AN OCTOBER PREDICTION OF THE MICHIGAN MARCH PRICE FOR POTATOES AT THE FARM LEVEL

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Ronald A. Hagaman

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AN OCTOBER PREDICTION OF THE MICHIGAN MARCH PRICE FOR POTATOES AT THE FARM LEVEL

by

Ronald A. Hagaman

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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Approved by Lester V. Manderscheid

ABSTRACT

An October Prediction of the Michigan March Price for Potatoes at the Farm Level

This study was concerned with predicting the Michigan March price of potatoes at the farm level. The prediction was intended to be available during October as an aid to producers in making the decision of whether to store their potatoes or to sell them at harvest.

The actual Michigan March prices, as well as other monthly prices, are estimated average prices for first sales of potatoes; regardless of variety, quality, size, amounts sold, or location through-out Michigan. These prices are reported by the Crop Reporting Service of the United States Department of Agriculture.

Several multiple regression equations were computed by methods of least squares from twelve independent variables. The observation period included the years 1930-1958 but was later divided into Period A (1930-1942) and Period B (1947-1958). Equations were computed for both periods individually and for the periods combined. This division proved helpful for studying economic changes in the effect of independent variables.

All the equations were calculated in natural numbers, except Equation V which was computed in logarithms. The data

for Equation V was used for calculating Equation IV which was computed in natural numbers. Computations in natural numbers did an equally good job of predicting the March price and perhaps a cent or two per bushel better than logarithms for Period B.

The Durbin-Watson test for serial correlation of unexplained residuals was applied to the residuals of Equation IV for Period A and Period B individually. Results of this test were inconclusive.

Unexplained residuals during Period A were relatively small since the simple correlation coefficient between the Michigan October price and the March price was +.85, but the correlation coefficient was +.26 during Period B which accounted for some of the large unexplained residuals in the post-World War II period.

The best multiple regression equation for predicting the actual March price during Period B was Equation VI-B. The independent variables were: (1) Michigan October price, (2) an average of the previous two March prices, (3) late summer and fall production per capita, and (4) the October index of prices received for Michigan farm products. An average of the previous two March prices had a regression coefficient statistically different from zero at the ten per cent level. The other independent variables were not significant at the ten per cent level. The adjusted multiple correlation coefficient was .42, and the standard error of estimate was 49 cents per bushel. However, the average error of prediction was 29 cents per bushel which was the lowest of any computed for predicting Period B.

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CHAPTER I

INTRODUCTION

OBJECTIVE:

The primary objective of this study was to formulate a multiple regression equation for predicting the Michigan March price of potatoes at the farm level. This prediction was intended to be available by the end of October. Therefore, only data that were compiled or estimated by October could be used.

PURPOSE:

The primary purpose of the prediction was to provide a basis for potato producers to answer the annual question of whether they should sell their crop at harvest time or to store their potatoes and sell at a later date in the marketing season. However, this prediction would benefit the potato buyers as well as the producers. In fact, potato firms outside of Michigan could utilize this information for procurement of Michigan potatoes or shipment of potatoes into Michigan markets.

PROBLEM:

The problem was to select independent variables that would account for much of the year to year variation in the

Michigan March price. The Michigan October price was one of several independent variables injected into the multiple regression equation. In fact, October might be considered the starting place since its price indicated the supply and demand forces that could be expected to continue through March. However, the October to March price differential varied from no price change to $1.29 per bushel increase and $1.20 per bushel decrease for the period 1930 through 1958. The month of October was also the deadline since the prediction was based on information available by the end of October.

The problem focused mostly on the demand phase of the market forces since the supply phase was assumed as given by the October estimates of total Michigan production, United States late summer and fall production, and United States total production.

The actual Michigan March prices, as well as other monthly prices, were average prices estimated by the Michigan Crop Reporting Service and on file with the Department of Agricultural Economics at Michigan State University. The estimated average prices included first purchase of potatoes from the farm, regardless of the varieties, quality, amounts sold, or location through-out the state.

Conceptually, an analysis of prices for a state or any specific area is more complex than regional studies or United States aggregates. Also, an analysis of prices for a particular month is more complex than average seasonal prices or annual prices. As the study becomes more specific, the size of error increases because: (1) adequate information is unavailable or impossible to attain, (2) the data collection error increases, or (3) the general complexity of the economy is not being related in the selected variables or functions.

ORGANIZATION OF THESIS

Chapter Two is concerned with background information about the potato industry, in which, special attention is given to Michigan potatoes. Previous studies of potato prices are also reviewed.

In Chapter Three, several multiple regression equations have been computed from twelve independent variables in an attempt to predict the Michigan March price of potatoes at the farm level. The first two equations have been computed for the entire observation period (1930-1958). In the remaining equations, the observed years have been divided into Period A (1930-1942) and Period B (1947-1958). An equation has been computed for Period A and Period B individually and for both periods combined. Some economic changes have been noted between Period A and Period B. All of the equations have been computed from actual data in natural numbers, except Equation V which has been calculated in logarithms.

The study is summarized and conclusions are indicated in Chapter Four.

CHAPTER II

BACKGROUND AND PREVIOUS STUDIES

DESCRIPTION OF POTATO SEASONS

Potatoes are produced in every month of the year in the United States, but only certain states have the proper climatic conditions for year-around production. Most all states produce some potatoes, but their production is seasonal or bi-seasonal. Total United States production as a supply indicator is not specific enough when a price analyst attempts to predict a regional season average price or a monthly state price. The problem becomes a question of selecting suitable seasonal categories, and dividing United States production by states into the proper seasonal categories.

Prior to 1956, the United States Department of Agriculture divided potato production into "early", "intermediate", and "late" categories. State production was reported in these categories by the criterion of when the bulk of the crop was harvested. Michigan production was recorded under the late category, but a number of Michigan potatoes were harvested during the "intermediate" period. Therefore, a new classification was formulated for reporting seasonal production. The new categories were winter, early spring, late spring, early summer, late summer, and fall.

Then Michigan production was reported more accurately under both categories of late summer and fall.

The seasonal periods could hardly be considered exclusive because there is some overlapping and variation among time of planting, harvesting, and marketing dates. Also, there has been shifts toward earlier production which may put some areas into another season.

The marketing period begins at the same time the harvesting period does, but marketing may continue for sometime after harvesting is completed. The length of time that elapses between harvesting and marketing depends upon the market price, the storage qualities of seasonal potatoes, and the availability of new potatoes from succeeding seasonal crops.

A brief discussion of the new classification might be helpful for understanding the potato seasons. These will be discussed from the standpoint of: (1) per cent of United States production, (2) period of harvest, (3) period of marketing, (4) adaptability to storage, and (5) states included in each season.

WINTER

The most active period of harvest for this small crop (about 1.7 per cent of United States production for the period 1949 through 1958) is from January through March, but marketing may continue into April. These potatoes are not stored because prices tend to be relatively high during this season. This crop is produced mostly in the states of California and Florida.

EARLY SPRING

This crop is also relatively small (about 1.5 per cent of total production) with most active harvesting and marketing from April first through the middle of May. These potatoes are not stored because larger seasonal production will soon be on the market. The leading producing states are Florida and Texas.

LATE SPRING

This seasonal production accounts for the first substantial sized crop (about 11.2 per cent of total production) and is usually harvested and marketed between May 15 and June 30. These potatoes are not stored and warm weather prevents leaving them in the ground for any period of time. The leading states are North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas, Arizona, and California.

EARLY SUMMER

Producers appear to take a breather during this season as indicated by a smaller crop (about 4.1 per cent of total production) than the late spring crop. The most active harvesting and marketing period is from July through the middle of August. This crop is not stored either. The producing areas are Missouri, Kansas, Delaware, Maryland, Virginia, North Carolina, Georgia, Kentucky, Tennessee, and Texas.

LATE SUMMER

The volume of production increased somewhat (about 13.8 per cent of total production) during this season. These potatoes reach the market from the middle of August to the end of September. These potatoes are not stored generally, but a large crop may compete with fall potatoes and influence the amount of fall storage. The states that produce during this season are Massachusetts, Rhode Island, New York, New Jersey, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Nebraska, Maryland, Virginia, West Virginia, North Carolina, Idaho, Wyoming, Colorado, New Mexico, Washington, Oregon, and California. Many of the later summer producing states also produce during the fall season.

FALL

The most active period of harvest for this major crop (about 69.6 per cent of total production) is October through December. Some of the fall crop is harvested during September because cold weather becomes a limiting factor in certain areas. The fall potatoes are the ones that are stored, and because of this fact they may appear on the market as late as June of the following year. The fall producing areas may be divided into Eastern, Central, and Western States. The Eastern States are Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York and Pennsylvania. Central States include Ohio, Indiana, Michigan, Wisconsin, Minnesota, Iowa, North Dakota, South Dakota and Nebraska. The Western States include Montana, Idaho, Wyoming, Colorado, Utah, Nevada, Washington, Oregon, and California.

Dalrymple indicated that the timing of harvest, timing of market, and supply of potatoes could be influenced by three main factors.[1] They were: (1) time and size of planting - usually determined by physical or economic factors, (2) influence of seasonal growth and maturity of the crop, and (3) physical and economic factors at harvest time.

For a better comprehension of the seasonal production, a person must keep in mind the characteristics of the product. Some of the characteristics of the potato crop are:

1. It is bulky with 75-85 per cent water.
2. It is perishable and can not be carried over from year to year.
3. It is expensive to ship, store, and is susceptable to handling damage.
4. It is adapted to most soils and climates.

These characteristics are also attributable causes for some of the changes that have taken place in the potato industry.

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[1] Dana Dalrymple, _Predicting August Potato Prices at Planting Time_, A cooperative publication from the Storrs Agricultural Experiment and the Agricultural Extension Service, University of Connecticut, Storrs, Connecticut, Progress Report 29, February, 1959, p. 14.

THE POTATO INDUSTRY

Gray, Sorenson, and Cochrane presented one of the best descriptions of the potato industry. They attributed the characteristics of the potato crop, in part, for the fact that the industry has been constantly on the move.

> "...It moved with population as long as transportation was the limiting factor; then away from the producing areas as the transportation barrier was overcome. It has moved away from diseased soils, from warmer climates, and from areas where other crops or crop systems have forced it out. It has moved toward irrigation, toward early producing regions, and toward areas needing an intertilled crop. It would be impossible to select a five-year period of near stability in the potato industry of the United States. Besides some of the major factors noted, there has been the constant interplay of variety and seed development, changing production practices, mechanization, and consumer preferences, with the result that the industry picture over any sizable time and space interval is truly kaleidoscopic."[2]

The potato industry began as a small, side-line enterprise, in which most of the potatoes were consumed at the farm. Over the years tremendous changes have taken place in the potato industry, until today there are many farmers who do not raise any potatoes. Potato production in the United States has increased steadily since 1866, but the major part of this increase occurred prior to 1910. Since 1910, the greatest increase occurred in the fall Western and in the early states. Production increased slightly in the

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[2] Roger W. Gray, Vernon L. Sorenson, and Willard W. Cochrane, _An Economic Analysis of the Impact of Government Programs on the Potato Industry_, University of Minnesota Agricultural Experiment Station, Technical Bulletin 211, June, 1954, pp. 21-22.

fall Eastern States but declined in the fall Central and the early summer states. Potato acreage increased rapidly from 1866 to 1910, but remained fairly stable from 1910 to the early 1930's and then rapidly declined.[3] In recent years, the potato industry has been characterized by a sharp decline in acreage planted, a phenomenal rise in average yield per acre, and maintenance of a high level of production. Per capita production for late summer and fall combined has declined to a low of 102 pounds in 1951.

