a]	18.1	-258
85------:	559[a]	579[a]	577[a]	519[a]	537[a]	509[a]	82.9	-262[c]
86------:	128	145	138	154	166	152[a]	-426[a]	-696[a]
87------:	-67	-58.8	-49.8	-82.4	-64.4	-73.1	-763[a]	-976[a]
88------:	4.5	18.0	13.1	-42.5	-34.8	-11.2	-668[a]	-886[a]
89------:	138	169	145	27.9	33.8	80.4	-468[a]	-599[a]
90------:	-32.6	-34.2	-15.4	-51.2	-32.8	-56.4	-647[a]	-852[a]
91------:	-81.7	-80.5	-78.1	-105	-100	-112	-555[a]	-727[a]
92------:		119				57.1	-447[b]	-627[a]
93------:	-90.1	-98.3	-74.1	-104	-83.0	-132	-640[a]	-773[a]
94------:	-234[c]	-231[a]	-225[c]	-278[b]	-267[b]	-287[a]	-674[a]	-864[a]
95------:	-104	-87.3	-101	-176	-169	-168	-623[a]	-772[a]
96------:	-180	-184[c]	-153	-134	-103	-127	-801[a]	-863[a]
97------:	-497	-45.4	-45.1	17.0	24.8	41.3	-552[a]	-457[b]
98------:	-295	-290[c]	-282	-245	-228	-220	-763[a]	-713[a]
99------:	-204	-249[c]	-184	-125	-109	-197	-965[a]	-1219[a]
100-----:	-123	-164	-109	-12.0	-.894	-84.9	-622[a]	-804[a]
101-----:	20.2	-50.3	33.1	52.7	56.1	11.8	-640[a]	-626[a]
102-----:	23.3	-49.5	47.5	31.8	58.6	41.0	-395[a]	-364[a]
103-----:	-35.4	-99.1	-29.3	96.1	105	24.0	-615[a]	-691[a]
104-----:	-90.2	42.1	-83.8	49.7	57.7	250[c]	-418[a]	-306
104-A---:	25.6		26.6	248	258			

-Continued

Table B, Part 1.--Continued

Variable number	Equation number 1	2	3	4	5	6	7	8
105------	336	362[c]	336	536[b]	546[b]	524[b]	-123	-156
106------	230	273	231	369[c]	384[c]	336[c]	48.9	-100
107------	78.4	135	97.6	217	249	204	-184	-283
108------	568[b]	632[a]	559[b]	614[a]	621[a]	561[a]	322	162
109------	248	292	242	365	371	332	-83.3	-265
110------	-134	-89.6	-138	-27.2	-12.3	-99.7	32.0	17.4
117------	-4177[a]	-4125[a]	-4089[a]	-4151[a]	-4069[a]	-3790[a]	-4702[a]	-3989[a]
118------	5531[a]	5594[a]	5449[a]	5427[a]	5371[a]	5071[a]	6076[a]	4598[a]
119------	-2356[a]	-2412[a]	-2327[a]	-2306[a]	-2293[a]	-2161[a]	-2623[a]	-1818[a]
120------	46.1[a]	476[a]	456[a]	452[a]	451[a]	424[a]	523[a]	342[a]
121------	-47.1[a]	-48.9[a]	-46.5[a]	-46.2[a]	-46.1[a]	-43.4[a]	-54.5[a]	-34.1[b]
122------	2.6[a]	2.7[a]	2.6[a]	2.5[a]	2.5[a]	2.4[a]	3.1[a]	1.8[b]
123------	-.072[a]	-.075[a]	-.071[a]	-.070[a]	-.070[a]	-.066[a]	-.087[a]	-.050[b]
124------	.001[a]	.001[a]	.0008[a]	.001[a]	.001[a]	.001[a]	.001[a]	.0005[c]
125------	-6.6[a]	-5.9[b]	-6.2[b]	-5.3[b]	-4.9[b]	-4.2[c]	-11.4[a]	-11.8[a]
126------	10.3[a]	9.4[a]	9.9[a]	8.2[a]	7.7[b]	6.2[b]	16.9[a]	13.4[a]
127------	-4.6[a]	-4.2[a]	-4.4[a]	-3.6[a]	-3.3[b]	-2.6[b]	-7.7[a]	-5.2[a]
128------	.924[a]	.832[a]	.887[a]	.691[a]	.640[b]	.465[c]	1.6[a]	.943[a]
129------	-.096[a]	-.086[a]	-.093[a]	-.069[b]	-.063[b]	-.043	-.168[a]	-.092[b]
130------	.005[a]	.005[a]	.005[a]	.004[b]	.003[b]	.002	.010[a]	.005[b]
131------	-.0002[a]	-.0001[a]	-.0002[a]	-.0001[b]	-.0001[c]	-.0001	-.0003[a]	-.0001[b]
132------	$2x10^{-6}$[a]	$2x10^{-6}$[a]	$2x10^{-6}$[a]	$1x10^{-6}$[b]	$1x10^{-6}$[c]	$1x10^{-6}$	$3x10^{-6}$[a]	$2x10^{-6}$[a]
133------	7.2[a]	7.0[a]	7.0[a]	7.0[a]	6.9[a]	6.4[a]	8.0[a]	6.7[a]
134------	-9.3[a]	-9.4[a]	-9.2[a]	-9.0[a]	-8.9[a]	-8.4[a]	-10.0[a]	-7.5[a]
135------	3.9[a]	4.0[a]	3.9[a]	3.8[a]	3.7[a]	3.5[a]	4.3[a]	2.9[a]
136------	-.761[a]	-.785[a]	-.753[a]	-.729[a]	-.727[a]	-.686[a]	-.846[a]	-.538[b]
137------	.077[a]	.080[a]	.076[a]	.074[a]	.074[a]	.070[a]	.088[a]	.053[b]
138------	-.004[a]	-.004[a]	-.004[a]	-.004[a]	-.004[a]	-.004[a]	-.005[a]	-.003[b]
139------	.0001[a]	.0001[a]	.0001[a]	.0001[a]	.0001[a]	.0001[a]	.0001[a]	.0001[c]
140------	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$	$-2x10^{-6}$[a]	$-1x10^{-6}$[c]

Table B, Part 2

Variable number	Equation number 9	10	11	12	13	14	15	16
R^2------:	.736	.502	.614	.623	.752	.758	.761	.760
$\bar{R}^2$------:	.713	.466	.583	.592	.731	.737	.739	.738
D.F.----:	593	600	596	595	593	592	591	589
0-------:	2990[a]	7095[a]	2603[b]	2947[a]	1821[b]	1240	2175[b]	1211
2-------:	1759[a]				1963[a]	1708[a]	1741[a]	1815[a]
3-------:	.204			-1.0[a]	-.408[c]	-.291	-.247	-.422[c]
4-------:	.128							.354[c]
5-------:	-5.8							-21.5
6-------:	3.7[a]					2.5[a]	2.5[a]	2.5[a]
7-------:							-62.8[a]	
8-------:	.0003							.0001
9-------:	18.5[a]				14.4[a]	14.2[a]	14.2[a]	15.2[a]
10------:			1014[a]	1131[a]	698[a]	597[a]	168	647[a]
11------:			515[a]	605[a]	255[a]	178[a]	-198	227[a]
12------:			544[a]	584[a]	340[a]	330[a]	46.7	367[a]
13------:			360[a]	433[a]	329[a]	323[a]	364[a]	332[a]
14------:	21.2[a]	12.5[c]	.124[b]	.105[c]	.178[a]	.159[a]	.187[a]	15.7[a]
84------:	293[b]	-339[c]	574[a]	536[b]	597[a]	524[a]	505[a]	386[a]
85------:	352[a]	-337[b]	606[a]	580[a]	592[a]	572[a]	564[a]	425[a]
86------:	96.3	-692[a]	163	132	186	218	208	77.0
87------:	-91.1	-943	-89.0	-77.7	60.8	84.2	92.9	-67.6
88------:	-128	-932[a]	-88.3	-104	31.5	36.0	37.3	-98.4
89------:	-169	-761[a]	54.4	42.4	112	82.7	70.6	-43.6
90------:	-41	-804[a]	17.0	75.2	112	131	137	-20.3
91------:	-169[c]	-743[a]	22.2	13.9	60.3	-12.9	-5.6	-146
92------:	-85.9	-663[a]						-39.2
93------:	-102	-717[a]	18.2	178	97.7	87.9	94.5	-69.3
94------:	-334[a]	-862[a]	-97.7	-89.9	-61.4	-153	-147	-294[a]
95------:	-224	-745[a]	-38.4	-27.1	-58.6	-85.5	-86.6	-172
96------:	123	-848[a]	-171	-81.8	-24.1	-14.3	-8.4	-188[c]
97------:	-22.6	-475[b]	15.1	17.2	93.6	10.9	15.7	-129
98------:	-189[c]	-626[a]	-147	-134	-127	-173	-168	-310[c]
99------:	-230	-1200[a]	-374[c]	-342[c]	-206	-136	-50.4	-296[b]
100-----:	-119	-796[a]	-58.1	-11.1	-155	-64.5	12.1	-221
101-----:	-52.7	-694[a]	-28.2	62.3	14.3	44.7	144	-102
102-----:	26.3	-392[a]	663[a]	786[a]	188	192	191	-88.5
103-----:	-25.3	-738[a]	142	236	127	57	66	-188[c]
104-----:	225	-306	-147	-116	-60.2	-50	-39	-38.1
104-A---:			68.3	86.7	130	107	82.5	

-Continued

Table B, Part 2.--Continued

Variable number	Equation number							
	9	10	11	12	13	14	15	16
105-----	569[b]	-33.7	420	443	450[c]	466[c]	426[b]	328
106-----	393[c]	13.1	518[b]	520[c]	434[b]	383[c]	335	245
107-----	301	-177	336	354	304	273	203	138
108-----	655[a]	253	879[a]	989[a]	859[a]	761[a]	676[a]	646[a]
109-----	428[c]	-157	485	533[c]	394	418[c]	364	298
110-----	123	208	631[b]	671[b]	353	147	66.9	44.0
117-----	-232[a]	-289[a]	-204[b]	-199[b]	-144[c]	-157[b]	-145[b]	-167[b]
118-----	399[a]	491[a]	393[a]	377[a]	278[a]	295[a]	283[a]	298[a]
119-----	-183[a]	-220[a]	-187[a]	-178[a]	-131[a]	-140[a]	-136[a]	-140[a]
120-----	36.4[a]	42.7[a]	38.1[a]	36.1[a]	26.1[a]	28.2[a]	27.5[a]	28.0[a]
121-----	-3.7[a]	-4.2[a]	-4.0[a]	-3.7[a]	-2.6[a]	-2.8[a]	-2.8[a]	-2.8[a]
122-----	.179[a]	.224[a]	.221[a]	.206[a]	.137[a]	.151[a]	.149[a]	.151[a]
123-----	-.005[a]	-.006[a]	-.006[a]	-.006[a]	-.004[b]	-.004[a]	-.004[a]	-.004[a]
124-----	.0001[a]	.0001[b]	.0001[a]	.0001[a]	.00004[b]	.00004[b]	.00004[b]	.00004[b]
125-----	-1.3	-9.7[a]	-7.6[a]	-7.5[a]	-1.2	-1.4	-2.2	-1.5
126-----	1.7	10.8[a]	11.4[a]	11.3[a]	2.4	2.6	4.0	2.8
127-----	-.488	-40[b]	-5.2[a]	-5.2[a]	-1.2	-1.2	-1.9[b]	-1.3
128-----	.034	.670[b]	1.1[a]	1.1[a]	.237	.230	.405	.254
129-----	.002	-.061[c]	-.117[a]	-.116[a]	-.025	-.024	-.044	-.027
130-----	-.0004	.003	.007[a]	.007[a]	.001	.001	.003	.002
131-----	.00002	-.0001	-.0003[a]	-.0002[a]	-.00004	-.00004	-.0001	-.00004
132-----	$-2\text{x}10^{-7}$	$1\text{x}10^{-6}$	$2\text{x}10^{-6}$[a]	$2\text{x}10^{-6}$	$1\text{x}10^{-6}$	$5\text{x}10^{-7}$	$1\text{x}10^{-6}$	$1\text{x}10^{-6}$

Table B, Part 3

Variable Number	Equation number 17	18	19	20	21	22	23	24
R^2	.762	.763	.762	.762	.762	.761	.759	.758
$\bar{R}^2$	.739	.740	.739	.740	.740	.740	.738	.738
D.F.	589	588	589	590	591	592	593	594
0	2088[a]	1920[a]	1534[a]	1531[a]	1614[a]	1637[a]	1380[a]	1397[a]
2	1780[a]	1817[a]	1842[a]	1841[a]	1844[a]	1845[a]	1824[a]	1829[a]
3	-.271	-.408	-.400	-.400	-.408	.389	-.366	-.375
4		.318[c]	.299	.298	.296	.301[c]	.311[c]	.317[c]
5	-22.4	-20.7	-20.9	-20.9	-21.0	-20.7	-20.4	-20.1
6	2.6[a]	2.6[a]	2.6[a]	2.6[a]	2.6[a]	2.6[a]	2.7[a]	2.7[a]
7	-63.4[a]	-61.4[a]	-47.8[b]	-47.6[b]	-48.5[b]	-51.9[b]	-52.3[b]	-49.0[b]
8	.0002	.0001	.00007	.00007	.00008	.0001	.00004	.00004
9	15.2[a]	15.1[a]	15.3[a]	15.3[a]	15.5[a]	15.2[a]	14.7[a]	14.7[a]
10	180	226	287	288	291	262	269	277
11	-190	-144	-95.2	-93.6	-102	-110	-127	-123
12	60.7	85	98.9	99.6	88.2	85.6	77.5	86.0
13	374[a]	372[a]	341[a]	340[a]	341[a]	330[a]	314[a]	303[a]
14	18.8[b]	19.4[a]	17.8[a]	17.8[a]	17.6[a]	17.8[a]	18.1[a]	18.3[a]
84	504[a]	497[a]	520[a]	521[a]	520[a]	525[a]	570[a]	554[a]
85	561[a]	546[a]	558[a]	559[a]	559[a]	564[a]	624[a]	608[a]
86	203	194	212	212	212	216	272[c]	257[c]
87	80.8	67.6	71.8	73.0	72.8	61.3	58.8	42.3
88	38.4	31.8	40.1	40.7	41.5	35.6	28.5	15.1
89	75.0	68.7	81.3	81.4	84.0	76.7	86.6	77.4
90	132	118	123	124	125	117	115	103
91	-9.3	-11.8	-10.9	-10.5	-8.5	-12.9	-32.3	-43.8
92	97.8	74.2	71.7	72.1	74.4	64.9	57.0	49.6
93	-156	-163	-167	-166	-166	-172	-190	-201
94	-52.5	-53.7	-47.4	-47.1	-49.8	-54.5	-50.8	-57.6
95	-24.6	-48.6	-51.2	-51.0	-50.6	-58.9	-61.8	-67.2
96	2.5	-1.6	.719	.400	.313	-5.2	-20.8	-19.4
97	-176	-185	-179	-180	-181	-183	-184	-180
98	-68.5	-88.4	-81.0	-80.1	-80.5	-76.8	-24.7	-40.2
99	-8.9	-21.3	-14.0	-13.5	-12.8	-4.9	28.4	18.3
100	149	138	122	121	122	125	145	142
101	181	160	150	149	148	145	151	151
102	61.8	56.4	51.8	50.9	49.9	64.4	68.0	80.8
103	-47.1	-54.8	-53.3	-54.1	-52.2	-37.5	-33.4	-28.9
104	62.1	59.1	66.0	64.0	61.6	59.2	91.1	101

-Continued

Table B, Part 3.--Continued

Variable number	Equation number							
	17	18	19	20	21	22	23	24
105------	413[c]	412[c]	421[c]	419[b]	414[c]	409[c]	432[c]	446[c]
106------	306	303	302	299	302	301	339	355
107------	194	180	215	212	212	217	245	267
108------	664[a]	674[a]	708[a]	705[a]	704[a]	713[a]	732[a]	756[a]
109------	351	357	365	362	359	372	413[c]	434[c]
110------	75.5	81.0	111	108	108	112	98.9	124
117------	-142[c]	-152[b]	-137[c]	-137[c]	-131[c]	-131[c]	-132[c]	-135[c]
118------	278[a]	284[a]	258[a]	259[a]	252[a]	253[a]	247[a]	247[a]
119------	-134[a]	-135[a]	-121[a]	-121[a]	-119[a]	-120[a]	-116[a]	-116[a]
120------	27.1[a]	27.2[a]	23.8[a]	23.9[a]	23.5[a]	23.9[a]	23.3[a]	23.2[a]
121------	-2.7[a]	-2.8[a]	-2.3[a]	-2.3[a]	-2.3[a]	-2.3[a]	-2.3[a]	-2.3[a]
122------	.147[a]	.148[a]	.120[b]	.120[b]	.119[b]	.122[b]	.123[b]	.123[b]
123------	-.004[b]	-.004[b]	-.003[b]	-.003[b]	-.003[b]	-.003[b]	-.003[b]	-.003[b]
124------	.00004[b]	.00004[b]	.00003[c]	.00003[c]	.00003[c]	.00003[c]	.00003[c]	.00003[c]
125------	-2.2	-2.4	.690	.613	.901	1.2[a]	.263	.106
126------	4.0	4.2	-.119	-.025	-.286	-.500[a]	-.048	-.014
127------	-1.9	-2.0[c]	-.025	-.058	.010	.048[b]	.001	
128------	.406	.429[c]	.003	.008	.001	-.001[b]		
129------	-.044	-.047[c]	-.00002	-.0004	-.00005			
130------	.003	.003[c]	-.000007	.000006				
131------	-.0001	-.0001[c]	.0000002					
132------	.000001	.000001						

Table B, Part 4

Variable number	Equation number							
	25	26	27	28	29	30	31	32
R^2------	.758	.758	.756	.749	.748	.746	.745	.743
$\bar{R}^2$------	.738	.738	.737	.730	.729	.728	.727	.725
D.F.----	595	596	597	598	599	600	601	602
0-------	1390	608[b]	635[b]	666[b]	692[b]	647[b]	600[b]	440
2-------	1837[a]	1836[a]	1858[a]	1860[a]	1858[a]	1866[a]	1837[a]	1881[a]
3-------	-.370	-.357	-.388	-.342	-.358	-.360	-.416[c]	.350
4-------	.319[c]	.330[c]	.334[c]	.366[b]	.409[b]	.456[b]	.476[a]	.484[a]
5-------	-20.9	-21.8	-24.0	-23.0	-23.8	-22.8	-23.4	-24.1
6-------	2.7[a]	2.8[a]	2.7[a]	2.8[a]	2.8[a]	2.7[a]	2.7[a]	2.7[a]
7-------	-52.0[b]	-50.8[b]	-56.2[a]	-56.4[b]	-59.0[a]	-55.4[b]	-52.8[b]	-42.6[b]
8-------	.0001	.0002	.0001	.0002	.0002	.0001	.0001	.0002
9-------	14.9[a]	15.1[a]	15.0[a]	14.9[a]	15.2[a]	14.9[a]	15.1[a]	14.7[a]
10------	258	288	279	282	287	306[c]	341[c]	382[b]
11------	-152	-146	-170	-167	-183	-142	-94.9	-61.5
12------	74.2	115	105	96.3	68.4	73.2	100	109
13------	309[a]	326[a]	361[a]	351[a]	351[a]	340[a]	357[a]	338[a]
14------	18.1[a]	19.1[a]	19.6[a]	17.2[a]	16.5[a]	16.7[a]	16.5[a]	17.7[a]
84------	552[a]	590[a]	595[a]	543[a]	526[a]	505[a]	512[a]	539[a]
85------	599[a]	633[a]	630[a]	573[a]	550[a]	529[a]	540[a]	561[a]
86------	247[c]	275[b]	278[c]	244[c]	231	219	228	251[c]
87------	58.7	79.8	107	85.9	97.7	93.8	104	121
88------	35.2	56.3	69.3	51.9	48.2	38.2	66.5	77.4
89------	97.2	116	128	46.2	22.9	14.8	45.3	68.1
90------	117	134	164	152	163	157	176	192
91------	-30.9	-29.0	-6.8	-32.7	-24.6	-28.2	-8.6	10.3
92------	60.1	62.2	96.5	61.2	78.6	77.8	96.0	109
93------	-192	-195	-175	-204	-188	-192	-170	-158
94------	-54.1	-61.5	-39.8	-80.0	-52.2	-57.5	-34.0	-33.2
95------	-65.4	-67.3	-39.9	-83.4	-64.4	-69.4	-63.8	-41.6
96------	-19.5	-49.5	-23.5	-79.5	-66.9	-72.2	-61.1	-67.4
97------	-184	-223	-202	-242	-231	-241	-219	-236
98------	-65.0	-37.2	-1.7	-43.3	-43.1	-38.6	-50.4	-51.4
99------	-16.6	.889	31.5	2.9	6.9	6.1	-2.3	-30
100-----	156	169	196	175	164	148	148	172
101-----	157	162	183	143	144	131	141	166
102-----	61.8	55.8	63.0	14.2	20.9	15.1	24.3	34.3
103-----	-59.4	-64.6	-65.4	-102	-101	-105	-98.3	-95.4
104-----	5.0	-21.1	-13.8	-67.9	-68.8	-87.5	-94.8	-62.0