The size of enterprise has undergone changes also. For instances, in the six Lake States (Minnesota, Michigan, Wisconsin, Ohio, New York, Pennsylvania) the number of farmers reporting five to nine acres of potatoes declined by two-thirds, the number reporting ten to 25 acres declined by one-half, and the number reporting 25 acres or more increased somewhat between 1940 and 1950.[4] Besides increased specialization and larger potato enterprises, the growers have become more efficient in their production practices. Higher yields per acre have been instrumental in reducing the average costs of producing a bushel of potatoes. The increased yields have resulted from improved seed development, larger applications of fertilizer, and irrigation practices. Also insecticides and fungicides have played a major role in

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[3] R. L. Bere and M. E. Cravens, Trends in the Potato Industry with Emphasis on Ohio 1909 to 1956, Ohio Agricultural Experiment Station, Wooster, Ohio, Research Bulletin 811, July, 1958, pp. 9-12.

[4] Gray, Sorenson, and Cochrane, Op. Cit., p. 174.

improving yields.

MICHIGAN POTATOES

Since this study originated in Michigan, perhaps some special attention should be given it with respect to the nation as a whole plus its individual state characteristics. First, Michigan needs to be located in the nation from the standpoint of time of production. Until 1956, Michigan production was recorded under late production. Since 1956 and going back to 1949, production for the new seasonal classification was recorded under late summer and fall. The major portion of Michigan's potatoes are produced during the fall season.

The Michigan potato trends have been similar to the national trends, however, Michigan production has declined faster and Michigan yields per acre are below the national average. Michigan's production as a percentage of United States production was 8.89 per cent in 1934, and reached a low of 2.48 per cent in 1955. During the 1930's Michigan ranked between first and third for acreage planted among all states. In production it ranked among the upper five states; except for 1930 and 1931 when Michigan was seventh. Recently it has ranked ninth and tenth for acreage, and production ranked between twelfth and thirteenth among late producing states. Besides reduced acreage to explain declines in production, Michigan has failed to keep pace in the yield department as compared to other states. Michigan's average yield per acre for the period 1949-1954 was only 188 bushels as compared with Maine's 418, Idaho's 291, all fall production's average of 271, and the United States average yield of 248 bushels per acre.[5]

The leading potato producing counties in Michigan for 1957 were Montcalm, Bay, Presque Isle, Houghton, and Lapeer. From records of 101 potato farms through-out the state, Karl Wright[6] reported that growing costs per bushel on the low-cost ten farms ranged from 32 cents to 46 cents a bushel, while the comparable figures on the high-cost ten were 82 cents to $1.45 a bushel. Most of the increase in cost was attributed to poor production practices which led to low yields. Location of the growers apparently had some influence because six of the low-cost farms were in northern Michigan, with five farms in Presque Isle County. For the high-cost ten farms, six of them were in northern Michigan, but five of this six were in Antrim and Grand Traverse Counties, with yields of only 100 to 157 bushels per acre.

Price wise, Michigan has commanded a fairly high price for potatoes. During the last twenty years, potato prices in Michigan have risen from about 90 per cent to 110 per cent

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[5] United States Department of Agriculture, Crops and Markets, U.S.D.A., A.M.S. Washington, D.C., Vol. 34, 1957, pp. 32-34.

[6] Karl T. Wright, "Potato Growing and Harvesting Costs and Returns in Michigan 1957," Agricultural Economics Department, Michigan State University, East Lansing, April, 1958, p. 13.

of the United States average farm price.[7] Michigan October price as a percentage of Maine October price ranged from 92 per cent in 1939, to a high of 186 per cent in 1940. The price in Maine was higher than Michigan in only two years - 1939 and 1948. A simple explanation for these better than average prices is the fact that Michigan has shifted from a net exporter of potatoes to a net importer.

During the period 1930 to 1958, the Michigan March price averaged $1.05 per bushel with a low of 24 cents in 1935, and a high of $2.40 for 1958. The average October price was 94 cents per bushel with a low of 26 cents in 1932, and a high of $2.25 for 1952. The price from October to March went up in 19 years, down in nine years, and one year remained the same. If your normal expectation was that the March price would be higher than the October one, then you would have been wrong about one-third of the time.

DEMAND

Since United States potato production has exhibited no increasing trend and population has continued to grow, per capita consumption has declined. A person might think that potato prices should have increased considerably, but this has not been the case. The price elasticity of demand for potatoes has an inelastic characteristic. The income elasticity for potatoes has been quite low also. The low

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7 R. L. Bere and M. E. Cravens, <u>Op</u>. <u>Cit</u>., p. 23.

price and income elasticity means that approximately the same quantity of potatoes are demanded with changes in prices and incomes.[8]

Shuffett reported in a study from 1921 to 1941, that a change of one per cent in per capita production of late states was associated with a four per cent change of the farm price in the opposite direction. A change of one per cent in disposable income per capita was associated with a change of 1.4 per cent of the farm price in the same direction.[9]

The inelastic demand of potatoes is one in which the price is changing faster than the change in quantity on a percentage basis, and the changes are in opposite directions. To the producer this means that his small crop will return him more total revenue than his large crop providing the industry as a whole has a similar size crop. An important factor for long-range consideration is per capita consumption, but for a given crop year price elasticity of demand is extremely important in determining returns to producers.[10]

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[8] Dana G. Dalrymple, Op. Cit., p. 15.

[9] D. Milton Shuffett, The Demand and Price Structure for Selected Vegetables, United States Department of Agriculture, Washington, D.C., Technical Bulletin No. 1105, December, 1954, p. 3.

[10] Kenneth W. Meinken, Factors That Affect Price and Distribution of New Jersey Potatoes, New Jersey Agricultural Experiment Station Rutgers, The State University New Brunswick, in Cooperation with Maine Agricultural Experimental Station, Bulletin 786, June, 1957.

Some of the reasons for the decline in potato consumption include:[11]

1. A greater variety of food substitutes.
2. A larger portion of families in urban areas.
3. Higher family incomes.
4. Less heavy manual labor of wage earners.
5. Relatively greater time and expense in preparing potatoes compared with other foods.

Perhaps, more specifically, the decline in demand for potatoes pertained to the total used fresh in homes because there has been a sharp increase in the amount consumed in the processed forms. In 1940, about two per cent of the potatoes for food use was in a processed form; while in 1956, this proportion was a little more than 21 per cent.[12] In 1956, about 70 per cent of the potatoes processed went into potato chips. Increased demand by processors in the chipping industry and increased demand by consumers for the usually higher-priced "new crop" potatoes have expanded winter and early spring acreage.[13] Since Michigan potatoes

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[11] C. H. Merchant and A. G. Waller, Shifts and Trends in the Potato Industry in the Northeastern United States, Maine Agricultural Experiment Station, Bulletin 566, November, 1957, p. 8, as reported by Dana G. Dalrymple, Op. Cit., p. 16.

[12] National Potato Council, "U.S. Production, Utilization, and Use of Designated Potato Crop," Agricultural Marketing Service, and Other Sources, 1956.

[13] Olman Hee, "Highlights of Changes in Acreage for Seasonal Potato Crops," The Vegetable Situation, United States Department of Agriculture, April, 1958, pp. 19-24.

are produced mostly in the fall, they have not been able to take advantage of the increasing demand for the early season crops.

SUPPLY

The supply of potatoes is considered very inelastic also. Pubols and Klaman estimated supply elasticity to be about 0.23.[14] Hee stated that when the regression coefficients are expressed as elasticities of acreage with respect to previous years' price, and elasticities of yield with respect to previous years' price; they were both found to be around 0.1.[15] These two studies are not mentioned for conflicting values of elasticities since the time periods were different. The important point is that they are in agreement that the supply elasticity is very low.

Historically it appears that potato price expectations are based largely upon prices in the two previous years, so that a price and production cycle of approximately four years' duration has prevailed. Pubols and

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[14] B. H. Pubols and S. B. Klaman, Farmers Response in the Production of Potatoes, 1922-1941, Bureau of Agricultural Economics, United States Department of Agriculture, 1945, as reported by Olman Hee, "The Effect of Price on Acreage and Yield of Potatoes," Agricultural Economics Research, United States Department of Agriculture, Agricultural Marketing Service and Agricultural Research Service, Vol. X, No. 4, October, 1958, p. 131.

[15] Olman Hee, "The Effect of Price on Acreage and Yield of Potatoes," Agricultural Economics Research, United States Department of Agriculture, Agricultural Marketing Service and Agricultural Research Service, Vol. X, No. 4, October, 1958, pp. 134-135.

Klaman indicated that from 1920 to 1941, about three-fourths of the year to year variation in the harvested acreage of potatoes in Idaho, in 18 fall states, and in the United States could be accounted for by prices received by farmers for the production within these areas during the two preceding years.[16]

Olman Hee was partially concerned with an evaluation of farmers' response to expected "normal" price of potatoes as contrasted with previous year's price.[17]

> "Because of price uncertainty, producers tend to make adjustments in acreage and yield based on some notions of expected 'normal' price. Apparently, potato growers not only look back at previous prices; they also look forward, in some sense, to long-run price expectations. But such long-run expectations are modified each year by some ratio of the relation between last year's price expectation and last year's actual price. Specifically, they tend to change their notion of long-run expected price by about one-fourth of the difference between the price they expected the previous year and the price they actually received."

Hee also indicated that relative to the magnitude of changes in actual prices the producers tend to change their production plans little from year to year, however, high prices for potatoes tend to encourage expansion of acreage and yields but low prices tend to discourage expansion.[18]

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16 B. H. Pubols and S. B. Klaman, <u>Farmers Response to Price in the Production of Potatoes</u>, 1922-1941, Bureau of Agricultural Economics, United States Department of Agriculture, 1945. As reported by D. Milton Shuffett, <u>Op. Cit</u>., p. 47.

17 Olman Hee, "The Effect of Price on Acreage and Yield of Potatoes," <u>Op. Cit</u>., p. 140.

18 <u>Ibid</u>., p. 140.

Bean reported that the price received for production during the preceding season was the dominant factor in explaining the change of production in any given year.[19] He indicated that prices only moderately different from plus or minus ten per cent of the equilibrium price tend to be followed by about the same percentage change in acreage, but very high prices had no significantly greater affect on acreage than moderately high prices. He observed that a year of high prices affected potato acreage for only one succeeding season but a year of low prices continued to exert an influence on acreage for the next two seasons.

Supply can be assumed known for the purpose of this study since fall production is estimated by the end of October. The study is concerned with production which occurs after October and before March, that is, winter and early spring production. Since these crops are quite small (less than five per cent) relative to the total fall production and since their production has deviated little from an increasing trend, we need not be overly concerned about their effect on our price forecasts.

MICHIGAN POTATO MARKETS

Most of the information for this section was taken from a bulletin prepared by George Motts.[20] Much of the

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19 L. H. Bean, "The Farmers Response to Price," Journal of Farm Economics, Vol. 11, No. 3, July, 1929, pp. 368-385.

20 George N. Motts, Marketing Michigan Potatoes, Extension Bulletin 331, Michigan State College Cooperative Extension Service, September, 1954, pp. 1-23.

data was obtained from 250 representative potato growers in Michigan. Michigan growers have sold about one-third of their potatoes to country shippers, another third to wholesalers and jobbers, and the balance largely to merchant truckers and retailers. Since the 1949-1950, about 75 to 80 per cent of Michigan production has been marketed in five states - Michigan, Ohio, Indiana, Illinois, and Wisconsin. A fairly representative marketing pattern of Michigan potatoes by months has been August 11 per cent, September 16 per cent, October 11 per cent, November 11 per cent, December ten per cent, January ten per cent, February ten per cent, March 11 per cent, and April six per cent. These percentages were computed from total production of the five year average, 1948-49 to 1952-53. About 80 per cent of the 250 growers used their own storage facilities while 20 per cent rented storage space. The common reason for storing potatoes (42 per cent) was that prices usually rise as the season progresses, while three per cent indicated the reason for not storing was the lack of storage facilities. Only seven per cent stored potatoes because they lacked time at harvest for handling their crop.

The rule of thumb concerning storage has been to figure a two per cent shrinkage for each month that potatoes are in storage. In other words, if a producer stores his potatoes for five months and the price rises only ten per cent above the harvest price, his shrinkage offsets the price rise. If the fall crop was relatively large, early selling of potatoes has been usually a wise decision. Late selling of small crops has been generally more profitable.

GOVERNMENT POLICY

The potato industry was affected by government policy. During the days of the Federal Farm Board, potatoes were designated as a commodity for which loans could be made. This program was to improve merchandising operations. The Farm Credit Administration transferred these activities to Banks for Cooperatives but continued to make loans to potato cooperatives. The Agricultural Adjustment of 1933 provided a program for potatoes under the marketing agreement provisions. Potatoes were not classified as a "basic" commodity. However, growers took action to influence the enactment of the Potato Control Act of 1935 which designated potatoes as a basic commodity and made provisions for control over quantities marketed by levying a tax on marketings in excess of producer allotments. The legality of this act was tested in the Hoosac - Mills Case and it was ruled unconstitutional by the decision of the Supreme Court.[21]

The next government policy was the Price Support Program of 1943 to 1950. An excellent summary of the support program was that by Gray, Sorenson, and Cochrane.[22]

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[21] The preceding was based on M. Benedict and O. C. Stine, The Agricultural Commodity Programs, The Twentieth Century Fund, New York, 1956, pp. 416-40.

[22] Gray, Sorenson, and Cochrane, Op. Cit., pp. 5-7.

"Beginning with the 1943 crop, potatoes were affected by the Steagall amendment, which provided for price supports at not less than 90 per cent of parity. This had the effect of creating an unlimited market and growers immediately responded by increasing their plantings: 1/3 in the Outlying Specialist States, but only one-fifth in the Lake States. The program came in two phases: first, a non-restrictive phase (1943 to 1945), during which increased production was sought; and secondly, a restrictive phase (1947 to 1950), during which efforts were made to curb production. Production restriction was pursued by acreage controls, but yield per acre received no attention. Prior to 1943, the supply curve was moving to the right and the demand curve slowly to the left, resulting in a secular decline of the equilibrium price. If these trends had persisted after 1942, in the absence of price supports, then the equilibrium price would have declined; with the result that consumers would not have obtained the full benefit of the elimination of the cobweb. It can be argued, for example, that supply under free market conditions would not have continued to expand during the war. Demand, on the other hand, probably would have risen during the war. The combination of these two possibilities would have resulted in an equilibrium price higher than the presupport equilibrium, so that, consumers would obtain an additional benefit from the program in the form of a reduction in price below the free market equilibrium. The cost of this program in government outlays, exclusive of administrative costs, was approximately 552 million dollars. However, this saved the consumer of paying a higher price by the tune of $367 million; therefore, the cost to taxpayers was probably $200 million."

The potato price-support program received a great deal of public criticism - both from the consumer and the producer. The consumer was dissatisfied with the idea of paying twice-once at the market and again in form of taxes. The growers thought they would have received a higher farm price under the free market and they disliked acreage controls. Benedict and Stine considered the basic difficulties of this program centered around three problems.

"(1) The type of support programs provided by Congress was wholly unsuited to potatoes; (2) The phenomenal increases in yields that occurred in these years could not be foreseen by either the Congress or administrators in charge of the program; (3) The price commitment proved to be much too high in view of the cost reductions that were occurring and the static character of demand."[23]

In 1949, the support level was reduced from 90 per cent of parity to 60 per cent. The support prices were abandoned after the 1950 crop. The over-all cost to the government for potato programs during the years 1933 to 1953, was estimated at $635.8 million.[24]

The Fresh Irish Potato Diversion Program XMD3A was first introduced in 1955, and has been in operation during parts of 1956, 1957, 1958, and 1959.[25] The objectives of the program were to encourage the domestic consumption of fresh Irish potatoes and to divert quantities from the normal channels of trade and commerce. The Secretary of Agriculture was given the power to use Section 32 (Public Law 320, 74th Congress, 1935) funds for diversion of potatoes to livestock feed and to starch possessing. Section 32 amended the Agricultural Adjustment Act of 1933, and provided funds by allocating 30 per cent of the collections from tariffs on all dutiable imports to the Secretary of

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23 Benedict and Stine, Op. Cit., p. 430.

24 Ibid., p. 431.

25 Much of the information is taken from, James H. Cothern, "The Importance and Impact of the 1955 and 1956 Government Potato Diversion Program on the Potato Industry," Thesis for the Degree of Master of Science, Michigan State University, 1957, pp. 7-9.

Agriculture for the accomplishment of re-establishing farmers' purchasing power by making payments in connection with the normal production of any agricultural commodity for domestic account.[26]

The diversion program was utilized in those areas which were able to develop an acceptable marketing plan. The areas included such states as California, Colorado, Idaho, Maine, Minnesota, North Dakota, Oregon and Washington. Some potatoes were diverted by the program in Pennsylvania, Utah, and New York during 1955 and 1956.

The program was oriented toward late summer and fall production and was designed to divert large quantities of Specification A potatoes from normal marketing channels and to discourage growers from holding stocks until late spring months. Specification A potatoes were those which equaled or exceeded U.S. No. 2 quality requirements. Growers received payments for withholding cull potatoes from the market also. The diversion program usually was started in September or October and terminated no later than June 30 of the following year.

The volume of potatoes diverted by the diversion program was 4.5 per cent of total United States production in 1955, 7.6 per cent in 1956, 4.8 per cent in 1957, and about 8.4 per cent in 1958. Cothern indicated that the program did not accomplish its objective during 1955 and 1956.

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[26] Rainier Schickele, Agricultural Policy, Mc Graw Hill, New York, 1954, p. 227.

However, the diversion program had considerable influence in 1958, as indicated by the higher price during March through May.

PREVIOUS STUDIES

One of the early analytical studies of factors affecting potato prices was carried on by Holbrook Working between 1922 and 1925.[27] Working considered six factors which he felt affected fall and winter price: (1) value of the dollar, (2) trend of the value of potatoes, (3) fluctuations in production of potatoes, (4) price of potatoes in August, (5) variation in quality, and (6) loss in storage and transit. He considered fluctuations in production of potatoes were of the greatest importance. Working was in some doubt as to whether he should use total production or just fall harvest. He decided to use the late crop estimates of 27 states and stated that it is only the part of production which is available for use after the first of September that affects the price after the first of September. In his study he did not use statistical concepts, but graphic evidence indicated the results were fairly accurate.

About this same time another study was under way by

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[27] Holbrook Working, Factors Affecting the Price of Minnesota Potatoes, University of Minnesota, Agricultural Experiment Station, Technical Bulletin 29, October, 1925, pp. 1-40.

Frederick V. Waugh.[28] He was attempting to predict New Jersey Cobbler prices as of August first for the August - November period. Waugh studied the four factors: (1) the production of potatoes in the United States, (2) the trend of potato production in the United States, (3) the level of wholesale prices of all commodities, and (4) the trend of prices of New Jersey Cobblers. The average error of the unexplained residual was 9.8 per cent or 21.5 cents per 150 pound sack over the twenty year period. In only two years was the error more than 20 per cent. His results were quite satisfactory, in view of the fact that they were for a state, as opposed to a national price. Waugh also included basic information and formulas which he felt that anyone with ordinary mathematical ability could use to arrive at a forecast of prices.

Meinken studied the factors that affect price and distribution of New Jersey potatoes.[29] The years included were 1933 to 1941 and 1951 to 1954 and all variables were converted to logarithms. The New Jersey season average farm price deflated by per capita disposable income was designated X_1' and then related to New Jersey production (X_2) and Long Island production (X_3). His equation was $X_1' = 4.16 - 1.40 \log X_2 - 1.70 \log X_3$. From this analysis

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[28] Frederick V. Waugh, Forecasting Price of New Jersey White Potatoes and Sweet Potatoes, New Jersey State Department of Agriculture, Circular No. 78, July, 1924, pp. 1-26.

[29] Kenneth W. Meinken, Op. Cit., pp. 1-45.

about 64 per cent of the variation in adjusted New Jersey prices was attributable to these factors.

Meinken was also concerned with transportation rates and their effect upon regional prices and specialization. He expressed the season average price received by farmers in Idaho, a surplus state, as a ratio to the United States production for the years 1929 to 1935 and 1951 to 1954, and similar relationships for New Jersey, a deficit state. For Idaho, prices during 1951 to 1954 averaged much higher relative to the United States price than during the 1929 to 1935 period despite a substantial increase in production relative to United States production. For New Jersey just the opposite occurred: New Jersey prices are lower relative to United States production. His explanation for shifts in the relationships of relative prices to relative supplies was that the shift for New Jersey can be attributed to the depressing effect of increased Long Island production on New Jersey prices; for Idaho, a possible explanation lies in changed transportation rates and the general level of prices. However, an explanation that does not account for changes in the processing facilities of Idaho may be incomplete to explain Idaho price changes.

Another study that flashes some light on the problems of price prediction was conducted by D. Milton Shuffett.[30] He was concerned with the factors affecting the price of

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30 D. Milton Shuffett, Op. Cit., pp. 44-65.

early and intermediate as well as the late commercial potato crop. From the observation period 1921 to 1941, he developed an equation for estimating the season average price. Then he applied this equation to information for predicting the price from 1942 to 1952.

For the late crop Shuffett considered only production per capita (X_2) and disposable income per capita (X_3). The equation was $X_1' = -0.0360 - 4.028X_2 + 1.426X_3$. $R^2 = .896$. The predicted price was computed by multiplying actual price in the preceding year by the percentage from the above equation when all variables are expressed as first differences of logarithms. Together these two variables explained 90 per cent of the year to year variation in the prices received by producers for late potatoes in surplus - producing states. This was true for the years 1921 to 1941; however, in the period 1942 to 1953, the computed price differed from the actual by as much as 75 cents per bushel in six years.

Shuffett stated that:

> "When the ratio of price of present year to the price in the preceding year is multiplied by the actual price in the preceding year to give an estimate of the expected price in the year for which a forecast is made, there is a 65 to 70 per cent chance that the estimated price will differ from the actual price by not more than 23 per cent."[31]

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[31] Ibid., p. 59.

This statement may be true for the period of his study, 1921 to 1941, but the average error of prediction for the period 1942 to 1953, was 73 cents per bushel.

A more recent study of potato prices was conducted by Dana G. Dalrymple.[32] Particular emphasis was focused on an attempt to predict the August price at planting time. An equation was finally constructed using the following varibles for the years from 1936 to 1956. The equation was: $Y = 3.254176 + .422458X_1 - 1.288369X_2 + 1.37487X_3 + .938261X_4$. Logarithms were used and the calculated average farm price per bushel received by United States farmers in August (Y) was related to these variables: average March price (X_1), late spring and early summer production (X_2), late summer production (X_3), and per capita disposable income (X_4).

The multiple coefficient of determination obtained was .74 and its F value was significant at the five per cent level. The t values for X_1 and X_2 were significant at the five per cent level, X_4 was significant at the one per cent level, and X_3 was not significant. All coefficient coincided with expectations, except X_3 which was positive and interpreted as indicating that a one per cent increase in late summer production was associated with a 1.37 per cent increase in the August price.

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[32] Dana G. Dalrymple, Op. Cit., pp. 1-47.

Dalrymple judged the performance of his estimates by comparison with the futures market. An August futures price was not given, but a November futures was. Therefore, a new equation was set up to predict November price using total late summer and fall production for X_3 instead of late summer production.

Estimated November prices calculated from an equation varied from 64 per cent to 166 per cent of the actual price. The average closing price of November futures the last day of trading in November varied from 65 per cent to 149 per cent, with a twelve year average (no trading during the war) of about 97 per cent. In predicting the price for November, 1957 an estimate of $2.10 per cwt. was obtained. The actual price was $1.68 per cwt., an error of 25 per cent. The error in the futures market was only five per cent. Thus, it appeared that the futures price might give a better estimate of the November price than was possible with an equation. If this is the case, it seems probable that those playing the futures market might also do as good or better a job of predicting August price.