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Table B, Part 4.--Continued

Variable number	Equation number 25	26	27	28	29	30	31	32
105	308	308	352[c]	265	251	250	227	267
106	202	181	210	103	100	113	75.0	97.7
107	109	100	113	50.9	57.9	46.1	39.3	80.6
108	603[a]	610[a]	631[a]	590[a]	597[a]	595[a]	609[a]	637[a]
109	276[c]	279[c]	308[c]	250	255	263	265	297[c]
110	-22.5	-38.6	7.5	-65.8	-53.8	-57.9	-28.2	17.6
117	-145[b]	-145[b]	-39.6	102[a]	56.6[b]	27.4	-.672	21.5[b]
118	253[a]	254[a]	104[b]	-70.1[a]	-27.9[c]	-6.7	5.8[b]	.254
119	-118[a]	-119[a]	-49.1[a]	16.1[b]	5.0[b]	1.1	-.248[b]	
120	23.7[a]	24.0[a]	9.0[a]	-1.5[b]	-.293[c]	-.038[c]		
121	-2.4[a]	-2.4[a]	-.758[a]	.061[b]	.005[c]			
122	.126[b]	.129[a]	.030[a]	-.0009[c]				
123	.003[b]	-.003[b]	-.0004[a]					
124	-.00004[b]	.00004[b]						
125	-.051							

Table B, Part 5

Variable number	Equation number 33	34	35	36	37	38	39	40
R^2	.743	.728	.569	.578	.582	.583	.585	.586
$\bar{R}^2$	.725	.710	.547	.555	.558	.559	.561	.561
D.F.	603	604	612	611	610	609	608	607
0	458	889[a]	531[a]	221	178	208	225	222
2	1800[a]	1776[a]						
3	.353	-.463[c]						
4	.475[a]	.455[b]						
5	-23.9	-26.9						
6	2.7[a]	3.0[a]						
7	-44.5[b]	-46.8[b]						
8	.0003	.0002						
9	14.6[a]	14.4[a]						
10	375[b]	489[a]	1125[a]	1029[a]	1072[a]	1094[a]	1085[a]	1095[a]
11	-70.1	-73.1	368[a]	364[a]	387[a]	406[a]	379[a]	368[a]
12	98.9	24.5[b]	557[a]	438[a]	435[a]	446[a]	452[a]	464[a]
13	341[a]	494[a]	446[a]	352[a]	366[a]	374[a]	355[a]	363[a]
14	17.8[a]	15.6[a]	9.3	10.4[c]	10.0[c]	9.0	9.1	8.7
84	539[a]	480[a]	633[a]	666[a]	660[a]	640[a]	634[a]	653[a]
85	563[a]	547[a]	627[a]	632[a]	638[a]	621[a]	608[a]	625[a]
86	249[c]	140	151	236	228	210	198	208
87	117	-49.6	-91.9	47.2	33.0	8.2	-5.8	-.630
88	75.4	5.0	-19.7	33.6	21.2	11.7	-23.2	-14.6
89	65.1	188	248	146	121	105	69.2	77
90	190	37.9	35.7	169	163	138	116	121
91	10.4	-78.5	9.1	72.5	71.9	54.7	32.9	37.2
92	108	-52.8	-27.1	121	111	85.1	69.5	68.5
93	-158	-232[c]	-131	-80.5	-80.4	-92.5	-117	-113
94	-31.4	-21.6	-44.8	-50.6	-33.5	-33.4	-59.6	-55.5
95	-43.3	-234	-297	-133	-141	-170	-176	-173
96	-69.2	-162	-122	-58.8	-73.9	-69.1	-81.3	-76.0
97	-234	-307	-304	-250	-235	-223	-249	-241
98	-50	-259	-452	-269	-263	-290	-283	-291
99	-2.6	-201	-155	30.9	31.0	1.9	6.1	3.6
100	178	19.5	-73.3	71.2	94.1	55.2	52.6	58.7
101	169	9.2	580[a]	735[a]	731[a]	704[a]	696[a]	703[a]
102	38.7	-144	-61.9	86.8	103	88.1	83.3	84.6
103	-95.1	-222	-325[c]	-223	-225	-230	-239	-238
104	-648	-222	-288	-168	-192	-218	-208	-192

-Continued

Table B, Part 5.--Continued

Variable number	Equation number 33	34	35	36	37	38	39	40
105	270	47.9	-49.3	127	150	118	147	147
106	97.5	4.4	66.3	133	132	116	163	153
107	85.1	-50.7	-16.0	90.2	123	91.9	102	112
108	645[a]	483[a]	578[a]	707[a]	758[a]	733[a]	727[a]	730[a]
109	303[c]	120	65.6	216	272	247	246	240
110	25.1	-199	266	437	482[b]	446[b]	421[b]	426[b]
117	24.4[a]			18.8[a]	39.8[a]	23.2	56.5[b]	81.2[b]
118					-1.8[b]	2.3	-12.6	-30.7[c]
119						-.180	1.4	4.7
120							-.045[c]	-.262
121								.005

Table B, Part 6

Variable number	Equation number 41	42	43	44	45	46	47	48
R^2	.587	.595	.598	.600	.601	.603	.604	.604
$\bar{R}^2$	.562	.569	.571	.573	.574	.575	.575	.575
D.F.	606	605	604	603	602	601	600	599
0	221	180	227	2328[b]	2369[b]	2201[b]	2361[b]	2357[b]
10	1077[a]	1061[a]	1037[a]	961[a]	951[a]	995[a]	990[a]	987[a]
11	372[a]	359[a]	357[a]	348[a]	362[a]	412[a]	421[a]	432[a]
12	480[a]	480[a]	467[a]	363[a]	355[a]	377[a]	381[a]	393[a]
13	363[a]	369[a]	333[a]	279[a]	270[a]	296[a]	306[a]	297[a]
14	9.4	12.3[b]	11.8[c]	9.3	10.3[c]	9.6	9.2	9.1
84	668[a]	717[a]	714[a]	599[a]	604[a]	650[a]	618[a]	622[a]
85	644[a]	700[a]	705[a]	605[a]	621[a]	667[a]	627[a]	631[a]
86	219	253	248	169	186	228	193	196
87	-9.5	.169	-25.2	.101	.143	-98.1	-92.8	-98
88	-11.6	4.7	-11.1	-71.7	-108	-70.9	-67.2	-71.6
89	97.4	180	165	111	75.6	102	94.2	88.7
90	111	112	81.8	22.5	-12.1	20.6	23.5	21.1
91	31	52.9	29.9	14.3	-10.4	21.8	31.6	28.9
92	53.1	71.7	40.3	14.0	-15.3	6.2	11.2	8.8
93	-127	-103	-124	-129	-147	-115	-106	-110
94	-79.3	-41.0	-61.3	-41.0	-46.1	-28.9	-32.1	-35.0
95	-192	-160	-188	-198	-212	-196	-193	-195
96	-87.2	-30.9	-60.7	14.8	14.3	11.4	18.1	14.8
97	-251	-211	-235	-132	-127	-138	-139	-139
98	-285	-257	-280	-380[b]	-345	-314	-341	-337
99	8.1	22.8	3.5	-68.2	-17.6	-1.6	-14.1	-6.0
100	72.3	88.1	67.2	22.9	5.0	-3.5	-16.4	-17.0
101	700[a]	730[a]	706[a]	678[a]	661[a]	657[a]	654[a]	653[a]
102	78.0	121	118	124	160	127	119	132
103	-240	-202	-201	-186	-131	-142	-146	-134
104	-191	-134	-143	-71	98.3	77.1	56.8	57.9
105	159	252	199	200	444	412	400	400
106	157	266	232	285	547[b]	514[b]	492[c]	497[b]
107	104	165	153	174	447	399	383	392
108	725[a]	757[a]	740[a]	706[a]	969[a]	920[a]	906[a]	920[a]
109	236	294	260	251	524[c]	479	457	472
110	419[b]	484[b]	439[b]	465[b]	721[b]	664[b]	668[b]	677[b]
117	121[a]	-25.3	-154[c]	-156[b]	-138	-132	-131	-132
118	-68.3[b]	112[c]	296[a]	294[a]	281[b]	285[a]	289[a]	291[a]

-Continued

Table B, Part 6.--Continued

Variable number	Equation number							
	41	42	43	44	45	46	47	48
119	14.7[c]	-52.9[b]	-138[a]	-136[a]	-132[a]	-134[a]	-137[a]	-138[a]
120	-1.3[c]	9.5[a]	27.8[a]	27.1[a]	26.2[a]	26.7[a]	27.1[a]	27.5[a]
121	.054	-.794[a]	-2.8[a]	-2.7[a]	-2.6[a]	-2.7[a]	-2.7[a]	-2.7[a]
122	-.001	.031[a]	.151[b]	.145[b]	.140[b]	.141[b]	.141[b]	.143[b]
123		-.0004[a]	-.004[b]	-.004[b]	-.004[b]	-.004[b]	-.004[b]	-.004[b]
124			.00004[b]	.00004[c]	.00004[c]	.00004[c]	.00004[c]	.00004[c]
125				-141[b]	.134	.566	1.2[b]	1.4[c]
126					-.018	-.117[c]	.403[c]	-.560
127						.004	.003	.061
128							-.001	-.003
129								.00004

Table B, Part 7

Variable number	Equation number							
	49	50	51	52	53	54	55	56
R^2	.606	.606	.724	.722	.720	.720	.719	.709
$\bar{R}^2$	.575	.575	.707	.705	.703	.704	.703	.692
D.F.	598	597	605	606	607	608	609	610
0	2085[c]	2085[b]	851[a]	948[a]	919[a]	918[a]	524[a]	613[a]
2			1711[a]	1660[a]	1605[a]	1605[a]	1578[a]	1898[a]
3			-.508[b]	-.302	-.265	-.265	-.307	-.414
4			.433[b]					
5			-30.4[c]	-32.9[b]				
6			3.2[a]	3.3[a]	3.2[a]	3.2[a]	3.0[a]	
7			-31.3	-33.5	-33.6	-33.5		
8			-.0002	-.0001	.0001			
9			14.0[a]	14.1[a]	12.9[a]	12.9[a]	12.8[a]	12.8[a]
10	951[a]	951[a]	649[a]	586[a]	567[a]	566[a]	828[a]	961[a]
11	445[a]	445[a]	58.2	.041	-24.2	-25.3	199[a]	294[a]
12	423[a]	423[a]	403[a]	375[a]	359[a]	359[a]	528[a]	593[a]
13	301[a]	301[a]	562[a]	560[a]	560[a]	561[a]	543[a]	575[a]
14	10.0	9.9						
84	627[a]	628[a]	461[a]	468[a]	478[a]	477[a]	483[a]	620[a]
85	634[a]	634[a]	527[a]	544[a]	553[a]	552[a]	555[a]	620[a]
86	197	197	120	133	137	135	136	122
87	-97.9	-97.7	-60.4	-34.9	-33.5	-43.1	-42.6	-79.6
88	-72.0	-71.9	-10.3	1.9	7.6	6.1	6.0	3.0
89	80.1	80.2	189	196	202	202	203	261
90	19.7	19.9	19.9	45.4	43.4	36.6	40.0	.565
91	25.8	25.8	-98.3	-93.9	-89.2	-91.8	-88.0	-13.7
92	5.1	5.1	-79.5	-54.6	-58.5	-65.4	-57.0	-80.8
93	-108	-108	-233[c]	-222	-211	-213	-208	-107
94	-21.7	-21.7	18.8	18.9	-31.6	-31.8	-30.5	-2.1
95	-194	-194	-262	-223	-215	-222	-217	-264
96	20	19.9	-190	-186	-174	-175	-170	-107
97	-132	-132	-292	-288	-286	-287	-284	-269
98	-335	-335	-317[c]	-284	-290[c]	-302[c]	-351[b]	-436[a]
99	-10.2	-10.1	-249	-228	-235	-246	-291[c]	-413[b]
100	-12.7	-12.9	-85.3	-69.8	-77.4	-80.6	-125	-196
101	659[a]	659[a]	-33.3	-1.5	11.7	9.6	23.1	-14.1
102	142	142	-226	-215	-216	-216	-210	-160
103	-140	-140	-287[b]	-247[c]	-270[c]	-270[c]	-272[c]	-311[b]
104	65.5	65.1	-296[b]	-296[b]	-293[b]	-293[b]	-294[b]	-287[b]

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Table B, Part 7.--Continued

Variable number	Equation number							
	49	50	51	52	53	54	55	56
105-----	413	413	-16.7	-20.0	-32.6	-32.5	-34.5	-71.1
106-----	477[c]	476[c]	44.3	40.3	44.1	43.4	43.3	112
107-----	383	382	2.0	10.9	-11.2	-11.4	-11.3	36
108-----	921[a]	920[a]	599[a]	576[a]	561[a]	561[a]	568[a]	718[a]
109-----	471	470	199	187	173	173	172	151
110-----	679[b]	678[b]	-145	-162	-211	-212	-198	42.2
117-----	-158[c]	-158[c]						
118-----	319[a]	319[a]						
119-----	-147[a]	-147[a]						
120-----	28.8[a]	28.8[a]						
121-----	-2.8[a]	-2.8[a]						
122-----	.147[b]	.147[b]						
123-----	-.004[b]	-.004[b]						
124-----	.0004[c]	.00004[c]						
125-----	.278	.264						
126-----	.474	.492						
127-----	-.211	-.217						
128-----	.026	.027						
129-----	-.001	-.001						
130-----	.00002	.00002						
131-----		$-3x10^{-8}$						

Table B, Part 8

Variable number	Equation number 57	58	59	60	61	62	63	64
$\bar{R}^2$	.698	.576	.568	.216	.736	.741	.728	.727
R^2	.682	.553	.546	.182	.720	.724	.711	.711
D.F.	611	612	613	617	606	603	607	608
0	621[a]	604[a]	618[a]	1148[a]	4087[a]	5691[a]	5404[a]	5176[a]
2	2074[a]				1910[a]	1828[a]	1821[a]	1840[a]
3	-.313	-.976[a]			.300	-.431[c]	-.048	-.056
4					.210	.350[c]	.352[c]	.324
5					-7.7	-20.1	-15.2	-14.8
6					3.8[a]	3.3[a]	3.5[a]	3.5[a]
7						-77.1[a]	-27.5[a]	-24.5[a]
8					-.001[c]	-.001[a]	-.001[a]	-.001[a]
9					17.9[a]	15.1[a]	15.1[a]	15.5[a]
10	1072[a]	1236[a]	1146[a]			-53.8		
11	351[a]	465[a]	382[a]			-130		
12	606[a]	641[a]	605[a]			-24		
13	579[a]	561[a]	515[a]			367[a]		
14					22.1[a]			
84	610[a]	616[a]	627[a]	627[b]				
85	615[a]	610[a]	616[a]	616[a]				
86	118	128	132	132				
87	-107	-88.3	-127	-127				
88	-20.1	-38.8	-32.4	-32.4				
89	263	233	252	252				
90	-36.9	-79.8	1.3	1.3				
91	-39.0	-7.4	-6.1	-6.1				
92	-117	102	-70.9	-70.9				
93	-131	-124	-132	-132				
94	-7	-26	-22.7	-22.7				
95	-303[c]	-230	-338[c]	-338				
96	-123	-147	-137	-137				
97	-286	-308	-296	-296				
98	-476[a]	-436[b]	-509[a]	-509[a]				
99	-479[a]	-130	-213	-213				
100	-233	-23.3	-140	-140				
101	17.3	673[a]	534[a]	534[b]				
102	-187	-3.7	-114	-114				
103	-336[b]	-325[c]	-367[b]	-367				
104	-311[b]	-306[c]	-332[c]	-332				

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Table B, Part 8.--Continued

Equation number	Equation number							
	57	58	59	60	61	62	63	64
105------	-87.1	-58.4	-90.6	-90.6				
106------	107	85.8	93.0	93.0				
107------	24.8	29.0	15.8	15.8				
108------	696[a]	752[a]	651[a]	651[a]				
109------	135	156	110	110				
110------	-2.4	329	301	301				
111------					187[a]	39.1	113[b]	128[b]
112------					507[a]	162	317[b]	330[b]
113------					766[a]	524[a]	659[a]	657[a]
114------					590[a]	369[c]	522[a]	558[a]
115------					846[a]	757[a]	865[a]	887[a]
116------					309	196	306	342
117------					-4196[a]	-2599[a]	-2433[a]	-2358[a]
118------					5564[a]	2949[a]	2809[a]	2667[a]
119------					-2340[a]	-1047[a]	-1031[a]	-970[a]
120------					452[a]	166[a]	170[a]	159[a]
121------					-45.6[a]	-13.1[a]	-14[a]	-13[a]
122------					2.5[a]	.512[a]	.584[a]	.535[a]
123------					-.068[a]	-.009[a]	-.011[a]	-.010[a]
124------					.001[a]	.00003	.0001[a]	.00005[a]
125------					-5.4[b]	-7.1[a]	-4.8[c]	-2.0
126------					8.3[a]	10.8[a]	7.3[b]	3.3[b]
127------					-3.5[a]	-4.8[a]	-3.1[b]	-1.3[a]
128------					.675[a]	.942[a]	.575[b]	.201[a]
129------					-.067[b]	-.097[a]	-.055[c]	-.015[a]
130------					.004[b]	.005[a]	.003[c]	.0005[a]
131------					-.0001[b]	-.0002[a]	-.0001	-.00001[a]
132------					.000001[b]	.000002[a]	.000001	
133------					7.1[a]	4.4[a]	4.0[a]	3.9[a]
134------					-9.3[a]	-4.9[a]	-4.4[a]	-4.2[a]
135------					3.9[a]	1.7[a]	1.6[a]	1.5[a]
136------					-.743[a]	-.258[a]	-.245[a]	-.232[a]
137------					.075[a]	.020[a]	.019[a]	.018[a]
138------					-.004[a]	-.001[a]	-.001[a]	-.001[a]
139------					.0001[a]	.00001[a]	.00001[a]	.00001[a]
140------					-1×10^{-6}[a]			

Table B, Part 9

Variable number	Equation number 65	66	67	68	69	70	71	72
R^2	.724	.712	.711	.710	.710	.708	.708	.703
$\bar{R}^2$	.708	.696	.696	.694	.695	.694	.694	.689
D.F.	609	610	611	612	613	614	615	616
0	5311[a]	5454[a]	5460[a]	5416[a]	5460[a]	5558[a]	5478[a]	5313[a]
2	1864[a]	1873[a]	1881[a]	1888[a]	1886[a]	1888[a]	1883[a]	1894[a]
3	-.028	.095	.126	.130	.132	.136	.172	.223
4	.325[c]	.345[c]	.352[c]	.364[c]	.363[b]	.346[c]	.357[c]	.354[b]
5	-16.9	-18.5	-18.9	-18.2	-18.0	-19.1	-18.5	-19.3
6	3.4[a]	3.2[a]	3.2[a]	3.3[a]	3.3[a]	3.2[a]	3.3[a]	3.2[a]
7	-23.2[a]	-22.4[a]	-23.1[a]	-22.2[a]	-21.9[a]	-22.0[a]	-21.7[a]	-23.8[a]
8	-.001[a]	-.001[a]	-.001[a]	-.001[a]	-.001[a]	-.001[a]	-.001[a]	-.001[b]
9	15.4[a]	16.7[a]	16.8[a]	16.9[a]	16.8[a]	17.8[a]	17.8[a]	17.8[a]
111	108[b]	146[a]	146[a]	151[a]	152[a]	161[a]	153[a]	140[a]
112	328[b]	382[a]	401[a]	403[a]	407[a]	409[a]	391[a]	390[a]
113	675[a]	751[a]	776[a]	741[a]	748[a]	771[a]	747[a]	837[a]
114	556[a]	624[a]	660[a]	649[a]	654[a]	683[a]	680[a]	748[a]
115	901[a]	1009[a]	1040[a]	1047[a]	1051[a]	1070[a]	1054[a]	1093[a]
116	381[c]	556[a]	583[a]	567[a]	570[a]	591[a]	577[a]	605[a]
117	-2549[a]	-462	-432	-522	-415	-419	-382	428[c]
118	2793[a]	493	468	505	405[b]	395[b]	390[b]	-104
119	-966[a]	-120	-113	-103	-76.6[a]	-73.8[a]	-78.5[a]	4.5
120	149[a]	12.2	11.3	7.5	4.6[a]	4.3[a]	5.1[a]	-.004
121	-11.4[a]	-.661	-.6	-.213	-.082[c]	-.065	-.105[a]	-.0002
122	.418[a]	.019[c]	.018[c]	.002	-.0003	-.001		
123	-.006[a]	-.0003[a]	-.0002[c]					
125	-2.5[c]	-.217	.717	.527	.688	1.8[b]	1.8[b]	2.8[a]
126	3.8[b]	1.25	.132	.219	.087	-.852[b]	-.898[b]	-1.4[a]
127	-1.4[a]	-.555	-.162	-.169	-.136	.102[c]	.107[b]	.184[a]
128	.217[a]	.083	.024	.024	.020	-.005	-.005	-.009[a]
129	-.015[a]	-.006	-.001	-.001	-.001	-.0001	-.0001	-.0001[b]
130	.001[a]	.0002	.00002	.00002	.00002			
131	-.00001	-.000002						
133	4.5[a]	.771	.721	1.0	.815	.846	.729	-.697[c]
134	-4.8[a]	-.727	-.692	-.916	-.742[a]	-.750[b]	-.693[b]	.166
135	1.6[a]	.150	.143	.187	.141[a]	.143[a]	.138[a]	-.006
136	-.250[a]	-.011	-.011	-.014	-.009[a]	-.009[a]	-.009[a]	-.0001
137	.019[a]	.0003	.0003	.0004	.0002[a]	.0002[a]	.0002[a]	
138	-.001[a]	-.000004	-.000003	-.000004				
139	.00001[a]							