CHAPTER III

METHOD OF ANALYSIS AND EMPIRICAL ESTIMATES

A logical method of estimating this year's price would be to look at last year's price. Then you could take into consideration economic changes, such as, supply and demand shifts. If you weighed the economic changes properly, then you should come up with a fairly good estimate of this year's price. Proper weighing of economic factors can be gained by studying the past two years, or five years, or even a larger number of years. For example, in predicting the Michigan March price for 1959, the 1958 price might be a good indicator. In 1958, this price was $2.40 per bushel. However, with the use of more background information, you find that supplies were low in 1958, and maybe the price was higher than usual. The supplies for 1959, were estimated to be considerable larger and may account for the low price of 81 cents per bushel. Therefore, an average of the last five years could be considered as an indication of the normal price situation. This average price was $1.27 per bushel with a standard deviation of 68 cents per bushel. The average price was closer to the 81 cents than was the $2.40. The actual price may never equal the average price, but an average may be the best guesstimate in any given year. The standard deviation of the average may be reduced by increasing the number of observations, but the new average may be no better as a predictor of future prices.

The method of analysis used in this study was least squares regression. An attempt was made to minimize the squared residuals between the actual price and the predicted price. A multiple regression equation was constructed with Michigan March price as the dependent variable. A linear regression form was used and the general equation was:

$$\hat{Y} = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + U$$

Actual data should be used in preference to logarithms when:[33]

1. The relationships between the variables are believed to be additive rather than multiplicative.
2. The relations are believed to be more stable in absolute terms rather than in percentage terms.
3. The unexplained residuals are believed to be more uniform over the range of the independent variables when expressed in absolute terms rather than in percentage terms.

Logarthms should be used when the relationships between

[33] R. J. Foote and Karl A. Fox, Seasonal Variation: Methods of Measurement and Tests of Significance, Bureau of Agricultural Economics, United States Department of Agriculture, Agriculture Handbook No. 48, September, 1952.

the variables are believed to be multiplicative rather than additive.

First differences should be used in preference to actual data when successive unexplained residuals from single - equation analyses based on actual data are almost perfectly serially correlated with a positive sign.

After the regression equation was computed, the coefficients were checked for the proper sign and relative magnitude to make sure they were consistent with expectations based on economic theory. Next the regression coefficients were tested to see if they differed statistically from zero. Finally, the residuals were considered and an explanation of large residuals was sought in terms of economic theory and knowledge of the potato industry and its changes.

SOURCE OF DATA

The information for this study was secondary data. Most of the data were estimated by the United States Department of Agriculture, but other sources of published data were used. These sources were indicated by footnotes plus identification of the series used. Changes in the method of recording data were indicated to avoid misinterpretation of the information.

The following information was reported by Dana Dalrymple from correspondence with a United States

Department of Agriculture official concerning the calculation of average monthly prices of potatoes.[34]

> "Prior to January 1957, the current monthly potato price generally represented sales that occurred about mid-month. However, it was the practice to revise these prices at the end of the marketing year to what was essentially a monthly average price. From 1954 to 1957, the United States monthly potato prices were derived by weighting state prices by sales instead of production as in previous reports. United States monthly prices re-computed on this basis from January 1949 to December 1956 were published in Supplement No. 2 to the January 1957 issue of Agricultural Prices."
>
> "Beginning with January 1957 the potato price estimates each month relate to an average for the month. These estimates are prepared by State Statisticians on the basis of marketings and prices for the first half of the month, but take into consideration any significant changes in market prices that occur up to two days before the price report is released near the end of the month. At the end of the marketing season, monthly prices will be revised on the basis of data for the entire month."

The important fact concerning these average monthly prices by states are that they include most of the crop sold. This price includes first purchases of potatoes from the farm, regardless of the varieties, quality, amounts sold, or location through out the state. Also it is hard to put a value on potatoes used on the farm or to obtain accurate information as to the quantity. Therefore,

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[34] Dana G. Dalrymple, Op. Cit., pp. 18-19, from correspondence with B. R. Stauber, Chief, Agricultural Price Statistics Branch, Agricultural Marketing Service, United States Department of Agriculture, July, 1957.

the reported price is subject to certain limitations.

The reported average price may not apply to any particular farmer or transaction. This fact is mentioned as a limitation of the actual average price; so that, persons using this information are aware of some of its pitfalls. To the farmer it is mainly an indicator of month to month or year to year variations in relative demand and supply of potatoes.

Some of the prices and production data were reported in bushels and some were in hundred weights. Therefore, the data were converted to a common base for the observation period (1930 to 1958). The conversion factor for prices was cwt. x 6/10 = bu.; for production it was cwt. x $\frac{10}{6}$ = bu. The common base for this study was bushels merely because most of the data were reported in bushels. In recent years hundredweight has become the common base. Michigan prices have recently been published as dollars per hundredweight but these have been converted to bushels for consistency in the study and appear as such in the Appendix. Michigan production was also converted to bushels.

If January first was considered the most common starting point in time of a new calendar year, a person might become confused with this year's March price and last year's production. To eliminate some of this confusion, a production year was considered as opposed to the calendar year. A production year was defined as a period of one planting time to next year's planting. For example, potatoes planted in May, harvested in October, and marketed in March were considered within a production year; even though it does cut across two calendar years. Production reported in 1957 was matched with the 1958 March price which provided a method of analyzing the supply affects on the price during its marketing period. This method was carried on through-out the observation period and other independent variables were dated in the same manner.

THE STUDY

A good starting point in this study seemed to be a diagram showing the economic relationship of the more important variables. Since the analysis was oriented toward the demand phase, the supply phase was assumed as given or known. The diagram was rather general and appears as Figure 1. A diagram of the factors affecting the Michigan March price of potatoes was not to be found and this diagram was not offered as the last word. However, a number of the ideas were taken from comparable diagrams.[35] The diagram was quite satisfactory for this

[35] D. Milton Shuffett, The Demand and Price Structure for Selected Vegetables, United States Department of Agriculture, Washington D. C., Technical Bulletin No. 1105, December, 1954, p. 47. And Richard J. Foote, Analytical Tools for Studying Demand and Price Structures, United States Department of Agriculture, Agricultural Marketing Service, Agriculture Handbook No. 146, p. 4.

study and perhaps a great help in motivating the mind to actually analyze the factors affecting the price under consideration. It was difficult to select the proper factors and even harder to indicate the direction of the arrows. The process became even more difficult when indicating which factors had primary effects and which had secondary effects.

DIAGRAM OF FACTORS AFFECTING MICHIGAN MARCH POTATO PRICE

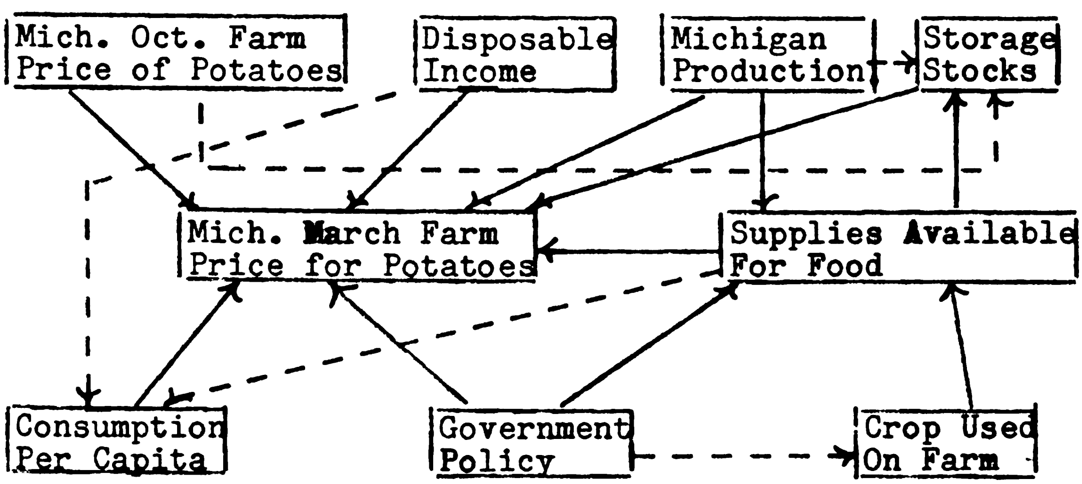

Figure 1

1. Arrows show direction of influence.
2. Black lines indicate primary effect.
3. Dotted lines indicate secondary effect.

Multiple regression equations were computed and discussed as single problems plus inter-problem comparisons. The equation was presented first with the standard error of b's appearing under the respective b coefficients. The standard error of estimate and multiple coefficient of determination plus an adjusted correlation coefficient[36] were presented. The variables were defined and the units of measurement indicated. Each independent variable was discussed individually from the standpoint of:

1. The reason for its being included.
2. The expected sign and size of the b coefficient.
3. Its related simple correlation with the dependent variable and its intercorrelation with other independent variables when unusually high.
4. The statistical significance of the regression coefficient.

EQUATION I

The predicting equation for 1930 through 1958 was:

$$\hat{Y} = 21.852 + \underset{(.2814)}{.107X_{11}} - \underset{(.0022)}{.001X_{12}} + \underset{(.7830)}{.985X_{13}} + \underset{(.2878)}{.589X_{14}} - \underset{(.2488)}{.235X_{15}}.$$

$\hat{Y}$ =	Predicted Michigan March price	cents/bu.[37]
X_{11} =	Michigan October price	cents/bu.
X_{12} =	Michigan production	1000 bu.
X_{13} =	Per capita consumption	lbs./person
X_{14} =	October index of prices received for Michigan products	1910-14 = 100
X_{15} =	United States production	1 million bu.

$R^2 = .6131$ $\bar{R} = .73$ $Sy.x = 37.24$

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36 $\bar{R}^2 = 1 - (1-R^2)\frac{(N-1)}{(N-M)}$ This formula was to adjust for degree of freedom.

37 This column indicates the unit of measurement for the respective independent variables. This procedure is continued for the remaining equations.

The actual Michigan March price received by farmers for their potatoes averaged $1.05 per bushel with a low of 24 cents in 1935, and a high of $2.40 in 1958.

Variable X_{11}

The Michigan October price was selected as one of the independent variable because of its possible two-fold influence:

1. As an indicator of the supply and demand conditions at harvesting time.
2. As a reflection of storage intentions which will have a more direct effect upon the March price.

Since the predicted March price was to be available by the end of October, the October price was the latest indicator of supply and demand forces which might continue in part through March. Obviously, the February monthly price is the best indicator of the March price, but no check was made to determine if the October price was a better indicator of the March price than monthly prices in September or August. The simple correlation coefficient between the October and March price was .68. The sign of the coefficient was positive as expected.

The October price varied from a low of 26 cents in 1932, and a high of $2.25 in 1952. The average price for the years observed was 94 cents per bushel which produced an average difference of 11 cents between the October price and March.

How does the potato producer appraise the Octobr price in regards to his storage intentions and March price expectations? There is no rule of thumb answer for this question. Many potato growers use their storage facilities every year because they expect potato prices to rise and they want to utilize the space available. The author's best approximation would be that growers tend to sell at harvest when the price is relatively high and the crop is large. There are those growers who figure that a relatively high price at harvest time indicates that prices will be higher later in the marketing season. These are conflicting views and it is difficult to indicate which is the method utilized by the majority of producers.

Variable X_{12}

Total Michigan production of potatoes was selected as an indicator of the immediate supply. However, fall production might have been sufficient since most summer potatoes are sold before October and have poor storage qualities.

Michigan production varied from a low of 9,385 thousand bushels in 1955 to a high of 36,176 thousand in 1936, for an average of 18,419 thousand. A thousand bushel increase in Michigan production was associated with a .001 cents per bushel decrease in the March price. Even though the economic relationship held true, the magnitude was very small. This fact might be interpreted as an indication that much of the supply force affecting Michigan

March price occurs from outside of the state. Perhaps, storage potatoes from other areas of the United States do compete to a certain extent with Michigan potatoes. These out of state potatoes come largely from Maine and Idaho storage warehouses.