Table B, Part 10

Variable number	Equation number 73	74	75	76	77	78	79	80
R^2	.700	.700	.700	.691	.691	.688	.686	.684
$\bar{R}^2$	.687	.687	.688	.679	.679	.677	.675	.674
D.F.	617	618	619	620	621	622	623	624
0	5376[a]	5388[a]	5392[a]	5094[a]	5025[a]	4905[a]	4868[a]	5379[a]
2	1880[a]	1881[a]	1881[a]	1881[a]	1887[a]	1880[a]	1830[a]	1826[a]
3	.247	.247	.247	.207	.199	.172	.138	.177
4	.316	.306	.305	.358[c]	.353[c]	.419[b]	.397[b]	.389[b]
5	-19.5	-19.8	-19.7	-19.4	-19.3	-19.0	-19.5	-20.3
6	3.3[a]	3.3[a]	3.3[a]	3.3[a]	3.3[a]	3.1[a]	3.2[a]	3.3[a]
7	-14.5[b]	-15.0[b]	-15.0[b]	-18.8[b]	-18.4[b]	-24.0[a]	-27.1[a]	-24.6[a]
8	-.001[b]	-.001[b]	-.001[b]	-.001[a]	-.001[a]	-.001[a]	-.001[b]	-.001[b]
9	19.3[a]	19.3[a]	19.3[a]	19.2[a]	19.2[a]	19.2[a]	19.5[a]	19.3[a]
111	108[b]	111[b]	111[b]	179[a]	171[a]	178[a]	162[a]	167[a]
112	416[a]	431[a]	430[a]	535[a]	526[a]	515[a]	483[a]	516[a]
113	866[a]	870[a]	870[a]	980[a]	956[a]	931[a]	881[a]	929[a]
114	767[a]	780[a]	781[a]	888[a]	878[a]	856[a]	788[a]	847[a]
115	1078[a]	1085[a]	1085[a]	1187[a]	1185[a]	1171[a]	1106[a]	1139[a]
116	608[a]	622[a]	623[a]	688[a]	691[a]	717[a]	644[a]	690[a]
117	406[c]	392[c]	403[b]	205	232	-89.7	-59.4	-105
118	-103	-106	-110[a]	-59.0[b]	-59.4[b]	15.6[a]	12.6[b]	9.6[b]
119	4.1	515	6.0[a]	3.1[b]	2.8[b]	-.296[b]	-.249[c]	
120	.067	-.045[a]	-.059[b]	-.017				
121	-.002							
125	1.9[a]	1.9[a]	1.9[a]	.110	.138	-.152	.226	.184
126	-.816[a]	-.829[a]	-.833[a]	-.025	-.028	.035	-.045[a]	-.045[a]
127	.079[a]	.080[a]	.081[a]	-.001	-.001	-.003[b]		
128	-.002[a]	-.002[a]	-.002[a]					
133	-.668	-.618	-.637[b]	-.331	-.401	.160	.114	.231[c]
134	.173	.161	.169[a]	.102[c]	.113[b]	-.016[c]	-.012	-.017[b]
135	-.007	-.007	-.007[a]	-.005[b]	-.005[b]			
136	-.00002	-.00002						

Table B, Part 11

Variable number	Equation number 81	82	83	84	85	86	87	88
R^2------	.682	.673	.670	.670	.624	.719	.734	.490
$\bar{R}^2$------	.672	.664	.661	.661	.615	.705	.718	.479
D.F.----	625	626	627	628	629	613	609	630
0-------	4887[a]	5527[a]	5429[a]	5296[a]	170	4024[a]	4768[a]	1020[a]
2-------	1818[a]	1820[a]	1805[a]	1809[a]	1917[a]	1979[a]	1984[a]	1363[a]
3-------	.159	.125	.188	.198	.135	.146	-.150	-.544[b]
4-------	.393[b]	.423	.347	.347[c]	.562[a]	.463[b]	.408[b]	.577[b]
5-------	-22.9	-29.3	-28.7[c]	-28.6[c]	-36.7[b]	-16.3	-18.4	-44.6[b]
6-------	3.4[a]	3.4[a]	3.3[a]	3.3[a]	3.4[a]	2.6[a]	2.4[a]	5.3[a]
7-------	-22.4[a]	-20.6[a]	-22.7[a]	-22.1[a]	-28.1[a]	-35.2[a]	-93.4[a]	-34.2[a]
8-------	-.001[b]	-.001	-.0005	-.001	.001	-.001[c]	-.001	-.001
9-------	20.5[a]	21.8[a]	21.6[a]	21.5[a]	22.2[a]	16.6[a]	16.6[a]	23.4[a]
10------							-116	
11------							-337[b]	
12------							-191	
13------							302[a]	
14------						20.2[a]	18.0[a]	
111-----	168[a]	32.7	42.9	41.9	90.8[b]	223[a]	133[b]	14.6
112-----	563[a]	138[c]	116	115	-78.7	474[a]	293[b]	-228[a]
113-----	972[a]	288[a]	290[a]	288[a]	176[b]	817[a]	643[a]	64.9
114-----	895[a]	178[b]	210[a]	210[a]	207[b]	665[a]	467[b]	43.3
115-----	1207[a]	480[a]	526[a]	529[a]	699[a]	967[a]	785[a]	465[a]
116-----	757[a]	96.5	141[a]	142	198	558[a]	372[c]	-182
117-----	27.5	-6.1	19.3	30.0[a]	52.0[a]	-250[a]	-165[b]	
118-----	.078	1.7[a]				400[a]	277[a]	
119-----						-179[a]	-123[a]	
120-----						35.5[a]	23.9[a]	
121-----						-3.6[a]	-2.4[a]	
122-----						.196[a]	.123[b]	
123-----						-.005[a]	-.003[b]	
124-----						.0001[a]	.00003[c]	
125-----	.371[b]	-.358[a]	-.351[a]	-.342[a]		-1.7	-2.0	
126-----	-.058[a]					3.7	4.4	
127-----						-1.8	-2.3[c]	
128-----						.356	.521[b]	
129-----						-.037	-.059[b]	
130-----						.002	.004[b]	
131-----						-.0001	-.0001[b]	
132-----						.000001	.000001[b]	
133-----	-.002	.028	.018					

Table B, Part 12

Variable number	Equation number							
	89	90	91	92	93	94	95	96
$\bar{R}^2$------	.486	.481	.480	.471	.383	.277	.053	.038
R^2------	.475	.471	.471	.463	.374	.268	.042	.029
D.F.----	631	632	633	634	635	636	637	638
0-------	1070[a]	980[a]	939[a]	680[a]	992[a]	1013[a]	1094[a]	1184[a]
2-------	1335[a]	1256[a]	1245[a]	1124[a]	1545[a]	2262[a]		
3-------	-.261	-.223	-.256	-.072	-.428[c]	.192	.842[a]	
5-------	-50.1[b]							
6-------	5.2[a]	5.0[a]	5.2[a]	6.1[a]				
7-------	-28.1[a]	-24.1[a]	-22.3[a]					
8-------	-.0004	-.0004						
9-------	23.2[a]	21.6[a]	21.9[a]	25.6[a]	34.2[a]			
111-----	8.7	4.2	10.5	6.1	31.5	25.5	-35.5	-42.7
112-----	-251[a]	-253[a]	-237[a]	-228[a]	-226[b]	-214[b]	-333[a]	-368[a]
113-----	40.7	34.5	45.0	40.7	123	190[b]	90.3	31.1
114-----	37.1	-4.8	8.4	4.5	78.1	128	26.5	-19.9
115-----	423[a]	393[a]	408[a]	384[a]	536[a]	542[a]	389[a]	399[a]
116-----	-210	-296	-296	-355[b]	147	64.1	298	265

Table B, Part 13

Variable number	Equation number 97	98	99	100	101	102	103	104
R^2	.741	.734	.486	.712	.458	.352	.566	.573
$\bar{R}^2$	.725	.718	.461	.699	.439	.347	.547	.554
D.F.	607	608	615	616	623	640	617	616
0	6208[a]	4668[a]	6761[a]	4076[a]	5237[a]	644[a]	7244[a]	7903[a]
2	1934[a]	1889[a]		1892[a]				
3	-.258	-.267		-.131				
4	.316[c]	.350[c]		.362[c]				
5	-29.5[c]	-29.0[c]		-25.1				
6	2.7[a]	2.8[a]		2.5[a]			6.8[a]	6.4[a]
7	-90.4[a]						-46.5[a]	-48.6[a]
8	-.001[c]	-.001[b]		-.001[c]				-.001[a]
9	16.1[a]	16.3[a]		18.1[a]				
10	-147	434[a]	941[a]	458[a]	952[a]	1146[a]		
11	-232	297[a]	687[a]	153[b]	576[a]	382[b]		
12	-167	230[a]	402[a]	137[c]	363[a]	605[a]		
13	326	246[a]	272[a]	185[a]	275[a]	515[a]		
14	20.1[a]	18.8[a]	14.6[b]	17.6[a]	13.9[b]		35.8	0.3
117	-4563[a]	-4774[a]	-4777[a]	-223[a]	-268[a]		-4831[a]	-5116[a]
118	5740[a]	6200[a]	6191[a]	328[a]	442[a]		5937[a]	6175[a]
119	-2344[a]	-2593[a]	-2687[a]	-142[a]	-199[a]		-2430[a]	-2498[a]
120	441[a]	499[a]	532[a]	26.9[a]	39.6[a]		455[a]	466[a]
121	-43.5[a]	-50.1[a]	-54.4[a]	-2.6[a]	-4.1[a]		-44.1[a]	-45.2[a]
122	2.3[a]	2.7[a]	3.0[a]	.135[b]	.224[a]		2.3[a]	2.3[a]
123	-.063[a]	-.075[a]	-.083[a]	-.004[b]	-.006[a]		-.60[a]	-.062[a]
124	.001[a]	.001[a]	.001[a]	.00004[c]	.0001[a]		.001[b]	.001[a]
125	-8.0[a]	-6.9[a]	-12.5[a]	-1.2	-7.8[a]		-12.3[a]	-12.3[a]
126	11.8[a]	10.1[a]	19.0 [a]	2.0	12.5[a]		17.7[a]	17.2[a]
127	-5.3[a]	-4.4[a]	-8.5[a]	-.957	-5.6[a]		-7.5[a]	-7.2[a]
128	1.1[a]	.870[a]	1.7[a]	.186	1.1[a]		1.4[a]	1.3[a]
129	-111[a]	-.089[a]	-.172[a]	-.019	-.117[a]		-.139[a]	-.131[a]
130	.006[a]	.005[a]	.010[a]	.001	.007[a]		.007[a]	.007[a]
131	-.0002[a]	-.0001[a]	-.0003[a]	-.00003	-.0002[a]		-.0002[a]	-.0001[a]
132	.000002[a]	.000002[a]	.000003[a]	.0000003	.000002[a]		.000002[a]	.000002[a]
133	7.8[a]	8.1[a]	8.0[a]				8.0[a]	8.5[a]
134	-9.7[a]	-10.4[a]	-10.1[a]				-9.5[a]	-10.0[a]
135	3.9[a]	4.3[a]	4.3[a]				3.8[a]	4.0[a]
136	-.737[a]	-.833[a]	-.855[a]				-.709[a]	-.730[a]
137	.073[a]	.084[a]	.087[a]				.068[a]	.070[a]
138	-.004[a]	-.005[a]	-.005[a]				-.003[a]	-.004[a]
139	.0001[a]	.0001[a]	.0001[a]				.0001[b]	.0001[a]
140	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]				$-1x10^{-6}$[b]	$-1x10^{-6}$[b]

Table B, Part 14

Variable number	Equation number 105	106	107	108	109	110	111	112
R^2	.633	.634	.634	.726	.727	.724	.721	.719
$\bar{R}^2$	.616	.616	.615	.711	.712	.709	.707	.706
D.F.	615	614	613	612	611	612	613	614
0	6796[a]	6640[a]	6608[a]	5143[a]	5200[a]	4985[a]	4909[a]	4933[a]
2				1865[a]	1904[a]	1899[a]	1903[a]	1933[a]
3		.222	.191	.105	.096	.056	.035	.057
4			.074	.359[b]	.333[c]	.351[b]	.302	.308[c]
5					-27.2[c]	-25.8[c]	-24.0	-25.3
6	5.6[a]	5.6[a]	5.7[a]	2.8[a]	2.9[a]	2.8[a]	2.9[a]	2.8[a]
7	-17.1[a]	-15.6[a]	-16.6[a]	-27.9[a]	-29.7[a]	-29.7[a]	-24.2[a]	-23.8[a]
8	-.001[a]	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.001[b]
9	28.8[a]	28.2[a]	28.2[a]	15.4[a]	16.4[a]	16.6[a]	17.1[a]	17.0[a]
14	6.6	7.3	7.4	21.2[a]	21.4[a]	21.8[a]	19.4[a]	20.7[a]
117	-4174[a]	-4142[a]	-4148[a]	-4122[a]	-4184[a]	-2464[a]	-2385[a]	-2555[a]
118	5186[a]	5180[a]	5178[a]	5293[a]	5364[a]	2968[a]	2782[a]	2889[a]
119	-2122[a]	2127[a]	-2124[a]	-2176[a]	-2204[a]	-1106[a]	-1026[a]	-1022[a]
120	400[a]	402[a]	401[a]	409[a]	414[a]	182[a]	167[a]	160[a]
121	-39.2[a]	-40.0[a]	-39.5[a]	-39.9[a]	-40.4[a]	-15.0[a]	-13.6[a]	-12.2[a]
122	2.1[a]	2.1[a]	2.1[a]	2.1[a]	2.1[a]	.614[a]	.544[a]	.451[a]
123	-.055[a]	-.056[a]	-.056[a]	-.056[a]	-.056[a]	-.011[a]	-.009[a]	-.006[a]
124	.001[a]	.001[a]	.001[a]	.001[a]	.001[a]	.0001[a]	.00004[b]	
125	-7.9[a]	-7.9[a]	-8.0[a]	-6.9[a]	-7.1[a]	-6.5[a]	-2.5[c]	-2.9[b]
126	11.6[a]	11.6[a]	11.8[a]	10.1[a]	10.3[a]	9.4[a]	3.6[b]	4.0[a]
127	-5.0[a]	-5.0[a]	-5.1[a]	-4.4[a]	-4.5[a]	-4.0[a]	-1.4[a]	-1.5[a]
128	.949[a]	.965	.977[a]	.847[a]	.870[a]	.758[a]	.210[a]	.222[a]
129	.094[a]	-.096[a]	-.097[a]	-.085[a]	-.087[a]	-.075[a]	-.015[a]	-.016[a]
130	.005[a]	.005[a]	.005[a]	.005[a]	.005[a]	.004[b]	.0005[a]	.001[a]
131	-.0001[b]	-.0001[a]	-.0001[a]	-.0001[a]	-.0001[a]	-.0001[b]	-.00001[a]	-.00001[a]
132	.000002[b]	.000002[b]	.000002[b]	.000001[a]	.000002[a]	.000001[b]		
133	6.8[a]	6.8[a]	6.8[a]	6.9[a]	7.0[a]	4.0[a]	3.9[a]	4.4[a]
134	-8.3[a]	-8.3[a]	-8.3[a]	-8.7[a]	-8.8[a]	-4.6[a]	-4.4[a]	-4.9[a]
135	3.3[a]	3.4[a]	3.4[a]	3.5[a]	3.6[a]	1.7[a]	1.6[a]	1.7[a]
136	-.623[a]	-.627[a]	-.626[a]	-.661[a]	-.670[a]	-.266[a]	-.249[a]	-.264[a]
137	.060[a]	.061[a]	.061[a]	.064[a]	.065[a]	.021[a]	.019[a]	.020[a]
138	-.003[a]	-.003[a]	-.003[a]	-.003[a]	-.003[a]	-.001[a]	-.001[a]	-.001[a]
139	.0001[b]	.0001[a]	.0001[a]	.0001[a]	.0001[a]	.00001[a]	.00001[a]	.00001[a]
140	-1×10^{-6}[a]	-1×10^{-6}[b]	-1×10^{-6}[b]	-1×10^{-6}[a]	-1×10^{-6}[a]			

Table B, Part 15

Variable number	Equation number 113	114	115	116	117	118	119	120
R^2------	.705	.704	.701	.701	.698	.698	.692	.689
$\bar{R}^2$------	.691	.691	.688	.688	.686	.687	.680	.678
D.F.-----	615	616	617	618	619	620	621	622
0-------	5324[a]	5304[a]	5491[a]	5511[a]	5782[a]	5744[a]	5454[a]	5292[a]
2-------	1921[a]	1931[a]	1923[a]	1923[a]	1913[a]	1911[a]	1934[a]	1938[a]
3-------	.204	.226	.245	.246	.243	.259	.286	.291
4-------	.310	.319[c]	.324[c]	.323[c]	.298	.307	.324[c]	.306
5-------	-25.6	-25.9	-24.8	-24.7	-26.0	-25.4	-27.0[c]	-27.5[c]
6-------	2.8[a]	2.8[a]	2.9[a]	2.9[a]	2.9[a]	2.9[a]	2.8[a]	2.8[a]
7-------	-20.8[a]	-21.6[a]	-19.9[b]	-19.7[b]	-19.4[b]	-19.3[b]	-23.3[a]	-16.6[b]
8-------	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.0005	-.0004
9-------	18.3[a]	18.3[a]	18.4[a]	18.4[a]	19.8[a]	19.8[a]	20.0[a]	21.3[a]
14------	19.7[a]	20.3[a]	18.4[a]	18.5[a]	17.3[a]	17.3[a]	18.1[a]	18.9[a]
117-----	-295	-275	-387	-319	-247	-338	527[b]	495[b]
118-----	420	402	433	370[b]	367[b]	369[b]	-163[b]	-160[b]
119-----	-120	-115	-95.6	-79[a]	-76.7[a]	-79.5[a]	10.5	10.1
120-----	13.7	13.0	7.1	5.4[a]	5.0[a]	5.4[a]	-16.1	-.101
121-----	-.811[c]	-.767[c]	-.2	-.118[b]	-.094[b]	-.115[a]	-.0004	-.002
122-----	.026[b]	.024[b]	.002	.0002	-.0003			
123-----	-.0003[a]	-.0003[a]						
125-----	-.550	.171	-.070	.032	1.5[b]	1.5[b]	2.6[a]	1.7[a]
126-----	1.3	.442	.523	.440	-.891[b]	-.909[b]	-1.5[a]	-.967[a]
127-----	-.575	.267	-.265	-.245	.095[c]	.097[c]	.19[a]	.099[a]
128-----	.083	.036[b]	.035	.033[b]	-.003	-.003	-.009[a]	-.003[a]
129-----	-.005	-.002[b]	-.002[b]	-.002[b]	.00001	.00001	.00001[b]	
130-----	.00001	.00003[b]	.00003[b]	.00003[b]				
131-----	-.000002							
133-----	.338	.302	.680	.560	.643	.602	-.921[b]	-.877[b]
134-----	-.487	-.461	-.745	-.635[b]	-.668[b]	-.646[b]	.275[b]	.281[b]
135-----	.114	.108	.163	.134[a]	.140[a]	.138[a]	-.016	-.018
136-----	-.009	-.008	-.012	-.009[a]	-.009[a]	-.009[a]	.0002	.0003
137-----	.0002	.0002	.0003	.0002[a]	.0002[a]	.0002[a]		
138-----	-.000002	-.000001	-.000002					