The simple correlation coefficient between total Michigan production and Michigan March price was .64. This was the same correlation coefficient for Michigan production and Michigan October price.

Variable X_{13}

Per capita consumption was selected as a variable to provide some insight as to the level of consumption which, in turn, might indicate something about the amount demanded. Some people are known to consume about the same amount of potatoes annually with little weighing of changing prices while other consumers tend to purchase substitutes when the potato prices become relatively high.

Per capita consumption varied from a high of 159 pounds in 1929, and followed a rather persistent trend except during World War II to reach a low of 100 pounds in 1956. The average consumption per person was almost 122.5 pounds for the period studied. The simple correlation coefficient between per capita consumption and Michigan March price was -.29. A pound increase in per capita consumption was associated with a .985 cent per bushel increase in the March price. To the economist this fact might be contrary to the "Law of Demand" for a single demand curve, but it becomes more realistic when visualized as demand shifting to the left on a series of demand curves.

Variable X_{14}

An index of prices received for Michigan farm products was selected as an indication of the level of prices and the value of the dollar. This index was for the month of October. This variable was 70 in 1932 for a low and high in 1947, with an index of 297. The average was about 180 during the period studied.

The farm price information was collected by the Office of the Michigan Agricultural Statistican, Agricultural Marketing Service, U.S.D.A. Prior to 1949, the index was based on 20 products weighted by their relative importance in the total cash farm income during 1924 to 1928 base weighting period was changed to 1924 to 1929 and applied only to years 1910 through 1934. A second base weighting period of 1937 to 1941 was used for weighting indexes during January 1935 through July 1946. A third base weighting period of 1948 to 1952 was used from August 1946 to the present. The indexes for these three base weighting periods were converted and linked together to give a weighted aggregative index with 1910 to 1914 = 100. The procedure used for computing the index of prices received by farmers in Michigan was essentially the same as used by the United States Department of Agriculture for computing a national price received index.

The simple correlation coefficient between the Michigan March price and the index of prices received for Michigan farm products was +.71. A unit increase in the index was associated with a .589 cents per bushel increase in the March price. The X_{14} regression coefficient was significantly different from zero at the five per cent level.

Variable X_{15}

Total United States production was included as the fifth variable to give some information concerning production of other regions which have an effect upon supplies in Michigan. Even though total production showed no increasing trend, its extremes were 320.5 million bushels in 1951, and 487.3 million in 1946, with an average of 381 million bushels annually. There was practically no correlation (.07) between total United States production and Michigan March price. However, a million bushel increase in total production was associated with a .235 cents per bushel decrease in the March price when the other variables were held constant.

Summary of Equation I

The result of Equation I was a multiple coefficient of determination of .6131 which produced an adjusted correlation coefficient of .73. This indicated that these independent variables accounted for 73 per cent of the year to year variation in the Michigan March price. The standard error of estimate was 37 cents per bushel.

The t test was used to indicate which independent variables had regression coefficients significantly different from zero. If the sign of the coefficient was opposite of economic expectation, the variable was discarded as a poor predictor. Consequently, only one tail tests were used in testing the b coefficients. The independent variable, an index of prices received by Michigan producers, was significantly different from zero at the five per cent level. The other independent variables were not significant at the ten per cent level.

The unexplained residuals were large since a great deal of the variation remained unexplained. The prediction equation over estimated the actual March price for 17 years out of the 29 years studied. The predicted price was within plus or minus ten cents of the actual price for only nine years and within 20 cents for an additional five years. The worst year's prediction in dollars and cents was 1958, when the residual was $1.14 per bushel as a result of an actual price of $2.40 and a predicted price of $1.26. This was an error of 48 per cent. The most accurate prediction was in 1950 when the error was two cents, or less than one per cent. A comparison of the actual and predicted price are included in Table I.

The result of Equation I left many answers to be desired. Therefore, the procedure called for revision of the independent variables in an attempt to improve the

Table 1 - A comparison of actual and predicted Michigan March price for Equation I, 1930-1958.

Years	Actual Mich. March Price (Y)	Predicted March Price ($\hat{Y}$)	Residuals ($Y-\hat{Y} = U$)	Relative Error ($\lvert U\rvert/Y$)
	cents/bu.	cents/bu.	cents/bu.	per cent
1930	125	153	-28	22
1931	75	102	-27	36
1932	27	49	-22	81
1933	26	33	- 7	27
1934	90	57	33	37
1935	24	36	-12	50
1936	55	65	-10	18
1937	110	85	25	23
1938	49	60	-11	22
1939	47	59	-12	26
1940	70	61	9	13
1941	55	60	- 5	9
1942	95	92	3	3
1943	140	108	32	23
1944	130	107	23	18
1945	165	138	27	16
1946	140	118	22	16
1947	115	138	-23	20
1948	175	193	-18	10
1949	145	136	9	6
1950	120	122	- 2	2
1951	105	113	- 8	8
1952	225	179	46	20
1953	105	166	-61	58
1954	66	129	-63	95
1955	120	132	-12	10
1956	129	122	7	5
1957	78	106	-28	36
1958	240	126	114	48

amount of variation explained and to reduce the standard error of estimate. Some of the variables remained the same and their description is mentioned in Equation I, but the new independent variables will be discussed below.

EQUATION II

The second predicting equation for the years 1930 through 1958 was:

$$\hat{Y}=130.522+\underset{(.2914)}{.303X_{21}}+\underset{(9.4842)}{2.384X_{22}}-\underset{(.0055)}{.003X_{23}}+\underset{(.3411)}{.463X_{24}}-\underset{(42.9020)}{63.482X_{25}}$$

$$+\underset{(3.1557)}{.713X_{26}}.$$

$\hat{Y}$	= Predicted Michigan March price	cents/bu.
X_{21}	= Michigan October price	cents/bu.
X_{22}	= Michigan production/United States production	percentage
X_{23}	= Michigan personal income	mil. dollars
X_{24}	= October index of prices received for farm products of Michigan	1910-14 = 100
X_{25}	= Late summer and fall production per capita	bushels
X_{26}	= Time	one

$R^2 = .6122$ $\bar{R} = .71$ $Sy.x = 38.12$

Variable 21

Michigan October price of potatoes was discussed on page 38.

Variable X_{22}

Michigan production as a percentage of United States production was selected as a single variable which enabled the combining of variables X_{12} and X_{15} of Equation I. This variable provided an indication of the relationship between Michigan production and United States production. A high percentage value resulted when Michigan harvests were large with respect to the national harvests or when Michigan was a major potato producing state of the United States. This relative expression of production was 8.89 per cent in 1936 for a high, and lowest in 1955 with a 2.48 percentage while the average was 4.88 per cent.

The simple correlation coefficient was -.63 between variable X_{22} and Michigan March price. In fact, the intercorrelation coefficients of this variable were high. The simple correlation coefficient between X_{22} and X_{21} was -.64; X_{22} and X_{23} was -.83; X_{22} and X_{24} was -.86; X_{22} and X_{26} was -.79.

The coefficient of X_{22} variable was positive and indicated that a percentage point increase in the ratio of Michigan production to United States production was associated with a 2.38 cents per bushel increase in the March price. The interpretation of this situation seemed to state that as Michigan production became larger relative to United States production, the Michigan March price would increase also. Expectations were that this coefficient would be negative. However, this situation of a positive regression coefficient and a negative simple correlation coefficient was possible since variable X_{22} had a negative intercorrelation with variables X_{21}, X_{23}, X_{24}, and X_{26}.

Variable X_{23}

This variable was Michigan personal income which was selected for its influence upon prices in general, and its influence on potato consumption. It was felt that when personal income was relatively low then potatoes might account for a larger proportion of the diet because of its high energy characteristic. Therefore, potatoes might command a relatively higher price than certain other food items when personal income was low. Thus, potatoes may be looked upon as an inferior commodity.

The symptoms of an inferior good comes in two parts. First, there is the substitution effect and secondly there is the income effect. The substitution effect is associated with price changes and the amount of a commodity purchased for maximizing utility. The substitution effect indicates that a consumer should buy more of a particular commodity when the price declines. The income effect is usually positive for price declines, but for certain commodities the income effect is negative and over rides the substitution effect; so that the consumer should buy less as his income increases. From this line of reasoning, inferior goods tend to be replaced in the consumption pattern by substitutes as the consumer's income becomes larger.

Fresh potatoes may fit into the category of an inferior good as indicated by the relationship between price, income, and consumption in this analysis. As consumer incomes increase they tend to purchase fewer potatoes in the fresh form and demand more highly processed potatoes in the form of potato chips, instant mashed potatoes, potato sticks, etc.

Michigan personal income varied from a low of 1.668 billion dollars in 1933, to a high of 16.706 billion dollars in 1957. This variable increased for every year; except during the first years of the 1930's which witnessed the depression. This fact was confirmed by a simple correlation coefficient of +.95 between personal income and the time variable X_{26}. The simple correlation coefficient between personal income and Michigan March price was +.57. The regression coefficient of variable X_{23} indicated that a million dollar increase in Michigan personal income was associated with a .003 cents per bushel decrease in the Michigan March price of potatoes at the farm level.

Variable X_{24}

An index of prices received for all Michigan farm products on a basis of (1910-14=100) was the same as variable X_{14} (See discussion on page 41). The b coefficient of X_{24} was +.463 as compared to +.589 for variable X_{14}. The regression coefficient of X_{24} was significantly different from zero at the ten per cent level.

Variable X_{25}

United States late summer and fall production per capita was selected as a variable to indicate supply fluctuations. Also it was used because Michigan potatoes are produced only during the late summer and fall season. The fall harvests were considered the main composition of storage stocks since summer potatoes have poor storage qualities and are off the market by early winter. National late summer and fall production was expressed in per capita terms for comparison with per capita consumption.

United States late summer and fall production per capita varied from a low of 102 pounds in 1951 to a high of 158 pounds in 1934. The average for the period 1930 to 1958 was about 130 pounds per person. A bushel per person increase in United States late summer and fall production was associated with a 63.482 cents per bushel decrease in the March price. The economic relationship coincided with expectations, however, the standard error of the b coefficient of X_{25} was rather large at 42.902 cents per bushel. The simple correlation coefficient X_{25} and the Michigan March price was -.46.

Variable X_{26}

A variable was needed to account for changes that affect prices in the form of a trend; therefore, time was included. This variable was introduced in the form of a constant increase, in which, the year 1930 was assigned a value of one and numbered consecutively until 29 was the number for 1958.

The time variable added virtually nothing in helping to explain year to year price variation. The t value of this variable was very low (.23). Therefore, the time variable was not used again in any of the following equations. The important point to remember concerning the time variable and Michigan personal income was the fact that they had a simple correlation coefficient of +.95. This indicates that they were almost perfectly correlated, in other words, personal income had nearly a constant year to year increase with very few years showing declines from the previous year. If the association of these two variables had been known, one could have been omitted from the equation.

Summary of Equation II

The result of Equation II was a multiple coefficient of determination of .6122 which produced an adjusted correlation coefficient of .71. This figure indicated that these six variables accounted for about 71 per cent of the year to year variation in the Michigan March price. The standard error of estimate was 38 cents per bushel.

The results for Equation II indicated that the analyst had accomplished the opposite of what he was attempting to do. Instead of improving the results of Equation I, he obtained approximately the same degree of year to year price variation explained. The adjusted correlation of Equation II was .71 and .73 for Equation I. The standard error of estimate increased a penny per bushel for Equation II. From a statistical point of view, these two problems were essentially the same from the standpoint of predicting the Michigan March price.