Table B, Part 16

Variable number	Equation number 121	122	123	124	125	126	127	128
R^2	.689	.689	.676	.676	.673	.672	.670	.665
$\bar{R}^2$	.679	.679	.666	.666	.664	.664	.662	.658
D.F.	623	624	625	626	627	628	629	630
0	5317[a]	5278[a]	5235[a]	5241[a]	5217[a]	5135[a]	5700[a]	5042[a]
2	1937[a]	1934[a]	1893[b]	1893[a]	1888[a]	1862[a]	1860[a]	1848[a]
3	.290	.291	.231	.232	.211	.193	.226	.206
4	.296	.307	.345[c]	.346[c]	.401[b]	.387[b]	.386[b]	.385[b]
5	-27.7[c]	-28.7[c]	-30.4[c]	-30.5[c]	-29.2[c]	-29.8[c]	-30.7[b]	-34.6[b]
6	2.8[a]	2.8[a]	2.8[a]	2.8[a]	2.8[a]	2.8[a]	2.9[a]	3.0[a]
7	-17.1[b]	-16.9[b]	-20.6[a]	-20.7[a]	-25.4[a]	-27.3[a]	-24.6[a]	-21.3[a]
8	-.0004	-.0004	-.001[c]	-.001[c]	-.001	-.001	-.0004	-.0004
9	21.3[a]	21.4[a]	21.4[a]	21.4[a]	21.1[a]	21.3[a]	21.2[a]	23.0[a]
14	18.6[a]	18.3[a]	14.4[a]	14.4[a]	13.6[a]	13.8[a]	13.8[a]	14.3[a]
117	477[b]	352[b]	135	133	-162[b]	-140[c]	-197[a]	-16.8
118	-162[b]	-107[a]	-48	-47.9	20.5[a]	18.5[a]	15.5[a]	2.3[a]
119	11.5	5.9[a]	2.4[c]	2.5[b]	-.313[b]	-.283[b]		
120	-.211	-.052[b]	.002					
125	1.7[a]	1.7[a]	-.562[b]	-.566[b]	-.822[a]	-.564[a]	-.622[a]	-.473[a]
126	-.982[a]	-.940[a]	.013	.014	.070	.020[a]	.025[a]	.012[a]
127	.101[a]	.096[a]	.0004	.0004	-.002			
128	-.003[a]	-.003[a]						
133	-820[b]	-.602[b]	-.281	-.273	.240[c]	.210	.348[a]	.030
134	.266[b]	.172[a]	.098	.097[c]	-.020[b]	-.018[b]	-.024[a]	
135	-.017	-.008[a]	-.005[b]	-.005[b]				
136	.003							

Table B, Part 17

Variable number	Equation number 129	130	131	132	133	134	135	136
R^2	.661	.654	.721	.726	.724	.720	.718	.630
$\bar{R}^2$	.654	.648	.706	.711	.710	.706	.705	.613
D.F.	631	632	612	612	613	614	615	616
0	4467[a]	4544[a]	4771[a]	5364[a]	5316[a]	4867[a]	4535[a]	5984[a]
2	1803[a]	1757[a]	1846[a]	1882[a]	1837[a]	1809[a]	1810[a]	
3	.211	.311	.292	.237	.258	.350[c]	.328[c]	.262
4	.329[c]	.207	.133					
5	-27.8[c]	-23.4	-20.0	-29.5[c]				
6	3.08[a]	3.1[a]	3.5[a]	2.9[a]	2.7[a]	3.3[a]	3.4[a]	6.1[a]
7	-21[a]	-23.1[a]		-25.4[a]	-23.1[a]			
8	-.0005	-.001	-.001[c]	-.001[b]	-.001[b]	-.001[b]		
9	22.8[a]	22.4[a]	19.1[a]	16.4[a]	15.3[a]	18.0[a]	18.6[a]	30.4[a]
14	19.8[a]	20.2[a]	19.8[a]	20.6[a]	20.3[a]	19.5[a]	21.4[a]	8.7[c]
117	-8.6	20.9	-3737[a]	-4164[a]	-4095[a]	-3907[a]	-3750[a]	-3854[a]
118	2.2[a]		5123[a]	5377[a]	5301[a]	5103[a]	4967[a]	4909[a]
119			-2110[a]	2217[a]	-2187[a]	-2106[a]	-2066[a]	-2032[a]
120			398[a]	417[a]	412[a]	397[a]	391[a]	386[a]
121			-39.1[a]	-40.9[a]	-40.3[a]	-39.0[a]	-38.4[a]	-38.1[a]
122			2.1[a]	2.1[a]	2.1[a]	2.1[a]	2.0[a]	2.0[a]
123			-.055[a]	-.057[a]	-.056[a]	-.055[a]	-.054[a]	-.054[a]
124			.001[a]	.001[a]	.001[a]	.001[a]	.001[a]	.001[b]
125	-.286[a]	-.291[a]	-5.7[b]	-6.7[a]	-6.5[a]	-5.6[b]	-5.5[b]	-7.2[a]
126			7.9[a]	9.8[a]	9.5[a]	7.8[a]	8.1[a]	10.7[a]
127			-3.3[a]	-4.3[a]	-4.2[a]	-3.3[a]	-3.4[a]	-4.6[a]
128			.608[b]	.825[a]	.797[a]	.599[b]	.639[b]	.871[a]
129			-.058[b]	-.082[a]	-.079[a]	-.057[b]	-.061[b]	-.085[a]
130			.003[c]	.004[a]	.004[a]	.003[c]	.003[b]	.005[b]
131			-.0001[c]	-.0001[a]	-.0001[b]	-.0001[c]	-.0001[c]	-.0001[b]
132			.000009[c]	.000001[b]	.000001[b]	.000001	.000001[c]	.000001[b]
133	.014	.006	6.6[a]	7.0[a]	6.9[a]	6.5[a]	6.2[a]	6.3[a]
134			-8.5[a]	-8.9[a]	-8.7[a]	-8.4[a]	-8.2[a]	-7.8[a]
135			3.5[a]	3.6[a]	3.6[a]	3.4[a]	3.4[a]	3.2[a]
136			-.649[a]	-.677[a]	-.667[a]	-.648[a]	-.635[a]	-.602[a]
137			.064[a]	.066[a]	.065[a]	.063[a]	.062[a]	.059[a]
138			-.003[a]	-.003[a]	-.003[a]	-.003[a]	-.003[a]	-.003[a]
139			.0001[a]	.0001[a]	.0001[a]	.0001[a]	.0001[a]	.0001[b]
140			-1×10^{-6}[a]	-1×10^{-6}[a]	-1×10^{-6}[a]	-1×10^{-6}[a]	-1×10^{-6}[a]	-1×10^{-6}[b]

Table B, Part 18

Variable number	137	138	139	140	141	142	143	144
	Equation number							
R^2	.557	.380	.724	.708	.218	.233	.238	.256
$\bar{R}^2$	.537	.354	.709	.693	.213	.227	.231	.248
D.F.	617	618	612	613	640	639	638	637
0	6013[a]	6486[a]	4984[a]	5349[a]	5228[a]	5429[a]	6208[a]	7389[a]
2			1899[a]	1885[a]				
3	.873[a]	1.0[a]	.056	.194				
4			.351[c]	.332[c]				
5			-25.8[c]	-25.2				
6	8.0[a]		2.8[a]	2.8[a]				
7			-29.7[a]	-24.5[a]				
8			-.001[b]	-.001[b]				
9			16.6[a]	18.2[a]				
14	3.4	16.1[b]	21.8[a]	19.7[a]	10.1[b]	8.6[c]	1.8	.8
117	-4489[a]	-3261[a]	-2464[a]	-111	134[a]	73.6	62.2	-289[a]
118	5658[a]	4005[a]	2968[a]	367		3.1[a]	3.1[a]	29.3[a]
119	-2332[a]	-1656[a]	-1106[a]	.156[b]				
120	442[a]	313[b]	182[a]	29[a]				
121	-43.5[a]	-30.5[b]	-15.0[a]	-2.9[a]				
122	2.3[a]	1.6[c]	.614[a]	.165[a]				
123	-.061[a]	-.040[c]	-.011[a]	-.005[a]				
124	.001[a]	.0004	.0001[a]	.0001[a]				
125	-10.9[a]	-13.5[a]	-6.5[a]	-2.4	-.309[a]	-.321[a]	-.518[a]	-.893[a]
126	14.8[a]	17.3[a]	9.4[a]	4.2			.012[c]	.037[a]
127	-6.1[a]	-6.9[a]	-4.0[a]	-2.0				
128	1.1[a]	1.2[a]	.758[a]	.388				
129	-.105[a]	-.118[a]	-.075[a]	.388				
130	.005[a]	.006[a]	.004[b]	.002				
131	-.0001[b]	-.0002[b]	-.0001[b]	-.001				
132	.000002[b]	.000002[b]	.000001[b]	.000001				
133	7.4[a]	5.3[b]	4.0[a]	-.250	-.205[b]	-.162	-.140	.479[a]
134	-9.1[a]	-6.3[b]	-4.6[a]	-.019				-.047[a]
135	3.7[a]	2.6[b]	1.7[a]	.002				
136	-.699[a]	-.479[b]	-.266[a]	.002				
137	.068[a]	.046[c]	.021[a]	-.0002				
138	-.004[a]	-.002[c]	-.001[a]	.00001				
139	.0001[a]	.0001	.00001[a]					
140	-1×10^{-6}[b]	-.000001						

Table B, Part 19

Variable number	Equation number							
	145	146	147	148	149	150	151	152
R^2------	.257	.258	.266	.266	.278	.278	.278	.278
$\bar{R}^2$------	.247	.248	.255	.254	.264	.263	.262	.261
D.F.-----	636	635	634	633	632	631	630	629
0-------	7790[a]	7973[a]	8056[a]	8123[a]	8362[a]	8370[a]	8363[a]	8371[a]
14------	.7	.6	2.7	2.1	4.9	5.0	5.4	5.3
117-----	-325[a]	-364[a]	97	76.6	256	297	320	340
118-----	27.7[a]	30.6[a]	-79.7[c]	-79.6[c]	-130[a]	-148	-146	-148
119-----	.152	.104	4.6[a]	5.0[a]	7.9[a]	9.8	7.9	7.9
120-----				-.016	-.065[c]	-.117	.035	.030
121-----							-.003	-.003
125-----	-.950[a]	-1.3[a]	-.796[b]	-.836[c]	1.2	1.2	1.2	1.4
126-----	.039[a]	.103[c]	-.004	.001	-.865[a]	-.879[a]	-.858[a]	-.997[b]
127-----		-.002	.002	.002	.089[a]	.090[a]	.088[a]	.112[c]
128-----					-.002[a]	-.002[a]	-.002[a]	-.004
129-----								.00003
133-----	.563[a]	.622[a]	-.182	-.124	-.390	-.462	-.538	-.573
134-----	-.050[a]	-.053[a]	.136[c]	.126[c]	.189[a]	.220	.240	.242
135-----			-.008[a]	-.007	-.010[a]	-.013	-.014	-.014
136-----						.001	.0001	.0001

Table B, Part 20

Variable number	Equation number 153	154	155	156	157	158	159	160
R^2	.295	.297	.315	.317	.321	.339	.358	.362
$\bar{R}^2$	.278	.278	.295	.296	.300	.317	.335	.338
D.F.	628	627	626	625	624	623	622	621
0	8579[a]	8615[a]	7798[a]	8014[a]	7757[a]	7761[a]	7135[a]	7039[a]
14	6.1	6.3	10.3[c]	10.8[c]	12.9[b]	9.1	11.1[c]	9.7
117	-1042[b]	-1065[b]	-937[b]	-292	-161	-338	-2789[a]	-2526[a]
118	677[a]	669[b]	644[a]	46.8	13.1	173	2864[a]	2694[a]
119	-130[a]	-121[a]	-121[a]	37.8	16.6	-31.1	-1018[a]	-1016[a]
120	8.5[a]	7.2[a]	7.8[a]	-9.2	-2.6	4.0	164[a]	174[a]
121	-.178[a]	-.112	-.165[b]	.613	-.025	-.442	-13[a]	-14.8[a]
122		-.001	.0002	-.013	.013	.025	.491[a]	.619[a]
123					-.0004[b]	-.0005[a]	-.007[a]	-.011[a]
124								.0001[c]
125	.050	-.034	-3.7[a]	-2.7[a]	-2.4	-7.9[a]	-10.3[a]	-9.6[a]
126	-.215	-.172	3.2[a]	2.4[b]	2.3[b]	9.1[a]	11.7[a]	11.1[a]
127	-.013	-.017	-.880[a]	-.677[b]	-.683[b]	-3.1[a]	-4.0[a]	-3.8[a]
128	.003	.003	.094[a]	.073[a]	.075[b]	.440[a]	.579[a]	.558[a]
129	-.0001	-.0001	-.004[a]	-.003[a]	-.003[a]	-.030[a]	-.041[a]	-.039[a]
130			.0001[a]	.0001[a]	.0001[a]	.001[a]	.001[a]	.001[a]
131						-.00001[a]	-.00002[a]	-.00002[a]
133	1.9[b]	2.0[b]	1.7[c]	.557	.116	.437	4.8[a]	4.1[b]
134	-1.2[a]	-1.3[a]	-1.1[a]	-.077	.248	.015	-4.7[a]	-4.0[a]
135	.225[a]	.229[a]	.204[a]	-.071	.248	.015	-4.7[a]	-4.0[a]
136	-.015[a]	-.015[a]	-.013[a]	.017	.021	.015	-.265[a]	-.243[a]
137	.0003[a]	.0003[a]	.0003[a]	-.001	-.001	-.001	.021[a]	.020[a]
138				.00002	.00002	.00002	-.001[a]	-.001[a]
139							.00001[a]	.00001[a]

Table B, Part 21

Variable number	Equation number 161	162	163	164	165	166	167	168
R^2	.364	.365	.345	.342	.340	.338	.335	.334
$\bar{R}^2$	.339	.339	.321	.319	.318	.317	.315	.315
D.F.	620	619	621	622	623	624	625	626
0	7103[a]	7211[a]	7687[a]	7483[a]	7312[a]	7328[a]	7211[a]	6847[a]
14	11.6[c]	11.4[c]	8.6	8.2	8.3	9.1	6.9	7.8
117	-2590[a]	-3451[a]	-80.4	-868[c]	-403	-115	-483[b]	-370[a]
118	2867[a]	4066[a]	80.3	787[a]	542[a]	418[a]	526[a]	514[a]
119	-1090[a]	-1639[b]	-70.8	-245[a]	-221[a]	-211[a]	-227[a]	-226[a]
120	187[a]	303[b]	23.0	38.6[a]	40.9[a]	40.7[a]	43.1[a]	43.1[a]
121	-16[a]	-28.8[b]	-3.2[b]	-3.5[a]	-4.1[a]	-4.0[a]	-4.2[a]	-4.2[a]
122	.68[a]	1.4[c]	.205[b]	.184[b]	.214[a]	.210[a]	.219[b]	.220[b]
123	-.013[a]	-.036	-.006[b]	-.005[b]	-.006[b]	-.006[b]	-.006[b]	-.006[b]
124	.00007[b]	.0003	.0001[b]	.0001[c]	.0001[b]	.0001[b]	.0001[b]	.0001[b]
125	-13.5[a]	-13.8[a]	-9.3[a]	-11[a]	-11.2[a]	-10.3[a]	-10.1[a]	-10.5[a]
126	16.5[a]	17.1[a]	11.4[a]	12.9[a]	13.5[a]	12.5[a]	11.5[b]	12.2[a]
127	-6.29[a]	-6.5[a]	-4.2[b]	-4.7[b]	-5.0[a]	-4.6[a]	-4.1[b]	-4.3[b]
128	1.07[a]	1.1[a]	.695[c]	.751[b]	.809[b]	.743[b]	.617[c]	.665[c]
129	-.094[b]	-.101[b]	-.059	-.063	-.068[c]	-.062	-.048	-.052
130	.005[b]	.005[b]	.003	.003	.003	.003	.002	.002
131	-.0001[c]	-.0001[c]	-.0001	-.0001	-.0001	-.0001	-.00004	-.00005
132	.000001	.000001	.000001	.000001	.000001	.000001	.0000003	.0000004
133	4.1[b]	5.7[b]	-.372	1.1	.191	-.354	.277	.083
134	-4.3[a]	-6.4[b]	.679	-.666	-.122	.128	-.015	
135	1.56[a]	2.5[b]	-.240	.112[c]	.020	-.006[c]		
136	-.258[a]	-.460[b]	.031	-.006	-.001			
137	.021[a]	.043[c]	-.002	.001				
138	-.0008[a]	-.002	-.00003					
139	.00002[a]	.0001						
140	-5×10^{-7}							

Table B, Part 22

Variable number	Equation number							
	169	170	171	172	173	174	175	176
R^2	.703	.696	.695	.690	.681	.681	.680	.678
$\bar{R}^2$	.691	.684	.684	.678	.670	.671	.670	.668
D.F.	619	620	620	621	622	623	624	625
0	4884[a]	4541[a]	5844[a]	5722[a]	5845[a]	5861[a]	5739[a]	5829[a]
2	1886[a]	1809[a]	1772[a]	1818[a]	1830[a]	1831[a]	1833[a]	1821[a]
3	.171	.343[c]	.112	.129	.194	.193	.206	.192
4	.371[b]	.149	.287	.263	.324[c]	.322[c]	.360[c]	.369[c]
5	-25.5	-18.0	-23.3	-24.3	-23.8	-23.8	-23.6	-22.3
6	2.67[a]	3.3[a]	3.15[a]	3.11[a]	3.07[a]	3.06[a]	3.09[a]	3.12[a]
7	-30.3[a]		-26.2[a]	-22.1[a]	-26.6[a]	-26.6[a]	-25.3[a]	-27.4[a]
8	-.0007[c]	-.0005	-.001[a]	-.001[a]	-.0009[b]	-.0009[b]	-.0009[b]	-.001[a]
9	18.0[a]	21.1[a]	17.6[a]	17.7[a]	17.5[a]	17.5[a]	17.7[a]	17.4[a]
14	18.4[a]	16.0[a]						
117	-297[a]	-283[a]	-295[a]	-115[b]	41.9	44.8	6.76	.276[b]
118	431[a]	413[a]	433[a]	172[a]	-26.9	-29.8[c]	-4.31	11.1[a]
119	-189[a]	-178[a]	-193[a]	-70.5[a]	4.97	5.76[b]	1.23	-.424[a]
120	37.0[a]	34.2[a]	38.2[a]	11.9[a]	-.255	-.342[c]	-.048[b]	
121	-3.73[a]	-3.4[a]	-3.88[a]	-.939[a]	.002	.006[c]		
122	.201[a]	.176[a]	.212[a]	.035[a]	.00007			
123	-.006[a]	-.005[a]	-.006[a]	-.0005[a]				
124	.00006[a]	.00005[a]	.00007[a]					
125	-2.83	-1.9	-1.93	.430	-1.03	-.992	-1.29	-1.29
126	4.52[c]	2.5	3.01	-.390	1.58	1.55	1.65	1.41
127	-2.05[c]	-.891	-1.33	.254	-.708	-.70	-.729	-.60
128	.392	.120	.233	-.104	.114	.114	.124	.103
129	-.039	-.007	-.021	.017	-.009	-.009	-.010	-.009
130	.002	.0001	.0010	-.001	.0003	.0003	.0005	.0004
131	-.00006	.000001	-.00002	.00004	-.000006	-.000006	-.00001	-.00001
132	.0000007	$-1x10^{-7}$	.0000002	$-6x10^{-7}$	$3x10^{-8}$	$4x10^{-8}$	.0000001	.0000001

Table B, Part 23

Variable number	Equation number 177	178	179	180	181	182	183	184
R^2------	.672	.669	.644	.644	.643	.639	.627	.625
$\bar{R}^2$------	.662	.660	.635	.635	.635	.632	.620	.618
D.F.----	626	627	628	629	630	631	632	633
0-------	5979[a]	6040[a]	8051[a]	7863[a]	7896[a]	7977[a]	8129[a]	8026[a]
2-------	1804[a]	1767[a]	1553[a]	1558[a]	1559[a]	1533[a]	1463[a]	1464[a]
3-------	.279	.324	.027	.027	.057	.074	.008	-.016
4-------	.373[b]	.287	.247	.233	.236	.218	.120	.135
5-------	-25.3	-21.1	-24.5	-24.0	-24.8	-25.8	-29.4[c]	-32[c]
6-------	3.26[a]	3.26[a]	3.68[a]	3.71[a]	3.70[a]	3.72[a]	3.93[a]	3.89[a]
7-------	-24.7[a]	-26.2[a]	-30.7[a]	-28.5[a]	-30.9[a]	-34.2[a]	-22.4[a]	-23.4[a]
8-------	-.0008[b]	-.0008[b]	-.002[a]	-.001[a]	-.002[a]	-.001[a]	-.001[a]	-.001[a]
9-------	17.3[a]	16.2[a]	16.5[a]	16.8[a]	16.7[a]	18.4[a]	22.11[a]	22.5[a]
117-----	8.16	26.8[a]						
118-----	1.71[b]							
125-----	-2.08	-3.0	-2.46	-1.08	.039	1.73[a]	.226	-.481[b]
126-----	2.81	3.76	3.26	1.34	.009	-134[a]	-.342[b]	-.022
127-----	-1.32	-1.61	-1.45	-.583	-.115	.211[a]	.034[b]	.001
128-----	.263	.302	.272	.092	.021	-.012[a]	-.0009[b]	
129-----	-.027	-.030	-.026	-.007	-.001[b]	.0002[a]		
130-----	.002	.002	.001	.0002	.00002[b]			
131-----	-.00004	-.00004	-.00004	-.000003				
132-----	.0000005	.0000005	.0000004					