The t test indicated that regression coefficients for the October index of prices received for all Michigan farm products and for late summer and fall production per capita were significantly different from zero at the ten per cent level. While the Michigan October price variable was not significant at the ten per cent level. Independent variables X_{22}, X_{23}, and X_{26} were not significant at the low level of 20 per cent.

The unexplained residuals computed by substracting the predicted price from the actual March price were altered very little from those for Equation I. Residuals of Equation II are presented in Table 2. The number of negative residuals or years in which the predicted price was greater than the actual price was sixteen. Ten years the residuals were less than plus or minus ten cents and an additional eight residuals were within the category of plus or minus 11-20 cents. The predicting equation for

Equation II produced more annual residuals of less than plus or minus 20 cents than the equation for Equation I. However, the average residuals were about the same size as indicated by almost identical correlation coefficients for both equations.

The correlation coefficients of these two equations may not be too bad in light of the fact that the time span covered included a depression, war, police action, price support program, and comparably drastic changes in the potato industry as a whole. These predictions were for a particular month and state which was expected to be less accurate than predicting a season average price for the United States. However, these predicting equations were not considered accurate enough for making forecasts.

EQUATION III

The procedure for Equation III was similar to the previous two equations, that is, an attempt to find independent variables that account for annual variations in the Michigan March price. However, in Equation III the observation period was divided into two periods. The years 1930 to 1942 inclusive were designated as Period A, and the years 1947 to 1958 inclusive were assigned to Period B. This division was used also in Equation IV. Periods A and B will be discussed individually and combined in Equation III-A and B or Equation IV-A and B.

The reasoning for omission of the years 1943 through

Table 2 - A comparison of actual and predicted Michigan March price for Equation II, 1930-1958.

Years	Actual Mich. March Price (Y)	Predicted March Price ($\hat{Y}$)	Residuals ($Y-\hat{Y} = U$)	Relative Error ($\lvert U \rvert /Y$)
	cents/bu.	cents/bu.	cents/bu.	per cent
1930	125	114	11	9
1931	75	88	-13	17
1932	27	34	- 7	26
1933	26	31	- 5	19
1934	90	61	29	32
1935	24	36	-12	50
1936	55	55	0	0
1937	110	99	11	10
1938	49	67	-18	37
1939	47	74	-27	57
1940	70	78	- 8	11
1941	55	66	-11	20
1942	95	92	3	3
1943	140	109	31	22
1944	130	105	25	19
1945	165	133	32	19
1946	140	119	21	15
1947	115	125	-10	9
1948	175	182	- 7	4
1949	145	136	9	6
1950	120	127	- 7	6
1951	105	108	- 3	3
1952	225	182	43	19
1953	105	194	-89	85
1954	66	125	-59	89
1955	120	140	-20	17
1956	129	123	6	5
1957	78	112	-34	44
1958	240	135	105	44

1946 from the analysis was quite understandable. The reason was that times of war and government programs could hardly be considered normal marketing conditions. Olman Hee used the two periods (1930 to 1941) and (1930 to 1941 and 1951 to 1956) which he considered to be as close to free market conditions as can be found in the potato industry during the last three decades.[38] If one used this criterion, he was justified to start Period B with 1947 from the standpoint of the war being over, but the price support program was in effect through 1950. If we rationalize a little, we can conclude that the support program had a different influence during 1947 to 1950, than it had during the period 1942 to 1946.

The years of the Korean Conflict were included in the study, but could have been omitted on the basis of being abnormal marketing conditions. These years were included because the post World War II period would have been composed of insufficient observations. If the Korean Conflict years were omitted and five independent variables were used in an equation, there would have been only two degrees of freedom. This number of degrees of freedom would be too small to conclude anything statistically.

When the price support program and World War II were in action at the same time, the market forces may not have been greatly upset. The price support program initiated mainly an increase in supply; while the war ignited an increase in demand. These hypotheses were confirmed by a little computation. United States production of potatoes averaged 408 million bushel during 1942 through 1945. During the four year period 1938 through 1941, total

[38] Olman Hee, "The Effect of Price on Acreage and Yield of Potatoes," Agricultural Economics Research, Vol. X, No. 4, October, 1958, p. 134.

production averaged 353 million bushels. This was an increase in production of almost 16 per cent. The average annual price received by potato farmers of the United States averaged $1.32 per bushel for the years 1942 through 1945. During the pre-war period 1938 through 1941, this price averaged only 64 cents per bushel. In percentage terms, the United States average price increased 106 per cent.

It would be incorrect to credit all the increase in supply to the price support program or to credit all the increase in demand to the war. Also it would be difficult to establish whether the price support program had a greater effect upon the supply schedule than the war had upon the demand schedule.

Perhaps, a real determining factor for the omission of the years 1943 through 1946 was the relatively large residuals of Equation II for this period. These residuals were 31, 25, 32, and 21 cents per bushel for the years 1943, 1944, 1945, and 1946, respectfully. Omission of years purely because the residual was large would give the appearance of an improved predictive equation, but the revised equation may be actually less accurate.

In discussing Equation III, the variables were the same for both Periods A and B. Periods A and B were discussed individually and combined in a single prediction equation.

EQUATION III-A

The predicting equation for the years 1930 through 1942 was:

$$\hat{Y} = 294.610 - .137X_{31} - .559X_{32} - .116X_{33} + .928X_{34} - 93.604X_{35}.$$
$$(.2455)\ (5.8881)\ (.0812)\ (.3415)\ (56.7937)$$

$\hat{Y}$	= Predicted Michigan March price	cents/bu.
X_{31}	= Michigan October price/Maine October price	percentage
X_{32}	= Michigan production/United States production	percentage
X_{33}	= Real disposable income per capita for United States	dollars
X_{34}	= October index of prices received for Michigan farm products	1910-14 = 100
X_{35}	= Late summer and fall production per capita	bushels

$R^2 = .7874$ $\bar{R} = .80$ $Sy.x = 19.64$

Variable X_{31}

It was felt that a price from a major potato producing area should be included in the analysis. The Maine October price was selected and was expressed as a relative of Michigan October price. The Maine price was expected to indicate the supply and demand condition for the major producing area. The ratio Michigan October price to Maine October price indicated that the Maine price was higher than the Michigan price in only 1939 and 1948. The Michigan price averaged about 33 per cent above the Maine price. Two of the reasons for the lower Maine price might be attributed to the fact that Maine potatoes travel further to market than do Michigan potatoes, and the fact that Maine's supply exceeds demand within the state.

The simple correlation coefficient between Michigan March price and variable X_{31} was -.50. A percentage point increase in Michigan October price relative to Maine October price was associated with a .137 cents per bushel decrease in Michigan March price of potatoes at the farm level. This was the situation for Period A, but Period B had a positive .368 regression coefficient.

Variable X_{32}

Michigan production as a percentage of total United States production was carried over from Equation II, and it was discussed on page 45. Michigan production as a percentage of total United States production had a positive b coefficient in Equation II, negative coefficient in Equation III-A and positive in Equation III-B. The t value of this variable was higher in Equation III-B than in either of the preceding equations, but not significantly different from zero at the ten per cent level.

Variable X_{33}

Real disposable income per capita for the United States was selected as a variable in preference of Michigan personal income. The real disposable income eliminated the absolute fluctuations in disposable income since it was divided by the consumer price index. This computation had the effect of eliminating higher personal income which resulted from higher price levels. A person's real disposable income may remain the same if his absolute income changed only by the change in the price index. The economic relationship between the price level and the value of the dollar is one which varies inversely.

Real disposable income per capita varied from a low of \$658 in 1933, to a high of \$1,486 in 1956, for the Periods A and B. The average for this variable was \$1,090 income per person. The average for Period A was \$844 as compared with Period B which was \$1,357.

Real disposable income per capita had a more significant t value in Period A (1.42) than it did in Period B (.35). In Period A a one unit increase in real disposable income per capita was associated with a .116 cents per bushel decrease in the Michigan March price. In Period B a one unit increase in this variable was associated with a 1.166 cents per bushel increase in the March price.

Variable X_{34}

This variable was an October index of prices received by Michigan farmers with 1910-14 = 100. It was discussed under variable X_{14}. The regression coefficient for Period A was significantly different from zero at the 2.5 per cent level, but in Period B it was not. Both periods had positive coefficients which met with expectations.

Variable X_{35}

Late summer and fall production per capita was discussed under variable X_{25} on page 48. In testing the b coefficient, neither Period A or Period B was significant at the 2.5 per cent level. The b coefficients were negative for both periods as expected which was interpreted to mean that an increase in per capita late summer and fall production was associated with a decrease in the March price.

Summary of Equation III-A

The result of Equation III-A was a multiple coefficient of determination of .6358 and an adjusted correlation coefficient of .80. This indicated that these independent variables accounted for 80 per cent of the year to year variation in the Michigan March price. The standard error of estimate was reduced to about 20 cents per bushel as compared to 38 cents in Equation II.

The t test indicated that variables (X_{33}) - real disposable income per capita for United States and (X_{35}) - late summer and fall production per capita were significantly different from zero at the ten per cent level. The index of prices received for all Michigan farm products was significant at the 2.5 per cent level. Regression coefficients associated with X_{31} and X_{32} were not significantly different from zero at the ten per cent level.

The unexplained residuals for Equation III-A were ten cents or less in eight years of the 13 year period which was an improvement over the predicting equation of Equation II for the same period. The actual March price, predicted price, residuals, and size of error were listed in Table 3.

Table 3 - A comparison of actual and predicted Michigan March price for Equation III-A, 1930-1942.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\lvert U \rvert / Y$) per cent
1930	125	120	5	4
1931	75	91	-16	21
1932	27	26	1	4
1933	26	30	- 4	15
1934	90	62	28	31
1935	24	25	- 1	4
1936	55	57	- 2	4
1937	110	94	16	15
1938	49	59	-10	20
1939	47	79	-32	68
1940	70	77	- 7	10
1941	55	45	10	18
1942	95	84	11	12

EQUATION III-B

The predicting equation for 1947 through 1958 was:

$$\hat{Y}=-303.265+.368X_{31}+29.430X_{32}+1.166X_{33}+1.221X_{34}-.082X_{35}.$$
$$(1.2244)\quad(61.8699)\quad(.3280)\quad(.9859)\quad(77.9959)$$

$R^2 = .3058$ $\qquad$ $R = .55$ $\qquad$ $Sy.x = 60.39$

The variables and units for Equation III-B were the same as those for Equation III-A, and will be the same for Equation III-A and B combined.

In reporting the results of Equation III-B, a minor change in terminology should be mentioned. When the adjustment formula for degrees of freedom, $\bar{R}^2 = 1-(1-R^2)\ (\frac{N-1}{N-M})$, was applied to the .3058 value; the adjusted multiple coefficient of determination ($\bar{R}^2$) became negative which has no meaning. Of course, the low multiple coefficient of determination indicated that a great deal of the price variation remained unexplained. This was the situation for Equation IV-B also. Therefore, the correlation coefficient for these two equations were reported in the unadjusted form.

Summary of Equation III-B

The multiple coefficient of determination was .3058 which produced a correlation coefficient of .55. The standard error of estimate increased to 60 cents per bushel which was considerably larger than for Equation I or Equation II. None of the regression coefficients was significantly different from zero at the ten per cent level for Equation III-B.

The unexplained residuals were expected to be relatively large, and they were. This fact was confirmed in Table 4.

The next logical thing to do was to compute a regression equation for Period A and B combined as a check on Equation III-A and B plus an attempt to improve the predicting equation.

EQUATION III-A & B

The predicting equation for Period A and B combined was:

$$\hat{Y}=257.585-.080X_{31}+1.366X_{32}-.073X_{33}+.676X_{34}-90.287X_{35}$$
$$(.3057)\ (10.0310)(.0775)\ (.2737)\ (39.0370)$$

$R^2 = .6361$ $\bar{R} = .74$ $Sy.x = 37.85$

Table 4 - A comparison of actual and predicted Michigan March price for Equation III-B, 1947-1958.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\lvert U\rvert/Y$) per cent
1947	115	127	-12	10
1948	175	172	3	2
1949	145	115	30	21
1950	120	100	20	17
1951	105	99	6	5
1952	225	201	24	11
1953	105	160	-55	52
1954	66	131	-65	99
1955	120	133	-13	11
1956	129	122	7	5
1957	78	124	-46	59
1958	240	139	101	42

As mentioned before, the independent variables and units were the same as discussed under Equation III-A.