Table B, Part 24

Variable number	Equation number 185	186	187	188	189	190	191	192
R^2	.624	.618	.703	.703	.702	.698	.697	.684
$\bar{R}^2$	.618	.613	.691	.691	.691	.688	.687	.674
D.F.	634	635	619	620	621	622	623	624
0	8041[a]	7976[a]	4884[a]	4697[a]	4647[a]	5006[a]	4887[a]	5014[a]
2	1481[a]	1395[a]	1886[a]	1891[a]	1902[a]	1883[a]	1879[a]	1842[a]
3	.004	.014	.171	.157	.181	.148	.131	.066
4	.139	.049	.371[b]	.341[c]	.356[c]	.326[c]	.306	.333[c]
5	-368[c]	-22.0	-25.5	-24.8	-25.6	-28.2[c]	-29.2[c]	-31.3
6	3.89[a]	4.12[a]	2.67[a]	2.73[a]	2.70[a]	2.73[a]	2.76[a]	2.84[a]
7	-21.5[a]	-20.2[a]	-30.3[a]	-26.9[a]	-28.4[a]	-29.3[a]	-24.2[a]	-25.6[a]
8	-.001[a]	-.002[a]	-.0007[c]	-.0007[c]	-.0007[b]	-.0006[c]	-.0006	-.0008[b]
9	22.5[a]	21.9[a]	18[a]	18.2[a]	18.3[a]	20.3[a]	21.6[a]	21.8[a]
14			18.4[a]	17.2[a]	18.0[a]	16.3[a]	16.9[a]	13.6[a]
117			-297[a]	-283[a]	-285[a]	-254[a]	-267[a]	-271[a]
118			431[a]	407[a]	404[a]	370[a]	387[a]	352[a]
119			-189[a]	-176[a]	-175[a]	-166[a]	-173[a]	-152[a]
120			37[a]	33.9[a]	33.7[a]	33[a]	34.5[a]	303[a]
121			-373[a]	-3.34[a]	-3.34[a]	-3.34[a]	-3.51[a]	-3.11[a]
122			.201[a]	.177[a]	.177[a]	.180[a]	.191[a]	.171[a]
123			-.006[a]	-.005[a]	-.005[a]	-.005[a]	-.005[a]	-.005[a]
124			.00006[a]	.00005[a]	.00005[a]	.00005[a]	.00006[a]	.00005[a]
125	-.653[a]	-.474[a]	-2.83	-.681	.253	2.15[a]	1.52[a]	-.593[a]
126	.013[a]		4.52[c]	1.47	.332	-1.29[a]	-.892[a]	.036
127			-2.05[c]	-.648	-.243	.163[a]	.094[a]	-.0008
128			.392	.096	.035[b]	-.007[a]	-.003[a]	
129			-.039	-.006	-.002[a]	.00009[c]		
130			.002	.0002	.00003[a]			
131			-.00006	-.000002				
132			.0000007					

Table B, Part 25

Variable number	Equation number							
	193	194	195	196	197	198	199	200
R^2	.684	.678	.334	.333	.311	.282	.282	.269
$\bar{R}^2$	.674	.669	.315	.316	.295	.266	.266	.255
D.F.	625	626	627	628	629	630	631	632
0	5021[a]	4588[a]	6284[a]	6126[a]	5974[a]	7138[a]	7112[a]	7077[a]
2	1832[a]	1770[a]						
3	.059	.043						
4	.325[c]	.275						
5	-31.6[c]	-23.4						
6	2.85[a]	2.93[a]						
7	-26.5[a]	-28.2[a]						
8	-.0008[b]	-.0009[b]						
9	21.8[a]	21.7[a]						
14	13.6[a]	18.8[a]	8.4	7.8	10.9[c]	5	5.2	3.0
117	-269[a]	-273[a]	-335[a]	-324[b]	-342[a]	-258[b]	-261[b]	-256[b]
118	353[a]	340[a]	526[a]	507[a]	504[a]	500[a]	413[a]	370[a]
119	-153[a]	-146[a]	-231[a]	-221[a]	-219[a]	-194[a]	-196[a]	-171[a]
120	30.5[a]	29.4[a]	44.1[a]	41.7[a]	42[a]	39.8[a]	40.2[a]	35.3[a]
121	-3.13[a]	-3.05[a]	-4.31[a]	-4.01[a]	-4.14[a]	-4.13[a]	-4.17[a]	-3.70[a]
122	.172[a]	.170[a]	.226[a]	.207[b]	.219[a]	.227[a]	.229[a]	.206[a]
123	-.005[a]	-.005[a]	-.006[a]	-.005[b]	-.006[a]	-.006[a]	-.006[a]	-.006[a]
124	.00005[a]	.00005[a]	.00006[b]	.00006[b]	.00006[b]	.00007[a]	.00007[a]	.00006[b]
125	-.492[a]	-.282[a]	-10.6[a]	-8.82[a]	-3.53[a]	1.34[c]	1.24[c]	-.773[a]
126	.015[a]		12.5[a]	10.1[a]	3.37[a]	-.919[b]	-.846[a]	.037
127			-4.48[a]	-3.42[a]	-.976[a]	.102[c]	.089[a]	-.0006
128			.703[b]	.483[a]	.108[a]	-.003	-.002[a]	
129			-.057	-.033[a]	-.005[a]	.00002		
130			.002	.001[a]	.00008[a]			
131			-.00006	-.00001[a]				
132			.0000005					

Table B, Part 26

Variable number	Equation number							
	201	202	203	204	205	206	207	208
$\underline{R}^2$	.269	.256	.654	.211	.647	.641	.636	.636
$\bar{R}^2$	.257	.244	.648	.207	.638	.632	.628	.627
D.F.	633	634	633	641	627	628	629	630
0	7091[a]	6183[a]	4500[a]	6699[a]	274[b]	207[c]	207[c]	206[c]
2			1758[a]		1917[a]	1971[a]	1980[a]	1966[a]
3			.315		.103	.144	.179	.189
4			.207		.554[a]	.568[a]	.594[a]	.616[a]
5			-23.3		-29.4[c]	-32.1[c]	-32.0[c]	-32.5[c]
6			3.09[a]		2.91[a]	2.77[a]	2.80[a]	2.86[a]
7			-22.9[a]		-32.4[a]	-3.16[a]	-32.3[a]	-32.3[a]
8			-.0005		.0001	.0002	.0004	.0004
9			22.3[a]		22.6[a]	22.9[a]	22.7[a]	23.1[a]
14	2.9	12.9[a]	20.2[a]	8.7[c]	30.0[a]	33.1[a]	30.6[a]	30.0[a]
117	-254[b]	-242[a]	24.4[a]	13.6[a]	-329[a]	-144[a]	-20.1	-46.7[c]
118	371[a]	331[b]			417[a]	155[a]	8.32	32.2[b]
119	-172[a]	-152[b]			-173[a]	-52.2[a]	1.72	-4.61[c]
120	35.4[a]	31.7[a]			33.8[a]	8.24[a]	-.387	.291[c]
121	-3.71[a]	-3.37[a]			3.46[a]	-.644	.025	-.006[c]
122	.206[a]	.191[a]			.191[a]	.024[a]	-.0005	
123	-.006[a]	-.005[b]			-.005[a]	-.0004[a]		
124	.00006[b]	.00006[b]			.00006[a]			
125	-.700[a]	-.377[a]	-.288[a]	-.414[a]				
126	.002[a]							

Table B, Part 27

Variable number	Equation number 209	210	211	212	213	214	215	216
R^2------	.633	.633	.629	.619	.115	.138	.139	.141
$\bar{R}^2$------	.626	.626	.622	.613	.112	.134	.133	.134
D.F.----	631	632	633	634	642	641	640	639
0-------	198[c]	196[c]	95.2	92.1	546[a]	606[a]	604[a]	606[a]
2-------	1978[a]	1980[a]	1984[a]	1934[a]				
3-------	.182	.180	.262	.374[c]				
4-------	.594[a]	.598[a]	.584[a]	.451[b]				
5-------	-34.3[b]	-34.3[a]	-34.7[b]	-29.9[c]				
6-------	2.84[a]	2.84[a]	2.98[a]	2.98[a]				
7-------	-32.1[a]	-32.3[a]	-25.2[a]	-28.2[a]				
8-------	.0004	.0004	.0006	.0006				
9-------	23.5[a]	23.5[a]	23.5[a]	23.2[a]				
14------	29.6[a]	29.6[a]	31.1[a]	31.9[a]	16.6[a]	14.8[a]	15.1[a]	15.3[a]
117-----	-11.4	-17.2	11.1	40.2[a]	33.6[a]	-10.1	-5.05	21.0
118-----	7.38	10.1[a]	2.59[a]			3.88[a]	2.58	-9.50
119-----	-.049	-.34[a]					.058	1.35
120-----	-.009							-.038

Table B, Part 28

Variable number	217	218	219	220	221	222	223	224
	Equation number							
R^2	.147	.158	.172	.184	.051	.538	.461	.459
$\bar{R}^2$	.139	.149	.161	.172	.050	.531	.454	.453
D.F.	636	637	636	635	643	635	636	637
0	629[a]	594[a]	560[a]	618[a]	883[a]	652[a]	996[a]	946[a]
2						1699[a]	1263[a]	1233[a]
3							-.356	-.384
4						.626[a]	.465[b]	.412[c]
5						-51.6[a]	-39.5[b]	-39.8[c]
6						3.65[a]	5.51[a]	5.77[a]
7						-37.4[a]	-30.9[a]	-27.8[a]
8						.0003	-.0006	
9						25.7[a]	23.5[a]	23.9[a]
14	16.2[a]	18.9[a]	24.0[a]	21.1[a]	29.5[a]	42.4[a]		
117	-41.3	62.2	135[c]	-390[a]		-.188		
118	34.3	-59	174[b]	537[a]				
119	-6.69[c]	18.1[c]	-67.2[b]	-235[a]				
120	.490[b]	-2.17[b]	11.4[a]	47.0[a]				
121	-.011[b]	.112[b]	-.939[a]	-4.87[a]				
122		-.002[a]	.037[a]	.270[a]				
123			-.0005[a]	-.008[a]				
124				.00009[a]				

Table B, Part 29

Variable number	225	226	227	228	229	230	231	232
	Equation number							
R^2	.446	.445	.444	.405	.301	.280	.402	.398
$\bar{R}^2$	.441	.440	.440	.402	.299	.278	.396	.392
D.F.	638	639	640	641	642	643	637	638
0	670[a]	634[a]	675[a]	627[a]	537[a]	639[a]	1511[a]	1475[a]
2	1080[a]	1051[a]	1057[a]				1663[a]	1619[a]
3	-.040	-.062	.027	.205	1.01[a]		-.580[b]	
4	.142	.201					.291	.039
5	-27.0						-8.85	-8.34
6	6.46[a]	6.26[a]	6.09[a]	7.10[a]	9.28[a]	9.20[a]		
7							-51.9[a]	-47.2[a]
8							-.002[a]	-.002[a]
9	27.6[a]	26.6[a]	26.1[a]	33[a]			23.5[a]	22.0[a]

Table B, Part 30

Variable number	Equation number 233	234	235	236	237	238	239	240
R^2-------	.361	.194	.193	.166	.005	.017	.260	.345
$\bar{R}^2$-------	.356	.189	.189	.163	.004	.015	.258	.342
D.F.----	639	640	641	642	643	643	642	641
0-------	1618[a]	1530[a]	1561[a]	1854[a]	1207[a]	1088[a]	1031[a]	1018[a]
2-------	2007[a]							1500[a]
3-------						.898[a]	-.218	-.386[c]
4-------	.160	.253						
5-------	15.5	109[a]	105[a]					
7-------	-64.8[a]	-62.6[a]	-60.4[a]	-74.6[a]				
8-------	-.002[a]	-.002[a]	-.002[a]	-.002[a]	-.0009[c]			
9-------							47.1[a]	34.4[a]

Table B, Part 31

Variable number	Equation number 241	242	243
R^2-------	.350	.351	.389
$\bar{R}^2$-------	.346	.346	.384
D.F.----	640	639	638
0-------	1097[a]	1051[a]	1439[a]
2-------	1483[a]	1445[a]	1633[a]
3-------	-.132	-.149	-.694[a]
4-------	-.508[b]	-.435[c]	.108
5-------		24.4	-5.45
7-------			-45.6[a]
9-------	32.6[a]	31.5[a]	24.9[a]

Table B, Part 32

Variable number	Equation number 244	245	246	247	248	249	250	251
R^2-------	.816	.798	.697	.677	.805	.785	.642	.619
$\bar{R}^2$-------	.779	.767	.640	.632	.768	.754	.578	.570
D.F.-----	536	559	543	566	540	563	547	570
0--------	3161[a]	822	5787[a]	3129[a]	3563[a]	1825[a]	7615[b]	5712[a]
2--------	1764[a]	1749[a]			1759[a]	1730[a]		
3--------	-.249	-.088			.315	.445[c]		
4--------	.241	.210			.064	.068		
5--------	-18.9	-15.7			-7.2	-5.0		
6--------	3.1[a]	2.9[a]			3.9[a]	3.6[a]		
8--------	-.0001	-.0002			.0003	.0001		
9--------	12.0[a]	11.7[a]			13.9[a]	13.4[a]		
10-------	536[a]	568[a]	943[a]	925[a]				
11-------	355[a]	228[a]	583[a]	444[a]				
12-------	455[a]	405[a]	542[a]	482[a]				
13-------	378[a]	345[a]	374[a]	349[a]				
14-------	20.6[a]	18.2[a]	18.7[a]	18.7[a]	27.9[a]	24.3	29.5[a]	26.1[a]
15-------	-514[c]	1.5	-669[c]	20.9	-418	6.7	-7.9[c]	17.9
16-------	258	25.3	23.5	49.0[b]	163	24.3	-496	26.9
17-------	382[c]	58.7[a]	21.9	83.7[a]	408[c]	80.5[a]	390	109[a]
18-------	-159	11.2	140	24.3	-339	13.3	-71.2	39.3[c]
19-------	193	-25.6	13.1	-22.1	271	-17.3	183	-31
20-------	-22.9	-41.8	62.6	-46.3[b]	35.2	-47.8	-83.1	-95.6[a]
21-------	-512[c]	17.7	-820[b]	-8.6	-348	40.9[a]	-499	14.8
22-------	137	-12.6	559[c]	-20.8	100	-5.6[b]	561	-31.1
23-------	-360	20.9	-638[c]	45.3[b]	-90.8	18.1	-318	28.5
24-------	205	21.7	262	12.2	508	41.7[b]	.173	32.2
25-------	201	41.7[c]	83.7	-6.4	95.6	45.4[b]	-30.3	9.4
26-------	-380	64.5[a]	-582	60.6[b]	-543	73.6[a]	-833	75.5[b]
27-------	-88.6	14.4	110	-18.7	-49.0	23.9	432	13.8
28-------	-771[b]	38.7[b]	-464	41.3[c]	-909[a]	36.2[c]	-644	30.8
29-------	-942[a]	22.6	-524	-29.0	-1067[a]	39.1[c]	-541	-3.6
30-------	-1012[a]	57.0[b]	-1094[a]	18.2	-921[a]	68.7[a]	-954[a]	23.1
31-------	-815[b]	-11.8	-261	-20.7	-826[b]	-8.0	-279	-17.5
32-------	-322	14.2	-.533	8.4	-335	12.2	-1.1	-3.6
33-------	-39.6	-22.4	-111	-34.6	-138	-10.4	-523	-4.4
34-------	108	79.6[a]	-4.1	52.5[c]	129	96.1[a]	236	66.6[b]
35-------	-36.6	-23.4	-313	-69.6[b]	196	-11.0	172	-30.7

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Table B, Part 32.--Continued

Variable number	Equation number							
	244	245	246	247	248	249	250	251
36------	-613[b]	-27.2	-761[c]	-45.9	-600[c]	-38.4	-443	-68[c]
37------	-32.5	-61.5	109	-77.2	94.6	-25.2	35	-53.7
38------	.115	.336	-1.1	-.741	.018	.238	-3.4[a]	-2.5[a]
39------	1.3[c]	.359	2.8[a]	2.3[a]	.629	-.145	1.4	1.5[c]
40------	-.894	-1.7[a]	-1.8[c]	-1.8[a]	-.826	-1.5[b]	-.927	-1.4[c]
41------	.987	1.2	1.0	.262	.02	.560	-.263	-.432
42------	.947	.78	2.2[b]	2.4[a]	.821	.214	2.6[a]	2.1[a]
43------	-.984	-.089	-2.3[c]	-2.0[c]	.103	1.1	-1.9	-1.1
44------	.898	1.0	.299	.568	1.1	.596	-.609	-1.2
45------	-2.3[a]	-2.3[a]	-1.1	-1.7[c]	-2.4[a]	-2.6[a]	-.703	-1.5[c]
46------	-2.2	-1.5	-1.9	-.569	-3.6[a]	-2.9[a]	-4.3[a]	-3.3[a]
47------	-.997	-1.1	.452	.003	-.456	-.645	.410	.681
48------	-.116	-.335	-.357	-.650[c]	-.376	-.451[c]	-.384	-.556
49------	2.0[c]	2.1[b]	-.647	.217	2.7[b]	3.0[a]	.620	1.6
50------	-2.9[a]	-3.3[a]	-2.8	-2.8[b]	-2.0[b]	-2.9[a]	-1.5	-2.5[b]
51------	-1.3	-.094	-1.7	-1.2	-1.3	.006	-1.9	-1.3
52------	-.799	.313	.057	.972	-.987	.496	1.5	2.6[a]
53------	1.9[c]	2.2[b]	.205	.745	2.9[a]	3.4[a]	2.7[b]	3.3[a]
54------	.593	1.2	-1.4	-.775	-.294	.216	-3.5[a]	-2.9[b]
55------	-.606	-.105	.597	.821	-.590	-.008	.484	.827
56------	1.9[a]	1.8[b]	313[a]	2.9[a]	1.6[b]	1.4[b]	3.5[a]	3.5[a]
57------	.006	.208	-1.0	-.938	-.288	-.231	-2.0[a]	-2.2[a]
58------	-.227	-.004	-1.6[c]	-1.0	.082	-.377	-1.2	-1.5[c]
59------	-1.6[c]	-.974	-2.5[b]	-1.6	-1.1	-.644	-1.8	-1.0
60------	-.387	-.956	1.4[c]	.954	-.088	-1.6[a]	.396	-.409
61------	.941		-1.3[c]		.768		1.3[c]	
62------	-.427		.040		-.264		.939	
63------	-.597		.110		-.620		-.520	
64------	.277		-.200		.576		-.173	
65------	-.367		-.077		-.484		-.375	
66------	-.004		-.139		-.117		-.002	
67------	.852[c]		1.3[b]		.606		.828	
68------	-.251		-.967[c]		-.191		-.975[c]	
69------	.585		1.1[c]		.142		.522	
70------	-.283		-.399		-.731		.319	
71------	-.254		-.139		-.097		.052	
72------	.663		.958		.945		1.4	