Summary of Equation III-A and B

The multiple coefficient of determination was .6361, and the adjusted correlation coefficient was .74. This indicated that 74 per cent of the year to year variation of the Michigan March price was explained by the independent variables of Equation III. In comparison, the adjusted correlation coefficient of Equation III-A and B combined was only one percentage point better than the $\bar{R}$ for Equation I and only three percentage points better than for Equation II. There appeared to be no significant improvement over the previous two equations. Equation III-A and B residuals were listed in Table 5.

A noteworthy contrast of the predicting Equation III was the size and sign of certain variables. In Equation III-A, the constant was +294.610 with variables X_{31}, X_{32}, X_{33}, and X_{35} having negative coefficients, but the constant value in Equation III-B was -303.265 with only variable X_{35} retaining a negative coefficient. When Periods A and B were combined in a single equation, the constant value was +257.585 and variables X_{31}, X_{33}, and X_{35} had negative coefficients. This indicated that variables X_{31}, X_{32}, and X_{33}, had undergone substantial changes in their economic relationship to the March price for the entire period, or that the number of years included was not sufficient to give reliable estimates.

The analysis was continued in an attempt to discover a more accurate predicting equation. The observed years were divided again into Period A and Period B because the results of Equation III indicated a change in structure between Period A and Period B.

EQUATION IV-A

The predicting Equation IV-A was:

Table 5 - A comparison of actual and predicted Michigan March price for Equation III-A and B, 1930-1942 and 1947-1958.

Years	Actual Mich. March Price (Y)	Predicted March Price ($\hat{Y}$)	Residuals ($Y-\hat{Y} = U$)	Relative Error ($\lvert U \rvert / Y$)
	cents/bu.	cents/bu.	cents/bu.	per cent
1930	125	103	22	18
1931	75	80	- 5	7
1932	27	31	- 4	15
1933	26	34	- 8	31
1934	90	60	30	34
1935	24	30	- 6	25
1936	55	56	- 1	2
1937	110	91	19	17
1938	49	61	-12	24
1939	47	78	-31	66
1940	70	76	- 6	9
1941	55	49	6	11
1942	95	83	12	13
1947	115	99	16	14
1948	175	173	2	1
1949	145	133	12	8
1950	120	119	1	1
1951	105	109	- 4	4
1952	225	187	38	17
1953	105	170	-65	62
1954	66	134	-68	103
1955	120	140	-20	17
1956	129	127	2	2
1957	78	114	-36	46
1958	240	132	108	45

$$\hat{Y} = 94.848 - .250X_{41} + .720X_{42} + .046X_{43} - .157X_{44} - 28.115X_{45}.$$
$$(.1913) \quad (.3761) \quad (.1072) \quad (.6282) \quad (55.1493)$$

$\hat{Y}$ = Predicted Michigan March price — cents/bu.

X_{41} = Michigan October price/ Maine October price — percentage

X_{42} = Michigan October price — cents/bu.

X_{43} = Real disposable income per capita — dollars

X_{44} = October index of prices received for Michigan farm products — 1910-14 = 100

X_{45} = Late summer and fall production per capita — bushels

$R^2 = .8602$ $\bar{R} = .87$ $Sy.x = 15.92$

The only independent variable in Equation IV that was changed from Equation III was X_2. In Equation III, it was Michigan production as a percentage of United States production; it was the Michigan October price in Equation IV. (See discussion under X_{11}, page 38) The reason which prompted this action was the fact that variable X_{32} had a low t value and considerable intercorrelation with variables X_{31} and X_{33}. It was felt that the Michigan October price would eliminate some of this intercorrelation and become a more important variable for predicting the Michigan March price. In fact, variable X_{42} was significant at the five per cent level for Equation IV-A, but it was not significantly different from zero at the ten per cent level for Equation IV-B or Equation IV-A and B.

A noteworthy contrast was the fact that variable X_{44} (an October index of price received for Michigan farm products) was not significantly different from zero at the ten cent level. This was partially understandable because variable X_{44} had a simple correlation coefficient of +.72 with X_{43} and +.81 with X_{42}. These relatively high intercorrelations provided difficulty in determining causal effects. Also X_{44} had a negative regression coefficient which did not meet with expectations.

Summary of Equation IV-A

The multiple coefficient of determination was .8602 which yielded an adjusted correlation coefficient of .87. This was interpreted as indicating that the independent variables accounted for 87 per cent of the year to year price variation during the period 1930 through 1942. The standard error of estimate was only 16 cents per bushel. These results were highly desirable since eight unexplained residuals were less than ten cents per bushel and the largest residual was 20 cents. An analysis of the unexplained residuals was presented in Table 6.

Table 6 - A comparison of actual and predicted Michigan March price for Equation IV-A, 1930-1942.

Years	Actual Mich. March Price (Y)	Predicted March Price ($\hat{Y}$)	Residuals ($Y-\hat{Y} = U$)	Relative Error ($\lvert U \rvert / Y$)
	cents/bu.	cents/bu.	cents/bu.	per cent
1930	125	128	- 3	2
1931	75	93	-18	24
1932	27	32	- 5	19
1933	26	33	- 7	27
1934	90	70	20	22
1935	24	22	2	8
1936	55	50	5	9
1937	110	92	18	16
1938	49	42	7	14
1939	47	65	-18	38
1940	70	80	-10	14
1941	55	57	- 2	4
1942	95	84	11	12

EQUATION IV-B

The equation for Period B was:

$$\hat{Y}=-111.014-.071X_{41}-.343X_{42}+.087X_{43}+1.528X_{44}-99.951X_{45}.$$
$$(1.0932)(.6745)\ (.3199)\ (1.2823)\ (92.4022)$$

$R^2 = .3094$ $\qquad$ $R = .56$ $\qquad$ $Sy.x = 60.23$

The variables and units were the same for Equation IV-B as those indicated for Eqution IV-A.

In comparing Equation IV-A and IV-B, the economic relationships as indicated by the negative and positive regression coefficients had reversed signs for certain variables. The constant term in Period A was +94.848, but it was -111.014 for Period B. The relationship between Michigan October price and Michigan March price was reversed also. In Equation IV-A, a cent per bushel increase in Michigan October price was associated with a .720 cents per bushel increase in the March price, but it was associated with a .343 cents per bushel decrease in the March price for Period B. This fact, in part, might be attributed to changes in viewpoints concerning the importance of storage. Perhaps, potato storage was on an individual basis during Period A while storage during Period B became more specialized and commercialized. Also, during Period B this fact might indicate that potato processing companies were willing to bid up prices in October to insure sufficient supplies later in the season.

The other reversed situation concerned variable X_{44} which was an October index of prices received for Michigan farm products. The regression coefficient was -.157 for

Equation IV-A and +1.528 for Equation IV-B. An explanation of this phenomenon might be rooted in the fact that a large number of potatoes are shipped into Michigan with the March price reflecting increased transportation rates for Period B. However, there was also the possibility that the index was not a causal factor but just happened to be highly correlated since all prices tend to be correlated.

Summary of Equation IV-B

Period B continued to be difficult to predict with any degree of accuracy. The multiple coefficient of determination .3094. When this coefficient was adjusted for bias, it became negative again, but mainly, as a result of insufficient degrees of freedom. The unadjusted correlation coefficient was .56. The standard error of estimate was 60 cents per bushel which was the same as for Equation III-B. None of the regression coefficients were significantly different from zero at the ten per cent level.

The unexplained residuals for Period B were large in certain years, however, the predicted price was less than ten cents per bushel from the actual price for six years out of the 12. The same number of residuals were within ten cents for Equation II during the same period. The notable improvement from the predicting equation for Equation IV-B was a reduction in the magnitude of large residuals, but the residual for 1958 remained above one dollar per bushel. (See Table 7).

Table 7 - A comparison of actual and predicted Michigan March price for Equation IV-B, 1947-1958.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\lvert U\rvert/Y$) per cent
1947	115	109	6	5
1948	175	176	- 1	1
1949	145	136	9	6
1950	120	86	34	28
1951	105	109	- 4	4
1952	225	198	27	12
1953	105	147	-42	40
1954	66	139	-73	111
1955	120	127	- 7	6
1956	129	132	- 3	2
1957	78	125	-47	60
1958	240	138	102	48

The 1958 residual may have been the largest in dollars and cents, but the 1954 residual had the greatest relative error.

EQUATION IV-A AND B

The same independent variables for Equation IV-A and Equation IV-B were combined in computing a new equation for the entire period. This new regression equation was:

$$\hat{Y}=267.655-.091X_{41}+.008X_{42}-.075X_{43}+.652X_{44}-88.340X_{45}.$$
$$(.2947)\ (.3294)\ (.0931)\ (.3929)\ (46.0682)$$

$$R^2 = .6358 \qquad \bar{R} = .73 \qquad Sy.x = 37.87$$

The signs of the equation were as expected, but perhaps a word should be mentioned about variable X_{43} - real disposable income per capita for the United States. This variable had a negative relationship in Equation III-A, III-A and B combined, and IV-A and B combined; but a positive relationship in Equations III-B, IV-A, and IV-B. The expected relationship was that this variable would be positive during Period A, negative during Period B, and negative during the combined Periods of A and B. The reasoning behind this hypothesis was that potatoes were a low income source of food. The economy was coming out of a depression, and the public was going back to work during Period A. World War II ignited an expanding economy, and people were moving to higher incomes during Period B. When the two periods were combined, it was felt that the influence of Period B would over-ride the influence of Period A to confirm the negative relation between income and the price of potatoes.

Summary of Equation IV-A and B

The multiple coefficient of determination was .6358 which yielded an adjusted correlation coefficient of .73. In other words, these independent variables accounted for 73 per cent of the year to year variation in the Michigan March price. Also the standard error of estimate remained about 38 cents per bushel.

The only variables that were significantly different from zero were X_{44} and X_{45}. The October index of prices received for Michigan farm products was significant at the ten per cent level. Late summer and fall production per capita was significant at the five per cent level.

The unexplained residuals remained relatively large for certain years. (See Table 8). In fact, only 11 residuals out of 25 years observed were less than ten cents per bushel. In 1936 and 1950, the predicted price was just equal to the actual price.

Table 8 - A comparison of actual and predicted Michigan March price for Equation IV-A and B, 1930-1942 and 1947-1958.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\lvert U \rvert/Y$) per cent
1930	125	104	21	17
1931	75	83	- 8	11
1932	27	32	- 5	19
1933	26	34	- 8	31
1934	90	61	29	32
1935	24	27	- 3	13
1936	55	55	0	0
1937	110	89	21	19
1938	49	60	-11	22
1939	47	77	-30	64
1940	70	77	- 7	10
1941	55	51	4	7
1942	95	82	13	14
1947	115	99	16	14
1948	175	173	2	1
1949	145	133	12	8
1950	120	120	0	0
1951	105	109	- 4	4
1952	225	186	39	17
1953	105	171	-66	63
1954	66	134	-68	103
1955	120	140	-20	17
1956	129	128	1	1
1957	78	114	-36	46
1958	240	132	108	45

EQUATION V

The only difference between Equation V and Equation IV was that Equation V was computed in logarithms while Equation IV was computed in linear form. If the true relationship between the variables were multiplicative rather than additive, logarithms would be more relevant than natural numbers in the regression equation.