-Continued

Table B, Part 32.--Continued

Variable number	Equation number 244	245	246	247	248	249	250	251
73------	.163		-.199		.106		-.683	
74------	1.3[b]		.826		1.5[a]		1.1	
75------	1.6[a]		.827		1.8[a]		.903	
76------	1.8[a]		1.9[a]		1.7[a]		1.6[a]	
77------	1.3[b]		.378		1.3[b]		.459	
78------	.577		.033		.605		.023	
79------	-.014		.116		.190		.893	
80------	-.082		.092		-.085		-.337	
81------	.013		.450		-.382		-.368	
82------	1.0[c]		1.2[c]		.976[c]		.641	
83------	-.117		-.381		-.305		-.229	
84------	539[a]	427[a]	267	161	515[a]	363[b]	250	92.3
85------	625[a]	461[a]	391[b]	220	575[a]	385[a]	275	105
86------	134	65.5	-175	-281[c]	136	50.5	-230	-342[b]
87------	-60.6	-51.1	-66[a]	-660[a]	-64.6	-88.6	-839[a]	-839[a]
88------	30.9	-54.2	-591[a]	-639[a]	16.6	-100	-793[a]	-840[a]
89------	303[c]	27.4	-218	-392[b]	240	-92.1	-340	-546[a]
90------	-35.6	-32.3	-588[a]	-597[a]	-65.8	-79.2	-801[a]	-779[a]
91------	-75.8	-125	-472[a]	-548[a]	-131	-169[c]	-677[a]	-684[a]
92------	201	52.1	-235	-377[c]	122	-41.1	-450[b]	-569[a]
93------	-103	-93.9	-557[a]	-566[a]	-150[c]	-151[c]	-687[a]	-648[a]
94------	-184[c]	-255[a]	-550[a]	-654[a]	-265[a]	-326[a]	-771[a]	-813[a]
95------	-18.6	-111	-484[a]	-559[a]	-136	-206	-693[a]	-707[a]
96------	-245[a]	-255[b]	-811[a]	-833[a]	-206[c]	-222[b]	-874[a]	-858[a]
97------	-2.6	-52.6	-469[b]	-537[a]	-10.8	-4.7	-540[b]	-519[a]
98------	-321	-335[b]	-789[a]	-800[a]	-362[b]	-301[c]	-921[a]	-818[a]
99------	-380[a]	-435[a]	-900[a]	-1006[a]	-401[a]	-440[a]	-1023[a]	-1124[a]
100-----	-300[c]	-389[b]	-587[a]	-702[a]	-288[c]	-363[b]	-639[a]	-766[a]
101-----	-78.8	-129	-660[a]	-660[a]	-35.7	-92.6	-597[a]	-663[a]
102-----	-199[c]	-265[b]	-368[a]	-475[a]	-152	-174[c]	-222	-331[b]
103-----	-172	-293[b]	-559[a]	-732[a]	-133	-202[c]	-568[a]	-703[a]
104-----	-130	-259	-560[a]	-760[a]	6.7	-62.2	-420[c]	-560[a]
105-----	13.5	-31.7	-346	-546[c]	55.8	110	-459	-509
106-----	-10.2	-138	-62.6	-391	-99.8	-109	-389	-517[c]
107-----	-276	-187	-388	-460	-257	-79	-561[c]	-489
108-----	127	140	-35.3	-111	-47.8	104	-375	-293
109-----	-188	-214	-392	-533[c]	-258	-130	-658[c]	-651[b]
110-----	-401	-354	-102	-191	-568[b]	-362	-337	-224

Table B, Part 33

Variable number	Equation number							
	252	253	254	255	256	257	258	259
R^2	.777	.776	.702	.702	.702	.676	.670	.650
$\bar{R}^2$	.747	.746	.662	.663	.663	.634	.628	.607
D.F.	566	567	568	569	570	571	572	573
0	5128[a]	5050[a]	6463[a]	6333[a]	6292[a]	7182[a]	6469[a]	5443[a]
2	1862[a]	1830[a]						
3	-.222	-.197	-.168					
4	.258	.269	-.011	-.058				
5	-26.0[c]							
6	2.8[a]	2.6[a]	5.7[a]	5.7[a]	5.7[a]	6.2[a]	6.5[a]	7.8[a]
7	-49.4[a]	-47.7[a]	-33.2[a]	-30.6[a]	-31.1[a]	-56.4[a]	-58.1[a]	
8	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.001[b]	-.002[a]		
9	13.2[a]	12.0[a]	22.1[a]	21.8[a]	21.8[a]			
14	22.1[a]	22.1[a]	8.11	8.41	8.63	3.82	5.94[b]	4.42
15	-630[b]	-619[b]	-664[a]	-648[b]	-651[b]	-802[b]	-740	-581[c]
16	357	352	361	348	348	288	526	405
17	428[a]	424[b]	266	268	264	227	108	393
18	-292	-281	-153	-144	-138	43.2	-27.9	-67.7
19	223	223	124	132	131	34.7	33.9	168
20	208	190	390	366	364	342	338	147
21	-672[b]	-637[b]	-731[b]	-720[b]	-725[b]	-724[b]	-688[b]	-382
22	161	134	274	279	284	282	310	261
23	-511[c]	-519[c]	-744[b]	-719[b]	-712[b]	-740[b]	-726[b]	-713[b]
24	839[b]	828[c]	860[c]	872[c]	879[c]	1023[b]	1118[b]	770
25	271	286	273	259	248	341	262	185
26	-456	-410	-912	-882	-896	-912	-981	-800
27	312	291	265	251	255	318	403	567
28	-694[b]	-697[b]	-624[c]	-611[c]	-597[c]	-718[c]	648[c]	-698[c]
29	-527	-529	-432	-426	-434	-329	-362	-304
30	-414	-403	-779[a]	-772[a]	-764[a]	-765[b]	-788[a]	-794[b]
31	-712[b]	-714[b]	-510	-482	-473	-541	-507	-537
32	-273	-49.7	-281	-250	-242	-372	-347	-328
33	157	185.2	78	91.4	92.9	-973	8.20	-164
34	-85.6	-88.1	-175	-162	-161	-236[b]	-257[b]	-99.8
35	-68.6	-43.7	-77	-76.6	-79.4	-216	-184	8.40
36	-237	-240	-413	-400	-395	-207	-185	184
37	-171	-190	-318	-314	-311	-364	-314	-387
38	.841	.871	.665	.663	.642	.301	.754	-.51
39	.894	.929	1.34[c]	1.28[c]	1.28	1.71[b]	2.30[a]	2.12[b]

-Continued

Table B, Part 33.--Continued

Variable number	Equation number 252	253	254	255	256	257	258	259
40------	-.702	-.712	-.916	-.930	-.92	-1.12	-1.26	-.493
41------	.013	.047	.138	.112	.112	1.04	1.03	.402
42------	.495	.560	1.58[a]	1.57[b]	1.56[b]	2.06[b]	1.90[b]	2.67[a]
43------	-.713	-.886	-.397	-.444	-.451	-1.11	-.908	-1.47
44------	.253	.327	-.812	-.775	-.791	-1.60	-1.60	-2.39[b]
45------	-2.87[a]	-2.96[a]	-2.42[a]	-2.46[a]	-2.43[a]	-2.53[b]	-2.55[a]	-2.56[a]
46------	-2.87[a]	-2.80[a]	-4.22[a]	-4.09[a]	-4.06[a]	-3.82[a]	-3.62[a]	-4.18[a]
47------	.166	-.008	2.37[b]	2.37[b]	2.39[b]	2.14[b]	2.39[b]	2.46[b]
48------	-.332	-.337	-.572[c]	-.571[c]	-.572[c]	-.783[b]	-.805[b]	-.886[a]
49------	1.14	1.33	1.33	-1.21	-1.19	-1.62	-2.12[c]	-1.71
50------	-1.74[c]	-1.75[c]	-1.44	-1.58	-1.61	-1.10	-.474	.217
51------	-1.33	-1.33	-1.78[c]	-1.73[c]	-1.74[c]	-1.91[c]	-2.16[b]	-1.44
52------	-1.05	-1.07	-.716	-.682	-.664	-.291	-.633	.562
53------	1.58[c]	1.69	1.36	1.52	1.53	.862	.618	2.32[c]
54------	1.39[c]	1.44[c]	.120	-.009	-.040	-.208	-.022	-1.35
55------	.181	.140	.348	.381	.381	1.06	1.10	1.07
56------	2.37[a]	2.43[a]	3.04[b]	3.10[a]	3.11[a]	3.95[a]	3.99[a]	4.15[a]
57------	-1.52[a]	-1.66[a]	-1.79[a]	-1.78[a]	-1.76[a]	-3.00[a]	-2.91[a]	-3.02[a]
58------	-.697	-.673	-.832	-.873	-.897	-1.53[c]	-1.50[c]	-.89
59------	-1.22	-1.17	-1.73[c]	-1.72[c]	-1.73[c]	-1.88[c]	-1.74[c]	-1.43[c]
60------	-1.24[b]	-1.34[b]	-.978	-.977	-.940	-.221	.029	-1.26[b]
61------	1.12[b]	1.10[b]	1.16[b]	1.13[b]	1.13[b]	1.41[b]	1.33[b]	1.01
62------	-.541	-.531	-.536	-.514	-.514	-.397	-.796	-.588
63------	-.658[c]	-.647[c]	-.356	-.355	-.348	-.26	-.046	-.549
64------	.498	.481	.243	.228	.218	-.087	.034	.102
65------	-.381	-.376	-.217	-.228	-.228	-.070	-.054	-.270
66------	-.345	-.315	-.682[c]	-.643[c]	-.641[c]	-.599	-.580	-.332
67------	1.14[a]	1.08[b]	1.20[b]	1.18[b]	1.19[b]	1.17[b]	1.10[b]	.608
68------	-.290	-.244	-.502	-.510	-.517	-.506	-.552	-.480
69------	.839[c]	.854[c]	1.21[b]	1.18[b]	1.17[b]	1.21[b]	1.19[b]	1.15[b]
70------	-1.27	-1.25[c]	-1.31[c]	-1.33[c]	-1.34[c]	-1.59[b]	-1.25[b]	-1.20
71------	-.350	-.373	-.346	-.325	-.309	-.455	-.332	.204
72------	.776	.706	1.45	1.41	1.43	1.46	1.55	1.29
73------	-.449	-.416	-.402	-.382	-.387	-.495	-.623	-.866
74------	1.20[b]	1.21[b]	1.08[c]	1.06[c]	1.04[c]	1.24[b]	1.13[c]	1.21c

-Continued

Table B, Part 33.--Continued

Variable number	Equation number							
	252	253	254	255	256	257	258	259
75	.966[c]	.967[c]	.768[c]	.760	.773	.593	.638	.557
76	.848[c]	.829[c]	1.49[a]	1.48[a]	1.47[a]	1.47[a]	1.51[a]	1.52[a]
77	1.18[b]	1.19[b]	.784	.738	.726	.818	.783	.862
78	.062	.096	.494	.445	.432	.624	.611	.589
79	-.327	-.356	-.205	-.224	-.225	-.052	-.074	.245
80	.295	.291	.437[b]	.411[c]	.411[c]	.488[b]	.535[b]	.253
81	.048	-.005	-.004	-.003	.003	.206	.170	-.147
82	.346	.352	.620	.600	.594	.248	.226	-.390
83	.134	.166	.385	.381	.380	.481	.415	.486

Table B, Part 34

Variable number	Equation number							
	260	261	262	263	264	265	266	267
R^2	.774	.588	.514	.767	.779	.511	.482	.365
$\bar{R}^2$	.743	.534	.455	.735	.747	.452	.442	.315
D.F.	565	570	574	567	563	575	597	597
0	3993[a]	6366[a]	6699[a]	4174[a]	4539[a]	7456[a]	6284[a]	724[a]
2	1801[a]			1780[a]	1820[a]			
3	-.311			.192	-.403[c]			
4				.008	.250			
5	-29.1[c]			-18.4	-24.7[a]			
6	3.2[a]			3.6[a]	2.9[a]			
8				-.001[b]	-.001[a]			
9	15.0[a]			16.7[a]	13.1[a]			
10	418[a]	862[a]			474[a]			
11	309[a]	592[a]			372[a]			
12	224[b]	272[c]			257[b]			
13	239[a]	156			261[a]			
14	22.2[a]	16.2[b]	14.1[b]	21.7[a]	20.9[a]		11.2[c]	19.0[a]
15	-549[b]	-588	-410	-458	-646[b]	-477		246
16	466[c]	451	179	249	273	167		-274
17	557[a]	-3.13	227	622[a]	645[a]	111		397
18	-262	62.9	-107	-330	-156	-194		-193
19	218	-134	62.3	341[c]	203	88		16.4
20	41.6	313	88.5	43.8	38.6	149		-91.7
21	-517	-671[c]	-372	-443	-580[b]	-309		713[c]
22	183	572[c]	464	131	174	501		879[a]
23	-601[b]	-722[c]	-680	-467	-619[b]	-645		760[c]
24	546	870	167	604	507	117		309
25	244	147	6.79	206	289	-334		227
26	-316	-918	-839	-243	-316	-959		467
27	316	567	1138[b]	349	242	1110[b]		1310[b]
28	-761[b]	-980[b]	-921[b]	-701[b]	-815[b]	-881[c]		-575
29	-455	113	335	-477	-456	407		-5.00
30	-521[b]	-871[b]	-862[b]	-429[c]	-490[c]	-835[b]		-848[b]
31	-594	-337	-480	-662[c]	-594	-432		-275
32	70.0	153	136	47.4	55.6	153		324
33	134	-175	-565[c]	103	131	-561		-744[b]
34	-50.5	-306[b]	-7.06	51.1	-44.6	-.795		579[b]
35	-17.1	133	363[c]	88.6	-66.6	335		912[a]

-Continued

Table B, Part 34.--Continued

Variable number	Equation number 260	261	262	263	264	265	266	267
36------	-184	-240	506	-31.6	-200	438		1142[b]
37------	-220	.275	.412	-215	-270	-421		-865[b]
38------	.832	.438	-2.08[b]	.147	.397	-1.83[c]	-1.04	
39------	1.19[c]	2.99[a]	3.30[a]	.570	.767	2.93[a]	1.56[b]	
40------	-.198	-.884	-.156	-.253	-.009	-.718	-1.38	
41------	.062	1.15	.423	-.606	.193	.439	.631	
42------	.657	1.83[b]	2.51[b]	.905	.791	2.26[b]	2.75[a]	
43------	-1.33	-1.80	-1.88	-1.1	-1.6[c]	-1.40	-1.39	
44------	.180	-1.22	-3.11[a]	.257	.335	-3.18[a]	-2.54[b]	
45------	-3.22[a]	3.21[a]	-2.98[a]	-3.0[a]	-3.2[a]	-3.27[a]	-3.85[a]	
46------	-1.97[c]	-2.38[c]	-4.21[a]	-3.1[a]	-1.9[c]	4.15[a]	-3.63[a]	
47------	.121	2.16[c]	1.91	.224	-.084	1.65	1.88[c]	
48------	-.293	-.802[b]	-.804	-.346	-.282	-.840[b]	-1.20[a]	
49------	.225	-3.53[a]	-2.24	1.7[c]	.628	-2.44[c]	-1.49	
50------	-2.01[b]	-.814	.835	-2.0[b]	-2.7[a]	1.14	-.746	
51------	-1.01	-2.69[b]	-2.70[b]	-.717	-.890	2.85[b]	-2.42[b]	
52------	-.902	-.584	1.45	-.316	-.557	1.35	2.13[b]	
53------	2.24[b]	.552	2.77[c]	3.2[a]	2.4[b]	3.15[b]	3.50[a]	
54------	1.23	-.592	-2.46[b]	.311	1.1	-2.87[b]	-1.62	
55------	.051	.262	-.242	.103	.004	-.227	-.138	
56------	2.33[a]	5.08[a]	6.43[a]	2.4[a]	2.4[a]	6.25[a]	6.91[a]	
57------	-1.38[b]	-2.99[a]	-3.63[a]	-1.4[b]	-1.5[a]	-3.45[a]	-3.42[a]	
58------	-.025	-.857	-.961	-.250	-.160	-.844	-1.54[c]	
59------	-1.19	-1.47	-.735	-.964	-1.4	-515	-.375	
60------	-1.76[a]	.148	-1.02	-2.3[a]	-1.8[a]	-1.09	-1.59[b]	
61------	.992[c]	1.13[c]	.782	.787	1.1[b]	.916	.003	-.539
62------	-.726	-.644	-.159	-.359	-.402	-.134	.120[b]	.558
63------	-.880[b]	.170	-.266	-.997[a]	-1.0[a]	-.070	.159[a]	-.544
64------	.450	-.065	.241	.564	.274	.383	.056	.303
65------	-.361	.224	-.12	-.567[c]	-.350	-.156	-.023	-.019
66------	-.077	-.528	-.290	-.119	-.078	-.372	-.143[a]	.008
67------	.880[c]	1.05[c]	.576	.779[c]	.984[b]	.469	-.013	-1.06[c]
68------	-322	-.952[c]	-.794	-.246	-.302	-.852	-.038	-1.37[b]
69------	.989[b]	1.20[c]	1.10	.764	1.0[b]	1.04	.01	-1.22[c]
70------	-.814	-1.36	-.237	-.888	-.754	-.158	.021	-.51

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Table B, Part 34.--Continued

Variable number	Equation number							
	260	261	262	263	264	265	266	267
71------	-.312	-.239	-.001	-.240	-.391	.065	.0001	-.437
72------	.55	1.47	1.39	.462	.554	1.59	.082	-.572
73------	-.447	-.886	-.176	-.501	-.335	-1.71[b]	.049	-2.13[b]
74------	1.31[b]	1.69[b]	1.61[b]	1.2[b]	1.4[a]	1.54[b]	.099[b]	1.05
75------	.830	-.167	-.499	.891	.839	-.60	.038	.058
76------	1.03[b]	1.64[b]	1.62[b]	.878[b]	.077[b]	1.58[b]	.194[a]	1.56[b]
77------	1.01[c]	.573	.844[c]	1.1[c]	.994[c]	.765	.026	.463
78------	-.081	-.208	-.179	-.051	-.077	-.206	-.020	-.507
79------	-.299	.328	1.09	-.216	-.302	1.10[c]	.144[b]	1.25[b]
80------	.24	.613[b]	.023	.047	.222	.011	.026	-.879[a]
81------	-.024	.109	-.733	-.209	.040	-.672	-.067	-1.71[a]
82------	.298	.363	-.950	.015	.313	-.832	-.054	-2.10[a]
83------	.188	.323	.521	.173	.272	.554	-.184[a]	1.48[b]

Table B, Part 35

Variable number	Equation number 268	269	270	271	272	273	274
$\bar{R}^2$	.480	.556	.645	.651	.656	.686	.686
R^2	.439	.518	.613	.620	.625	.656	.656
D.F.	597	593	592	591	590	587	588
0	5960[a]	4839[a]	4097[a]	5609[a]	5788[a]	5307[a]	5232[a]
3						.056	.066
4						-.106	
6			6.4[a]	6.5[a]	6.2[a]	5.7[a]	5.7[a]
7				-94.2[a]	-66.4	-70.3[b]	-68.7[b]
8					-.001[a]	-.0008[b]	-.0008[c]
9						23.0[a]	23.1[a]
10		899[a]	553[a]	-76.5	126	-124	-102
11		489[a]	263[a]	-289	-102	-298	-277
12		309[a]	239[b]	-176	-30.9	-86.3	-73.1
13		259[a]	308[a]	328[a]	323[a]	318[a]	319[a]
14	12.5[c]	15.4[b]	3.51	4.52	1.62	6.42	6.68
15	-5.73	-.115	-45.3[c]	-39.1	-55.8	-48.7[c]	-51.1[b]
16	717[a]	81.1[a]	63.8[a]	60.9[a]	46.9[a]	43.1[b]	43[b]
17	88[a]	91.1[a]	109[a]	91.8[a]	95.7[a]	78.2[a]	78.5[a]
18	30.8	18.0	-7.88	-5.13	-6.21	-2.56	-2.26
19	-11.3	-6.94	-4.8	-13.2	-18.7	-22.5	-22.8
20	-90.6[a]	-32.0	-41.8[c]	-43.1[c]	-46.6[b]	-53.2[b]	-53.3[b]
21	-9.22	-23	-15.1	-15.4	-12.8	2.61	2.72
22	-20.1	-1.2	-17.8	-19.3	-19.9	-28	-27.7
23	4.95	23.8	17.1	19.6	16.4	21.4	21.6
24	13.8	-3.58	-5.02	-.767	-.508	18.4	18.3
25	.320	-20.6	29.4	27.3	31.1	43.4[c]	41.2[c]
26	50.9	38.3	22.4	22.1	25.6	23.3	22
27	33.6	-4.55	-.467	-7.18	-7.70	1.08	1.36
28	56.7[b]	58.1[b]	46.1[b]	50.1[b]	41.5[c]	43.2[b]	42.6[b]
29	21.6	.309	11.3	4.42	9.45	17.8	18.9
30	113[a]	105[b]	111[a]	111[a]	104[a]	108[a]	109[a]
31	11.7	17.6	-14.8	-27.4	-37.6	-32.6	-31
32	-12.7	-7.09	-6.03	-12.3	-25.0	-8.4	-7.74
33	76.0[b]	27.7	-19.9	-28.7	-32.0	-25	-24.5
34	11.6	13.5	34.6	26.2	25.8	50.5[b]	51.9[b]
35	-35.1	-73.5[b]	-77.6[b]	-89.3[a]	-96.3[a]	-74.8[b]	-75.1[b]

-Continued

Table B, Part 35.--Continued

Variable number	Equation number						
	268	269	270	271	272	273	274
36------	-20.9	-15.7	7.23	-13.0	-21.7	-32.2	-32.5
37------	-109[b]	-95.9[b]	-98.3[b]	-91.3[b]	-97.1[b]	-89.8[b]	-87.6[b]
38------	-107	1972	1.01	1.22[a]	.932	.985	.948
39------	1.63	1.41[c]	.366	.553	.193	-.167	-.165
40------	-1.23	-1.40[a]	-1.51[c]	-1.59[b]	-1.57	-1.52[b]	-1.48
41------	.596	1.1	1.11	1.01	1.05	.812	.810
42------	2.79[a]	2.7[a]	2.74[a]	2.46[a]	2.56[a]	1.75[b]	1.76[b]
43------	-1.58	-2.61[b]	-1.99[b]	-1.65	-1.90[b]	-1.06	-1.08
44------	-2.67[b]	-.311	-.868	-1.07	-.724	-.298	-.306
45------	-3.61[a]	-3.67[a]	-3.15[a]	-3.12[a]	-2.99[a]	-2.76[a]	-2.72[a]
46------	-3.63[a]	-.798	-1.35	1.16[c]	-1.44	-1.64	-1.64
47------	1.83	1.3	1.63	1.93	1.77[c]	1.74[a]	1.76[c]
48------	-1.22[a]	-1.31[a]	-1.27[a]	-1.44[a]	-1.37[b]	-.971[a]	-.962[a]
49------	-1.41	-3.14[a]	-2.45	-274[b]	-2.33[b]	-1.68	-1.65
50------	-.593	-1.25	-1.74	-1.28	-1.90[c]	-2.27[b]	-2.29[b]
51------	-2.38[a]	-2.45[b]	-1.33	-1.93[b]	-1.59	-1.57[c]	-1.60[c]
52------	2.25[b]	.259	.704	.166	.528	.125	.170
53------	3.55[a]	1.13	1.87[c]	1.18	1.40	1.82	1.81
54------	-1.65	.137	.161	.333	.141	.728	.716
55------	-.006	.279	1.11	1.49[c]	1.34[c]	.638	.606
56------	6.93[a]	5.53[a]	4.17[a]	4.39[a]	4.31[a]	3.40[a]	3.39[a]
57------	-3.47[a]	-2.5[a]	-2.30[a]	-2.35[a]	-2.50[a]	-1.28[b]	-1.25[b]
58------	-1.56[c]	-.972	-.741	-1.23[c]	-1.19	-.937	-.947
59------	-.301	-.932	-1.26	-1.52	-1.42	-1.34	-1.35
60------	-1.69[b]	.264	-.922	-.184	-.526	-1.05	-1.02

Table B, Part 36

Variable number	Equation number							
	275	276	277	278	279	280	281	282
R^2	.765	.765	.748	.758	.428	.237	.478	.422
$\bar{R}^2$	.742	.742	.725	.734	.406	.209	.438	.401
D.F.	586	585	590	586	620	621	598	621
0	4774[a]	4782[a]	3513[a]	3276[a]	7544[a]	819[a]	6557[a]	8464[a]
2	1862[a]	1882[a]	1772[a]	1823[a]				
3	-.009	-.024	.410[b]	-.078				
4	.179	.169	.060	.242				
5		-16.1	-10.9	-15.7				
6	2.5[a]	2.6[a]	3.5[a]	2.8[a]				
7	-10.7[a]	-10.7[a]						
8	-.0007[c]	-.0007[c]	-.001[a]	-.001[a]				
9	12.0[a]	12.9[a]	16[a]	13.2[a]				
10	-282	-276		455[a]				
11	-441[a]	-435[b]		210[a]				
12	-309[b]	-299[b]		188[c]				
13	243[a]	247[a]		230[a]				
14	21[a]	21[a]	18.6[a]	18.7[a]				
15	-20.8	-20.8	-33.4	-35.3		-60.1[c]	1.1	
16	41[b]	40.6[b]	39.1[b]	38.9[b]		52.7[b]	74.5[a]	
17	73.6[a]	72[a]	86.7[a]	82.9[a]		82.4[a]	81.7[a]	
18	9.81	9128	8.0	5.9		-47.6[c]	29.3	
19	-16.1	-17.8	-4.9	-11.8		19.6	-10.2	
20	-21.8	-22.5	-35.9[c]	-23.4		-62.4[b]	-84.5[a]	
21	30.8	32.1[b]	45.1[b]	32.2		104[a]	-12.6	
22	-13.1	-14.1	-16.5	-12.9		56.2[b]	-19.6	
23	15.1	14.8	9.1	11.4		29.3	3.1	
24	26.5	26	36[c]	21.3		-2.6	16.0	
25	38.9[c]	39[c]	56.3[a]	40.9[c]		-40.6	1.4	
26	47.9[b]	47.3	53.9[b]	47[c]		64[c]	58.6[c]	
27	17.1	17.2	32.0[c]	23.5		23.4	37.7	
28	50.6[a]	50.6[a]	45.2[b]	42.8[b]		23.5	54.6[b]	
29	43[b]	44.1[b]	61.6[a]	52.5[b]		39.0	33.6	
30	89.7[a]	90.0[a]	95.8[a]	87.8[a]		58[c]	125[a]	
31	11.1	10.5	14.7	19.7		8.4	13.6	
32	-8.72	-7.63	-1.1	-5.4		49.0	-8.1	
33	-15.8	-16.3	6.7	-8.7		20	81.3[b]	
34	63.9[a]	66.8[a]	81[a]	75.7[a]		150[a]	9.9	
35	-41.5	-39.3	-18.9	-31.2		-9.4	-33.5	

-Continued

Table B, Part 36.--Continued

Variable number	Equation number							
	275	276	277	278	279	280	281	282
36------	-12.7	-13.1	-16.6	-11.1		-6.5	-23.6	
37------	-84.6[b]	-83.8[b]	-75.7[b]	-91.7[b]		41.4	-102[b]	
38------	1.39[b]	1.37[b]	.659	1.0[c]	1.3[c]		-.811	-1.0
39------	-.437	-.467	-.810	-.762	1.6[c]		1.4[c]	1.2[c]
40------	-1.50[b]	-1.51[b]	-1.5[b]	-1.4[b]	-1.6[b]		-1.5[c]	-1.8[b]
41------	.579	.592	.361	.723	-.694		.734	-.599
42------	.437	.386	.452	.762	2.7[a]		2.5[a]	2.4[a]
43------	-.778	-.700	-.312	-1.2	-.106		-1.4	-.059
44------	.837	.825	.461	1.1	-3.0[a]		-2.8[a]	-3.3[a]
45------	-3.20[a]	-3.16[a]	-3.16[a]	-3.1[a]	-3.4[a]		-3.9[a]	-3.6[a]
46------	-.933	-.967	-2.5[a]	-1.3	-2.0[c]		-3.5[a]	-1.7
47------	-.173	-.092	-.253	-.368	1.9[c]		1.4	1.4
48------	-.823[a]	-.808[a]	-.552[b]	-.621[b]	-1.3[a]		-1.2[a]	-1.2[a]
49------	.113	.028	1.6[c]	.400	-1.6		-1.5	-1.6
50------	-2.25[b]	-2.26[b]	-2.8[a]	-2.9[a]	-.756		-.118	-.421
51------	-.769	-.790	.045	-.115	-2.0[a]		-2.7[b]	-2.1[b]
52------	-.492	-.462	.654	.257	1.6[c]		2.1[b]	1.3
53------	1.63[c]	1.58	3.2[a]	2.3[b]	1.8		3.9[a]	2.1[c]
54------	2.02[b]	2.01[b]	1.2	1.7[b]	-2.6[a]		-1.9[c]	-3.0[a]
55------	.578	.589	.097	.138	.847		.096	.910
56------	2.62[a]	2.59[a]	2.4[a]	2.4[a]	5.5[a]		6.7[a]	5.1[a]
57------	-1.19[b]	-1.11[b]	-1.2[b]	-1.1[b]	-4.0[a]		-3.4[a]	-3.9[a]
58------	-.767	-.762	-.699	.266	-1.9[b]		-1.4[c]	-1.6[b]
59------	-.869	-.897	-.261	-.618	-.288		-.155	-.116
60------	-1.46[b]	-1.42[a]	-2.7[a]	-2.2[a]	-.338		-1.7[b]	-.333

Table B, Part 37[a/]

Variable number	Equation number 283[b/]	284	285	286	287
$\bar{R}^2$------	.8787	.8792	.8792	.7550	.8675
R^2------	.8542	.8548	.8548	.7094	.8420
D.F.----	536	536	536	543	540
0-------	2644.3[a]	2665.0[a]	2661.9[a]	5235.3[a]	2986.8[a]
2-------	1741.7[a]	1758.9[a]	1761.2[a]		1761.9[a]
3-------	.01138	.04363	.03317		.54712[a]
4-------	-.00103	-.02722			
4-A-----			209.90		1946.8
5-------	-17.111	-15.866	-15.923		-4.8790
6-------	2.9891[a]	2.8569[a]	2.8578[a]		3.6994[a]
8-------	-.00013				
8-A-----		-130.67	-129.15		-102.33
9-------	11.333[a]	11.270[a]	11.289[a]		13.388[a]
10------	524.22[a]	526.53[a]	528.20[a]	967.56[a]	
11------	347.44[a]	344.13[a]	346.37[a]	609.10[a]	
12------	423.11[a]	417.90[a]	419.46[a]	531.55[a]	
13------	371.12[a]	368.14[a]	367.60[a]	376.95[a]	
14------	21.398[a]	20.257[a]	20.344[a]	20.090[a]	27.170[a]
15------	-487.86[b]	-483.19[b]	-485.90[b]	-686.19[b]	-396.88[c]
16------	413.66[c]	392.23[c]	389.84[c]	206.56	250.25
17------	280.45[c]	302.44[c]	301.15[c]	-73.231	334.94[b]
18------	-150.71	-138.44	-137.52	146.99	-310.85[c]
19------	189.52	192.09	192.35	6.0363	274.47[c]
20------	-68.159	-56.935	-56.644	34.959	-4.0270
21------	-502.43[b]	-503.60[b]	-505.13[b]	-828.53[a]	-358.73[c]
22------	220.25	210.58	212.06	665.58[b]	176.99
23------	-229.24	-328.55	-326.93	-582.78[c]	-51.567
24------	255.08	289.06	291.70	304.66	578.17[c]
25------	248.57	255.03	253.96	130.15	152.78
26------	-262.52	-230.11	-237.67	-540.52	-397.62
27------	-137.72	-154.38	-150.49	75.604	-72.961
28------	-809.86[a]	-797.17[a]	-795.73[a]	-488.82	-909.94[a]
29------	-717.65[a]	-687.99[b]	-692.59[a]	-339.08	-831.06[a]
30------	-834.00[a]	-811.87[a]	-811.94[a]	-910.16[a]	-716.65[a]
31------	-827.04[a]	-816.37[a]	-815.21[a]	-291.27	-818.31[a]
32------	-205.89	-190.08	-193.37	91.919	-233.49
33------	-83.940	-79.714	-80.082	-163.38	-176.33
34------	116.97	105.15	104.76	.72457	135.26

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Table B, Part 37[a/].--Continued

Variable number	Equation number				
	283[b/]	284	285	286	287
35------	-9.0958	-24.607	-26.633	-307.41	198.45
36------	-230.25	-223.30	-222.63	-378.96	-181.32
37------	37.991	26.010	25.716	166.45	122.92
38------	-.06280	-.09279	-.10083	-1.2778	-.32137
39------	1.5160[b]	1.4594[b]	1.4558[b]	2.9779[a]	.72919
40------	-1.4091[b]	-1.3549[b]	-1.3515[b]	-2.2141[a]	-1.2049[b]
41------	.67002	.71161	.71854	.70915	-.16640
42------	1.2386[b]	1.1927[b]	1.1939[b]	2.4598[a]	1.1159[b]
43------	-.92115	-.86338	-.87645	-2.2415[b]	.06132
44------	1.1126	1.1777[c]	1.1686[c]	.44349	1.2621[c]
45------	-1.7183[b]	-1.8064[a]	-1.7918[a]	-.36733	-1.8553[a]
46------	-2.3113[a]	-2.3395[a]	-2.3292[a]	-2.0158[c]	-3.5921[a]
47------	-1.3935[c]	-1.3375[c]	-1.3379[c]	.14920	-.92535
48------	-.22706	-.21971	-.21829	-.44307	-.43997[c]
49------	2.5652[a]	2.5992[a]	2.6008[b]	-.11398	3.5013[a]
50------	-2.9286[a]	-3.0812[a]	-3.0774[a]	-2.8627[b]	-2.2833[a]
51------	-.86374	-.81095	-.81356	-1.3772	-.84688
52------	-.93882	-.85167	-.84896	-.05656	-.92720
53------	2.4821[a]	2.5418[a]	2.5329[a]	.63743	3.5065[a]
54------	.28534	.30000	.29712	-1.6170	-.60224
55------	-.73766	-.81380	-.81700	.42868	-.88692
56------	1.8913[a]	1.8750[a]	1.8736[a]	3.2210[a]	1.6118[a]
57------	.22077	.24357	.24589	-.75344	-.07360
58------	-.79115	-.77707	-.78866	-2.1711[a]	-.57849
59------	-1.5026[b]	-1.5208[b]	-1.5250[b]	-2.4800[b]	-1.0360
60------	.01259	-.03065	-.01931	1.8014[a]	-.49283
61------	.90120[b]	.88785[b]	.89201[b]	1.3043[b]	.72237[c]
62------	-.71460[c]	-.67863[c]	-.67476[c]	-.29495	-.43722
63------	-.39866	-.44057	-.43802	.29577	-.47684
64------	.26241	.24014	.23864	-.21203	.52778[c]
65------	-.35487	-.36180	-.36262	-.06039	-.48923[c]
66------	.08454	.06686	.06617	-.07939	-.04264
67------	.84382[b]	.84767[b]	.85039[b]	1.3490[a]	.63245[c]
68------	-.38699	-.37024	-.37254	-1.1395[a]	-.31465
69------	.49335	.54164	.53906	.98085[c]	.08578

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Table B, Part 37[a].--Continued

Variable number	Equation number				
	283[b]	284	285	286	287
70------	-.35919	-.41522	-.41943	-.46340	-.84384
71------	-.31823	-.32813	-.32681	-.20404	-.16653
72------	.49897	.44617	.45769	.90701	.73452
73------	.23850	.26352	.25754	-.14415	.14160
74------	1.3796[a]	1.3577[a]	1.3553[a]	.87128	1.5439[a]
75------	1.2394[a]	1.1943[a]	1.2021[a]	.53362	1.4626[a]
76------	1.5466[a]	1.5081[a]	1.5085[a]	1.6050[a]	1.3566[a]
77------	1.28736	1.2668[a]	1.2655[a]	.39882	1.3031[a]
78------	.40002	.37049	.37636	-.10284	.45007
79------	.07337	.06582	.06665	.21509	.27172
80------	-.10055	-.07953	-.07851	.08695	-.10258
81------	-.02122	.00153	.00535	.45521	-.37803
82------	.40692	.39397	.39267	.63670	.30629
83------	-.23651	-.22005	-.21887	-.47660	-.35560
84------	383.71[a]	383.14[a]	383.87[a]	99.119	364.83[a]
85------	239.96[b]	238.72[b]	239.46[a]	-6.9717	195.51[c]
86------	-10.118	-1.9825	-1.1370	-331.58[b]	9.5765
87------	-90.675	-46.758	-47.277	-712.33[a]	-22.044
88------	-38.463	-28.831	-28.036	-664.18[a]	-32.111
89------	176.90	180.87	182.83	-340.77[b]	133.56
90------	-61.358	-6.6425	-7.2118	-619.47[a]	-23.739
91------	-153.79[c]	-131.80[c]	-131.08	-552.85[a]	-177.03[b]
92------	60.776	71.943	72.877	-375.40[b]	3.8427
93------	-131.86[c]	-88.553	-88.744	-577.38[a]	-118.87
94------	-253.17[a]	-232.33[a]	-231.95[a]	-624.90[a]	-305.13[a]
95------	-134.65	-119.29	-118.41	-591.64[a]	-221.34[b]
96------	-253.25[a]	-241.53[a]	-242.09[a]	-827.88[a]	-182.69[b]
97------	-37.654	-21.273	-20.295	-507.41[a]	-18.183
98------	-361.90[a]	-345.26[a]	-345.34[a]	-836.29[a]	-378.74[a]
99------	-488.81[a]	-450.66[a]	-451.17[a]	-1012.2[a]	-432.90[a]
100-----	-416.01[a]	-389.83[a]	-389.56[a]	-697.88[a]	-332.97[a]
101-----	-110.31	-109.48	-108.61	-677.39[a]	-51.108
102-----	-277.74[a]	-288.60[a]	-286.60[a]	-434.02[a]	-235.47[a]
103-----	-260.09[a]	-264.38[a]	-262.65[a]	-635.47[a]	-214.87[b]
104-----	-230.09[c]	-228.98[c]	-227.20[c]	-650.40[a]	-78.152

-Continued

Table B, Part 37[a/].--Continued

Variable number	Equation number				
	283[b/]	284	285	286	287
105	-5.3315	-10.054	-7.7613	-345.20	49.257
106	-25.376	-14.801	-13.075	-72.637	-79.898
107	-293.17	-280.74	-282.32	-410.12	-271.09
108	100.40	114.73	115.69	-43.848	-42.182
109	-204.38	-198.67	-197.45	-391.39	-250.54
110	-425.89[b]	-415.86[b]	-414.43[b]	-121.96[b]	-567.82[a]

a/ All equations in parts 37, 38, 39, 40, and 41 were estimated using the corrected data.

b/ Equation 283 is the same as equation 244 except the corrected data were used for equation 283.

Table B, Part 38[a/]

Variable number	Equation number 288	289	290	291	292
R^2	.8451	.8639	.8284	.8567	.8631
$\bar{R}^2$	.8228	.8432	.8101	.8349	.8423
D.F.	563	559	582	559	559
0	3694.2[a]	1170.6[c]	239.60[a]	202.60[a]	802.65
2	1853.4[a]	1757.3[a]	1677.6[a]	1753.2[a]	1756.5[a]
3	-.03687	.16777	-.06079	-.02708	.17053
4A	-1572.6	852.35	2251.4	-192.13	731.22
5	-23.690[c]	-12.436	-22.702[c]	-27.205[b]	-12.019
6	2.6610[a]	2.5539[a]	2.8174[a]	3.3457[a]	2.6132[a]
8-A	-212.66[a]	-170.59[b]	-91.744	-94.878	-173.76[b]
9	13.135[a]	11.664[a]	13.090[a]	13.042[a]	11.412[a]
10	457.80[a]	554.63[a]	623.21[a]	527.52[a]	552.90[a]
11	340.23[a]	224.84[a]	208.44[a]	232.80[a]	222.85[a]
12	259.38[a]	345.13[a]	347.78[a]	369.57[a]	364.35[a]
13	259.27[a]	324.34[a]	299.81[a]	340.86[a]	341.96[a]
14	22.728[a]	17.265[a]	22.078[a]	24.623[a]	17.822[a]
15	-633.57[a]			-550.15[a]	.63074
16	472.25[b]			410.12[b]	14.413
17	529.11[a]			576.87[a]	63.892[a]
18	-148.23			-326.60[b]	9.4584
19	205.41			-272.08[b]	-21.302
20	-47.732			-100.60	-30.644[b]
21	-550.18[b]			-408.44[b]	22.472
22	216.84			366.84[b]	-13.022
23	-495.43[b]			270.11	19.583
24	550.78			123.49	22.677
25	202.62			212.14	50.658[a]
26	-236.96			75.781	72.837[a]
27	225.66			251.22	9.7896
28	-828.70[a]			-409.85[c]	40.070[a]
29	-260.35			-478.75[c]	29.820
30	-495.50[b]			-827.04[a]	73.424[a]
31	-642.06[b]			-780.23[a]	-33.587
32	174.56			18.030	22.400
33	82.732			-263.29	-19.149
34	-38.894			216.81[a]	77.895[a]
35	-90.199			203.55	-20.489
36	-72.091			99.411	16.647

-Continued

Table B, Part 38[a/]

Variable number	Equation number 288	289	290	291	292
37------	-258.20			-185.13	-73.040[b]
38------	.34330	.18372			.12655
39------	.73338	.18769			.18959
40------	-.63752	-2.2733[a]			-2.1256[a]
41------	.37935	.9349			.83307
42------	1.3007[b]	1.1192[b]			1.1175[b]
43------	-1.6389[b]	.12553			.08597
44------	.83058	1.6216[b]			1.5717[b]
45------	-2.4128[a]	-1.9726[a]			-1.8615[a]
46------	-2.4329[a]	-2.1897[a]			-1.9343[b]
47------	-.17224	-1.5481[b]			-1.5572[b]
48------	-.28238	-.47515[b]			-.44578[c]
49------	.54204	2.4200[a]			2.6075[a]
50------	-2.4000[a]	-3.5043[a]			-3.3984[a]
51------	-.73159	.30213			.24654
52------	-.25010	.07735			.21352
53------	2.5144[a]	3.0049[a]			2.9982[a]
54------	.40427	.83408			.76727
55------	-.11935	-.59752			-.47635
56------	1.9909[a]	1.7756[a]			1.6637[a]
57------	-.98687[b]	.41507			.53164
58------	-.43981	-.45393			-.49623
59------	-1.3381[c]	-.89633			-1.0105
60------	-.91531[c]	-.52802			-.54266
61------	1.1285[a]	.01277	.03347	.99652[a]	
62------	-.77176[c]	.01919	.03807	-.71414[b]	
63------	-.81393[a]	.11364[a]	.12233[a]	-.91775[a]	
64------	.25836	.01580	-.03661	.52172[b]	
65------	-.36192	-.03956	-.04703[c]	.41232[c]	
66------	.07970	-.04670[c]	-.02981	.15326	
67------	.94566[a]	.04000	.08077[a]	.73825[b]	
68------	-.37952	-.02496	.00385	-.60441[b]	
69------	.82191[b]	.03088	.07214[a]	-.39827	
70------	-.82571	.03726	.03933	-.15864	
71------	-.24426	.07836[a]	.07453[b]	-.27999	
72------	.43014	.10858[a]	.12302[a]	-.00161	
73------	-.31277	.01949	.04231[b]	-.36839	

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Table B, Part 38[a/].--Continued

Variable number	Equation number				
	288	289	290	291	292
74------	1.4101[a]	.06978[a]	.05781[a]	.73239[b]	
75------	.52984	.05722[b]	.02747	.84407[b]	
76------	.98764[a]	.12733[a]	.01161	1.4886[a]	
77------	1.0417[b]	-.04541	-.04208	1.1949[a]	
78------	-.25363	.03981	.07342[b]	.03587	
79------	-.21213	-.03023	-.02163	.41136	
80------	.21238	.14974[a]	.18289[a]	-.23735	
81------	.10649	-.03118	-.01397	-.39937	
82------	.12839	.02733	.02036	-.17184	
83------	.27769	-.13217[b]	-.08725[c]	.18418	
84------		354.50[a]	433.16[a]	459.20[a]	351.37[a]
85------		184.74[c]	294.78[a]	322.20[a]	180.38[c]
86------		-2.6348	112.97	132.82	-4.9980
87------		-14.822	-65.93	-70.853	-25.606
88------		-81.827	-157.36[b]	-68.392	-96.218
89------		-25.231	-118.58	92.948	-34.799
90------		30.108	-31.227	-46.912	13.574
91------		-142.01[c]	-258.26[a]	-207.00[a]	-159.33[b]
92------		-6.5329	-165.20	-59.393	-22.699
93------		-47.102	-113.65	-139.51[b]	-64.197
94------		-262.89[a]	-401.33[a]	-356.38[a]	-280.53[a]
95------		-164.40	-345.98[a]	-261.48[b]	-172.26
96------		-228.78[a]	-273.81[a]	-285.95[a]	-239.75[a]
97------		-37.55	-271.90[b]	-261.29[b]	-47.47
98------		-331.01[b]	-557.59[a]	-570.30[a]	-335.18[a]
99------		-469.82[a]	-228.37[b]	-200.56[b]	-468.15[a]
100-----		-438.36[a]	-184.50[c]	-158.82	-442.45[a]
101-----		-147.92[c]	-161.67[c]	-60.912	-134.89
102-----		-340.80[a]	-163.61[a]	-118.66[b]	-331.00[a]
103-----		-361.17[a]	-276.29[a]	-171.37[b]	-352.37[a]
104-----		-325.29[a]	-281.40[a]	-184.33[b]	-326.38[a]
105-----		-82.710	41.305	16.057	-66.22
106-----		-167.37	-80.849	-55.327	-158.36
107-----		-268.94	-185.69[b]	-194.85[c]	-238.14
108-----		42.185	221.18[b]	168.78	104.84
109-----		-304.89	-58.891	-90.270	-250.72
110-----		-423.95[b]	-242.28[b]	-424.93[a]	-384.54[b]

a/ All equations in parts 37, 38, 39, 40, and 41 were estimated using corrected data.

Table B, Part 39[a/]

Variable number	Equation number 293	294	295	296	297	298
R^2------	.8385	.8388	.6754	.7975	.8203	.8157
$\bar{R}^2$------	.8210	.8213	.6445	.7855	.8022	.7985
D.F.----	581	581	588	608	585	589
0-------	1662.8[c]	1727.8[b]	4417.0[a]	3903.0[a]	3049.5[a]	1736.4[b]
2-------	1844.1[a]	1844.5[a]		1931.8[a]	1844.5[a]	1796.0[a]
3-------	-.10584	-.05355		.07224	.47664[a]	-.18655
4-------	.09515					
4-A-----		-660.72		-910.69	1332.8	1642.4
5-------	-19.919[b]	-18.754		-25.795[b]	-3.3319	-20.760
6-------	3.0063[a]	2.9041[a]		2.5418[a]	3.7075[a]	2.3076[a]
8-------	.00011					
8-A-----		-99.172		-141.55[b]	-135.31	-117.64
9-------	12.654[a]	12.394[a]		15.467[a]	14.973[a]	14.675[a]
10------	540.45[a]	537.19[a]	993.57[a]	415.22[a]		617.20[a]
11------	320.43[a]	312.88[a]	656.48[a]	280.04[a]		210.13[a]
12------	433.94[a]	427.63[a]	624.15[a]	243.00[a]		330.00[a]
13------	383.44[a]	376.12[a]	395.37[a]	255.43[a]		313.58[a]
14------	20.462[a]	19.071[a]	15.167[a]	21.266[a]	25.896[a]	15.056[a]
84------	413.86[a]	411.97[a]	-76.446		343.97[a]	336.85[a]
85------	287.19[a]	287.33[a]	-220.10[c]		217.70[b]	184.24[b]
86------	82.684	92.864	-492.39[a]		111.45	47.649
87------	-90.120	-39.087	-799.64[a]		-8.2390	-54.498
88------	-53.999	-52.106	-740.32[a]		-68.042	-155.13[b]
89------	41.712	43.495	-595.21[a]		-30.821	-133.70
90------	-68.757	-18.799	-679.91[a]		-2.3759	8.7475
91------	-140.58[c]	-130.16[c]	-614.02[a]		-141.83[c]	-191.28[b]
92------	9.8550	13.747	-554.52[a]		-35.607	-128.23
93------	-140.76[b]	-98.727	-669.85[a]		-93.546	-48.680
94------	-294.02[a]	-283.14[a]	-738.84[a]		-317.43[a]	-337.48[a]
95------	-175.37	-170.71	-704.83[a]		-232.02[b]	-245.31[b]
96------	-203.21[b]	-183.59[b]	-824.84[a]		-104.74	-178.40[b]
97------	-105.69	-98.89	-612.61[a]		6.7152	-169.71
98------	-339.52[b]	-327.02[b]	-817.17[a]		-239.75[c]	-344.45[b]
99------	-280.75[a]	-226.40[b]	-1000.3[a]		-132.27	-261.50[b]
100-----	-204.70[c]	-157.24	-658.01[a]		-34.750	-191.90[c]
101-----	-79.558	-83.892	-657.74[a]		-17.357	-128.06
102-----	-84.167	-96.414	-419.81[a]		-8.3036	-117.30[c]
103-----	-147.12[c]	-155.92[c]	-657.47[a]		-34.426	-222.62[b]

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Table B, Part 39a/.--Continued

Variable number	Equation number					
	293	294	295	296	297	298
104	10.705	12.237	-444.73[a]		229.94[c]	-46.772
105	332.75[c]	330.45[c]	145.72		501.43[a]	301.57
106	242.48	262.31	14.310		343.17[b]	208.88
107	134.05	159.09	-198.91		218.54	113.50
108	598.44[a]	615.12[a]	302.96		569.65[a]	604.23[a]
109	283.46	293.90[c]	-82.240		349.40[c]	260.85
110	-106.79	-88.974	18.453		-81.299	30.317
117	-4025.7[a]	-3973.6[a]	-4672.2[a]	-4732.9[a]	-3558.5[a]	
118	5486.2[a]	5453.7[a]	6022.1[a]	6249.9[a]	4810.6[a]	
119	-2337.1[a]	-2325.9[a]	-2564.6[a]	-2613.7[a]	-2016.9[a]	
120	453.61[a]	451.35[a]	503.54[a]	500.21[a]	387.34[a]	
121	-45.796[a]	-45.542[a]	-51.660[a]	-49.936[a]	-38.742[a]	
122	2.4840[a]	2.4686[a]	2.8587[a]	2.6861[a]	2.0782[a]	
123	-.06857[a]	-.06810[a]	-.08081[a]	-.07373[a]	-.05657[a]	
124	.00076[a]	.00075[a]	.00092[a]	.00081[a]	.00061[a]	
125	-4.4307[b]	-4.3633[b]	-10.188[a]	-5.1197[b]	-2.8126	1.0078
126	7.2729[a]	7.1732[a]	15.042[a]	7.7006[a]	4.1811[c]	-1.0108
127	-3.2621[a]	-3.2034[a]	-6.8287[a]	-3.3900[a]	-1.6334	.43290
128	.65079[a]	.63635[a]	1.4102[a]	.65903[a]	.27574	-.08967
129	-.06778[a]	-.06605[a]	-.15207[a]	-.06684[a]	-.02401	.00931
130	.00383[a]	.00372[a]	.00886[a]	.00369[a]	.00113	-.00050
131	-.00011[a]	-.00011[a]	-.00026[a]	-.00011[b]	-.00003	.00001
132	$1x10^{-6}$[a]	$1x10^{-6}$[a]	$3x10^{-6}$[a]	$1x10^{-6}$[b]	$3x10^{-7}$	$-1x10^{-7}$
133	6.9371[a]	6.8424[a]	7.9751[a]	8.1126[a]	6.0676[a]	-.13468
134	-9.3001[a]	-9.2447[a]	-10.022[a]	-10.605[a]	-8.0410[a]	.30187[b]
135	3.9252[a]	3.9076[a]	4.2191[a]	4.4116[a]	3.3344[a]	-.14474[b]
136	-.75753[a]	-.75417[a]	-.82287[a]	-.84208[a]	-.63574[a]	.02852[b]
137	.07621[a]	.07584[a]	.08406[a]	.08393[a]	.06326[a]	-.00276[b]
138	-.00412[a]	-.00410[a]	-.00464[a]	-.00452[a]	-.00338[a]	.00014[c]
139	.00011[a]	.00011[a]	.00013[a]	.00012[a]	.00009[a]	$-3x10^{-6}$
140	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$-1x10^{-6}$[a]	$3x10^{-8}$

a/ All equations in parts 37, 38, 39, 40, and 41 were estimated using corrected data.

Table B, Part 40[a/]

Variable number	Equation number 299	300	301	302	303	304
R^2------	.8103	.8318	.8175	.8000	.7997	.7981
$\bar{R}^2$------	.7954	.8161	.8005	.7861	.7861	.7843
D.F.----	597	589	589	602	603	603
0-------	235.80[a]	210.32[a]	1363.5[c]	2224.5[a]	1808.4[b]	220.67[a]
2-------	1787.7[a]	1867.2[a]	1797.5[a]	1810.2[a]	1818.5[a]	1821.0[a]
3-------	-.14101	-.00979	-.16347	-.16131	-.12078	-.07878
4-A-----	1470.8	-862.82	1332.7	901.77	690.34	260.22
5-------	-24.029[b]	-20.288	-20.137	-22.096	-21.678	-23.863[c]
6-------	2.5202[a]	3.0195[a]	2.3425[a]	2.1376[a]	2.1746[a]	2.3440[a]
8-A-----	-100.72	-84.240	-117.49	-126.30	-129.60	-107.71
9-------	15.106[a]	13.204[a]	14.488[a]	14.024[a]	13.865[a]	14.026[a]
10------	682.20[a]	541.27[a]	608.68[a]	675.88[a]	657.28[a]	700.48[a]
11------	180.03[a]	216.93[a]	211.01[a]	230.81[a]	216.45[a]	215.31[a]
12------	395.37[a]	432.17[a]	340.60[a]	271.20[a]	264.21[a]	330.62[a]
13------	330.53[a]	357.98[a]	315.55[a]	300.87[a]	296.66[a]	336.99[a]
14------	15.563[a]	18.878[a]	15.992[a]	11.558[a]	12.093[a]	14.118[a]
84------	431.25[a]	454.50[a]	332.38[a]	284.20[a]	279.93[a]	340.55[a]
85------	273.12[a]	307.25[a]	181.31[c]	131.23	120.59	171.69[b]
86------	118.07	117.37	47.967	24.156	23.891	65.076
87------	-1.0378	-39.891	-56.284	-26.478	-21.409	12.244
88------	-107.37	-50.303	-159.55[c]	-148.53[b]	-150.71[b]	-120.59
89------	-73.504	62.228	-131.39	-176.04	-179.36	-155.29
90------	48.577	-13.726	-1.0494	59.039	56.887	75.915
91------	-193.30[b]	-165.67[b]	-194.15[b]	-164.97[b]	-167.40[b]	-171.99[b]
92------	-108.81	-13.031	-131.03	-115.38	-119.28	-117.89
93------	-43.77	-115.00[c]	-57.254	-3.7865	-9.5163	-16.427
94------	-356.71[a]	-343.85[a]	-342.74[a]	-312.68[a]	-319.31[a]	-333.25[a]
95------	-269.93[b]	-229.29[b]	-249.63[b]	-215.36[c]	-225.27[b]	-246.21[b]
96------	-190.30[b]	-207.29[b]	-181.86[b]	-164.06[c]	-166.46[c]	-174.43[b]
97------	-256.94[c]	-174.38	-169.16	-193.02	-197.85	-265.99[c]
98------	-440.53[a]	-407.81[a]	-348.36[b]	-334.93[b]	-344.36[b]	-427.93[a]
99------	-202.02[b]	-212.10[b]	-256.23[b]	-275.96[a]	-270.47[a]	-218.62[b]
100-----	-170.62	-180.73[c]	-193.44[c]	-214.90[b]	-216.36[b]	-186.25[c]
101-----	-91.998	-30.045	-127.05	-114.61	-110.61	-89.384
102-----	-154.74[a]	-114.46[b]	-116.34[c]	-141.08[b]	-146.64[b]	-167.79[a]
103-----	-268.85[a]	-202.00[a]	-222.63[b]	-276.72[a]	-281.83[a]	-303.82[a]
104-----	-240.57[a]	-171.09[b]	-41.534	-214.10[a]	-221.69[a]	-287.28[a]
105-----	93.507	78.08	311.85[c]	54.717	48.139	39.739

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Table B, Part 40[a/].--Continued

Variable number	Equation number					
	299	300	301	302	303	304
106	-16.403	-28.855	222.98	-32.071	-44.665	-99.762
107	-106.08	-53.186	136.67	-72.134	-77.064	-98.689
108	422.68[a]	414.23[a]	618.10[a]	446.70[a]	444.84[a]	453.18[a]
109	72.878	62.963	278.98	92.287	95.350	98.625
110	-215.57	-315.98[a]	38.427	-111.57	-117.22	-148.28
117		-3761.9[a]	-117.05[c]	-5.7404	24.819[a]	35.683
118		4884.6[a]	227.15[a]			
119		-2064.9[a]	-105.90[a]			
120		401.79[a]	20.717[a]			
121		-40.734[a]	-2.0142[a]			
122		2.2179[a]	.10261[b]			
123		-.06140[a]	-.00261[b]			
124		.00068[a]	.00003			
125			.78975	-.13671[b]	-.10719[b]	
126			-.54798			
127			.19486			
128			-.03675			
129			.00335			
130			-.00014			
131			$2x10^{-6}$			
132			$-1x10^{-8}$			
133	-.13632	6.4641[a]		.05118		-.01509
134	.29335[b]	-8.2785[a]				
135	-.14633[b]	3.4706[a]				
136	.03028[a]	-.67199[a]				
137	-.00309[b]	.06796[a]				
138	.00016[b]	-.00370[a]				
139	$-4x10^{-6}$[b]	.00010[a]				
140	$5x10^{-8}$[c]	$-1x10^{-6}$[a]				

a/ All equations in parts 37, 38, 39, 40, and 41 were estimated using corrected data.

Table B, Part 41[a/]

Variable number	Equation number 305	306	307	308	309
R^2------	.8000	.7974	.6302	.7521	.7517
$\bar{R}^2$------	.7864	.7840	.6090	.7462	.7361
D.F.----	603	604	609	629	606
0-------	2142.9[a]	201.24[b]	4397.6[a]	3909.4[a]	2862.2[a]
2-------	1812.0[a]	1808.8[a]		1865.6[a]	1682.1[a]
3-------	-.15340	-.11850		.25040	.59276[a]
4-A-----	860.78	386.19		1812.7	3786.2
5-------	-22.019	-25.213[c]		-15.905	-15.021
6-------	2.1441[a]	2.3629[a]		2.2180[a]	3.8770[a]
8-A-----	-126.58	-98.283		-99.800	-63.686
9-------	13.996[a]	14.273[a]		15.949[a]	22.750[a]
10------	672.12[a]	743.10[a]	982.90[a]	509.55[a]	
11------	228.12[a]	233.49[a]	409.37[a]	143.67[a]	
12------	269.57[a]	367.27[a]	340.92[a]	106.53[b]	
13------	299.73[a]	360.66[a]	308.32[a]	178.86[a]	
14------	11.673[a]	14.053[a]	6.9387	21.442[a]	13.306[a]
84------	283.23[a]	370.24[a]	-152.60		161.26
85------	128.92	207.34[b]	-344.66[a]		22.158
86------	24.017	81.564	-535.10[a]		53.446
87------	-25.537	18.291	-728.68[a]		43.420
88------	-149.16[b]	-104.55	-718.03[a]		-113.01
89------	-177.52	-134.34	-616.88[a]		-287.34[b]
90------	58.550	86.553	-577.16[a]		90.973
91------	-165.70[b]	-168.15[b]	-627.16[a]		-130.78
92------	-116.81	-106.09	-581.48[a]		-135.42
93------	-4.9491	-10.783	-583.70[a]		-2.5396
94------	-314.25[a]	-326.92[a]	-763.32[a]		-305.19[a]
95------	-217.81[c]	-235.94[b]	-703.42[a]		-215.34[c]
96------	-164.44[c]	-174.88[b]	-818.67[a]		-39.204
97------	-194.32	-281.63[b]	-634.46[a]		-49.163
98------	-337.18[b]	-442.54[a]	-785.49[a]		-169.50
99------	-274.73[a]	-208.21[b]	-1069.61[a]		-185.57[c]
100-----	-215.03[b]	-174.43[c]	-720.55[a]		-104.00
101-----	-113.81	-87.176	-672.14[a]		-20.560
102-----	-142.07[b]	-169.01[a]	-564.47[a]		-76.974
103-----	-277.79[a]	-304.42[a]	-833.50[a]		-136.02
104-----	-215.67[b]	-300.56[a]	-730.99[a]		-24.670
105-----	53.700	43.211	-525.60[a]		212.60

-Continued

Table B, Part 41[a].--Continued

Variable number	Equation number				
	305	306	307	308	309
106-----	-34.779	-100.87	-453.06[a]		35.126
107-----	-73.196	-99.13	-555.51[a]		-22.200
108-----	446.34[a]	458.82[a]	-32.438		379.35[a]
109-----	92.915	95.397	-487.96[a]		208.36[c]
110-----	-112.52	-153.49	-216.80		-124.96
117-----			-52.186	-5.0323	99.460[a]
125-----	-.13099[a]		-.24238[a]	-.26289[a]	-.19337[a]
133-----	.04170[a]	.04457[a]	.11794[c]	.04215	-.10819[b]

a/ All equations in parts 37, 38, 39, 40, and 41 were estimated using corrected data.

APPENDIX C

Table of Powers

Time period	Powers							
	0	1	2	3	4	5	6	7
1-------	1	1	1	1	1	1	1	1
2-------	1	2	4	8	16	32	64	128
3-------	1	3	9	27	81	243	729	2,187
4-------	1	4	16	64	256	1,024	4,096	16,384
5-------	1	5	25	125	625	3,125	15,625	78,125
6-------	1	6	36	216	1,296	7,776	46,656	279,936
7-------	1	7	49	343	2,401	16,807	117,649	823,543
8-------	1	8	64	512	4,096	32,768	262,144	2,097,152
9-------	1	9	81	729	6,561	59,049	531,441	4,782,969
10------	1	10	100	1,000	10,000	100,000	1,000,000	10,000,000
11------	1	11	121	1,331	14,641	161,051	1,771,561	19,487,171
12------	1	12	144	1,728	20,736	248,832	2,985,984	35,831,808
13------	1	13	169	2,197	28,561	371,293	4,826,809	62,748,517

-Continued

Table of Powers.--Continued

Time period	Powers							
	0	1	2	3	4	5	6	7
14------	1	14	196	2,744	38,416	537,824	7,529,536	105,413,504
15------	1	15	225	3,375	50,625	759,375	11,390,625	170,859,375
16------	1	16	256	4,096	65,536	1,048,576	16,777,216	268,435,456
17------	1	17	289	4,913	83,521	1,419,857	24,137,569	410,338,673
18------	1	18	324	5,832	104,976	1,889,568	34,012,224	612,220,032
19------	1	19	361	6,859	130,321	2,476,099	47,045,881	893,871,739
20------	1	20	400	8,000	160,000	3,200,000	64,000,000	1,280,000,000
21------	1	21	441	9,261	194,481	4,084,101	85,766,121	1,801,088,541
22------	1	22	484	10,648	234,256	5,153,632	113,379,904	2,494,357,888
23------	1	23	529	12,167	279,841	6,436,343	148,035,889	3,404,825,447