EQUATION V-A

The predicting equation in logarithms for the years 1930-1942 was:

$$\log \hat{Y} = .943 - \underset{(.3762)}{.492} \log X_{51} + \underset{(.3294)}{.864} \log X_{52} + \underset{(1.2309)}{.495} \log X_{53} - \underset{(.8618)}{.326} \log X_{54} - \underset{(2.0245)}{1.247} \log X_{55}.$$

$\hat{Y}$	= Predicted Michigan March price	cents/bu.
X_{51}	= Michigan October price/Maine October price	percentage
X_{52}	= Michigan March price	cents/bu.
X_{53}	= Real disposable income per capita for United States	dollars
X_{54}	= October index of prices received for Michigan farm products	1910-14 = 100
X_{55}	= Late summer and fall production per capita	bushels

$R^2 = .9093$ $\bar{R} = .92$ $Sy.x = .0941$

The independent variables were the same as those used in Equation IV. The b coefficients were given in logarithms for Equation V. Also the standard error of estimate was listed in logarithms, and it was log .0941.

Summary of Equation V-A

The results of Equation V-A indicated some improvement for the multiple coefficient of determination (.9093) and the adjusted correlation coefficient (.92). R^2 and $\bar{R}$ were .8602 and .87, respectively for Equation IV-A. Apparently, computations in logarithms increased the amount of year to year variation explained.

The b coefficients in logarithms indicate percentage changes which is different from the unit change for actual data. Take the coefficient of variable X_{51}. An increase of one per cent in the Michigan October price relative to the Maine October price is associated with a .492 per cent decrease in the Michigan March price. The same line of reasoning can be formulated for all b coefficients throughout Equation V.

Michigan October price had the only b coefficient significantly different from zero at the ten per cent level, and it was significant at the 2.5 per cent level.

If we define the average error of prediction as a simple average of the unexplained residuals regardless of the positive or negative signs, then the average error of prediction was ten cents per bushel for both Equation V-A and Equation IV-A. The unexplained residual in natural numbers are presented in Table 9.

Table 9 - A comparison of actual and predicted Michigan March price for Equation V-A, 1930-1942.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\lvert U\rvert/Y$) per cent
1930	125	136	-11	9
1931	75	93	-18	24
1932	27	31	- 4	15
1933	26	28	- 2	8
1934	90	71	19	21
1935	24	26	- 2	8
1936	55	44	11	20
1937	110	97	13	12
1938	49	40	9	18
1939	47	59	-12	26
1940	70	80	-10	14
1941	55	56	- 1	2
1942	95	81	14	15

EQUATION V-B

The predicting equation in logarithms for the years 1947-1958 was:

$$\log \hat{Y} = -1.412 + \underset{(1.0384)}{.035} \log X_{51} + \underset{(.6575)}{.088} \log X_{52} - \underset{(3.2282)}{.009} \log X_{53} + \underset{(2.4479)}{1.492} \log X_{54} - \underset{(1.4391)}{.9252} \log X_{55}.$$

$R^2 = .2539$ $\qquad$ $R = .50$ $\qquad$ $S_{y.x} = .1941$

None of the regression coefficients were significantly different from zero for Equation V-B at the ten per cent level. The residuals of Equation V-B were shown in Table 10; the average error of prediction was 31 cents per bushel.

EQUATION V-A AND B

The predicting equation in logarithms for Periods A and B combined was:

$$\log \hat{Y} = .738 - .473 \log X_{51} + .609 \log X_{52} + .309 \log X_{53} + .181 \log X_{54} - .896 \log X_{55}.$$
$$(.3222) \quad (.2683) \quad (.9220) \quad (.6357) \quad (.8127)$$

$R^2 = .7983$ $\quad\quad$ $\bar{R} = .86$ $\quad\quad$ $S_{y.x} = .1352$

Table 10 - A comparison of actual and predicted Michigan March price for Equation V-B, 1947-1958.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\|U\|/Y$) per cent
1947	115	114	1	1
1948	175	168	7	4
1949	145	126	19	13
1950	120	104	16	13
1951	105	101	4	4
1952	225	177	48	21
1953	105	165	-60	57
1954	66	121	-55	83
1955	120	122	- 2	2
1956	129	116	13	10
1957	78	106	-28	36
1958	240	125	115	48

The independent variables were the same as those mentioned for Equation V-A which were the same as those discussed in Equation IV-A.

The adjusted correlation coefficient was also higher in Equation V-A and B than it had been in previous equations for the same period. This indicated that a higher per cent of year to year price variation had been accounted for or explained. With the correlation coefficient increasing the residuals were expected to be smaller. However, the average error of prediction increased to 38 cents per bushel for Period B, but the average error of prediction during Period A was a little smaller. Since the correlation coefficient is an average, it was concluded that most of its increase came from Period A, because Period B residuals were not improved.

Since logarithms measure percentage changes and natural numbers measure absolute changes, they are difficult to compare. For example, Michigan March price averaged 99 cents per bushel for Equation IV-A and B, but this price averaged 1.9232 in logarithms for Equation V-A and B. The standard error of estimate was 38 cents per bushel and log .1352 respectively. If we take the mean plus or minus one standard error of estimate the range for natural numbers is 61 cents to $1.37 per bushel, and for logarithms the range is log 1.7880 to log 2.0584. The antilog for these numbers is 61 cents to $1.15 per bushel. The lower limit was the same for both equations, but the higher limit was somewhat different. This was understandable since logarithms have the characteristic of minimizing changes from a large base and maximizing changes from a small base.

The unexplained residuals in natural numbers are presented in Table 11. The residuals do not add up to zero, but this was a result of the conversion from logs to natural numbers, however, log Y - log $\hat{Y}$ equalled zero to four decimal places.

When the t test was applied to the regression coefficient, Michigan October price was significantly different from zero at the 2.5 per cent level. Michigan October price relative to Maine October price was significant at the ten per cent level. All these independent variables had the expected sign for its regression coefficient.

When the years observed were divided into Period A and Period B, the analyst noticed some changes in the signs of coefficients. Only variables - Michigan October price and United States late summer and fall production per capita were consistently positive and negative, respectively. Real disposable income per capita for the United States was positive during Period A, negative during Period B, and positive for both periods combined which was the only sign opposite of expectations. The October index of prices received for Michigan farm products was negative for Period A and positive for the other two periods. These were the same signs as in Equation IV which was in natural numbers.

Since Period B remained exceedingly difficult to predict as measured by the rather large residuals, an exploratory study was conducted to find new independent variables that were correlated with the unexplained residuals of Equation IV-B. This was done to reduce computational work involved in trying new independent variables

Table 11 - A comparison of actual and predicted Michigan March price for Equation V-A and B, 1930-1942 and 1947-1958.

Years	Actual Mich. March Price (Y)	Predicted March Price ($\hat{Y}$)	Residuals ($Y-\hat{Y} = U$)	Relative Error ($\lvert U \rvert / Y$)
	cents/bu.	cents/bu.	cents/bu.	per cent
1930	125	129	- 4	3
1931	75	86	-11	15
1932	27	32	- 5	19
1933	26	29	- 3	12
1934	90	61	29	32
1935	24	30	- 6	25
1936	55	48	7	13
1937	110	89	21	19
1938	49	44	5	10
1939	47	59	-12	26
1940	70	74	- 4	6
1941	55	53	2	4
1942	95	83	12	13
1947	115	108	7	6
1948	175	151	24	14
1949	145	130	15	10
1950	120	114	6	5
1951	105	89	16	15
1952	225	174	51	23
1953	105	230	-125	119
1954	66	100	-34	52
1955	120	139	-19	16
1956	129	104	25	19
1957	78	103	-25	32
1958	240	133	107	45

in multiple regression equations. If the simple correlation between the unexplained residuals and new variables was low, the new variables would not improve the amount of year to year variation explained. The new independent variables tried and their simple correlation coefficients were:

1. An annual weighted average price of potatoes received by Michigan farmers, -.25.

2. The actual Michigan March price of potatoes received by Michigan farmers, -.83.

3. A simple average of the previous two Michigan March prices, +.37.

4. March futures price on New York Mercantile Exchange for Maine grown, Contract No. 1 potatoes as of October 31, -.48.

5. Per cent of "total food use" potatoes being processed as reported by National Potato Council, +.13.

6. Michigan October - March price differential lagged, -.44.

7. Index numbers of railroad freight rates for fruits and vegetables, +.32.

It was felt that an independent variable of the simple average for the previous two Michigan March prices would be helpful in reducing the unexplained residuals of Equation IV-B. The results are presented in Equation VI-B.

EQUATION VI-B

The predicting equation in actual data for the years 1947 through 1958 was:

$$\hat{Y} = 69.415 + .006X_{61} - 1.010X_{62} - 37.352X_{63} + 1.097X_{64}.$$
$$(.5717) \quad (.6615) \quad (77.3212) \quad (.9291)$$

$R^2 = .4755$ $\bar{R} = .42$ $Sy.x = 48.60$

X_{61}	= Michigan October price	cents/bu.
X_{62}	= Average of previous two Michigan March prices	cents/bu.
X_{63}	= Late summer and fall production per capita	bushels

X_{64} = October index of prices received for Michigan farm products 1910-14 = 100

The independent variables were the same as those in Equation IV-B, except an average of the previous two Michigan March prices replaced Michigan October price as a percentage of Maine October price and real disposable income per capita was omitted. These independent variables were dropped because their regression coefficients were not significantly different from zero at the ten per cent level.

Variable X_{62}

This variable was calculated by taking a simple average of the previous two March prices, for example, the value for 1959 would be the 1958 price plus the 1957 price divided by two. This value would be \$1.59 per bushel. Besides the exploratory study which found this independent variable to have a simple correlation coefficient of +.37 with the unexplained residuals of Equation IV-B, there is some validity to the fact that Michigan potato prices move in the same direction for two years. However, there are equally as many years, in which, the price went up one year and down the next year or vice versa.

Summary of Equation VI-B

In Equation VI-B, the outstanding improvement was an adjusted correlation coefficient that was not negative when adjusted for bias. Also the standard error or estimate was reduced to 49 cents per bushel, instead of 60 cents for Equation III-B and Equation IV-B.

The regression coefficient of an average for the previous two March prices was significantly different from zero at the ten per cent level. Variable X_{61}, X_{63}, and X_{64} were not significant. The October price had the lowest t value, but it is possible that most its effect showed up in the October index of prices received by Michigan farmers since they did have a simple correlation coefficient of +.65.

Table 12 - A comparison of actual and predicted Michigan March price for Equation VI-B, 1947-1958.

Years	Actual Mich. March Price (Y) cents/bu.	Predicted March Price ($\hat{Y}$) cents/bu.	Residuals ($Y-\hat{Y} = U$) cents/bu.	Relative Error ($\lvert U \rvert/Y$) per cent
1947	115	115	0	0
1948	175	190	-15	9
1949	145	139	6	4
1950	120	74	46	38
1951	105	112	- 7	7
1952	225	194	31	14
1953	105	130	-25	24
1954	66	90	-24	36
1955	120	165	-45	38
1956	129	151	-22	17
1957	78	114	-36	46
1958	240	150	90	38

The average error of prediction for Equation VI-B was the lowest for all computed equations for Period B. The average error was 29 cents per bushel. The next best was 30 cents for Equation IV-B. In Equation VI-B, the unexplained residual for 1958 was less than one dollar per bushel; this was the first time any equation had accomplished this feat, but it remained quite large at 90 cents per bushel. However, Equation IV-B had six residuals less than plus or minus ten cents per bushel, and Equation VI-B had only three residuals in this category. On the other hand, the highest relative error from Equation VI-B was 46 per cent, but Equation IV-B had relative errors of 48, 60, and 111 per cent. Therefore, it seems that Equation VI-B had two factors in its favor: (1) the smallest average error of prediction, and (2) the lowest maximum relative error of all computed equations for Period B.

DURBIN-WATSON TEST

The Durbin - Watson test for serial correlation of unexplained residuals was applied to the residuals of Equations IV-A and IV-B. The computed values were 1.975 and 1.717 respectively. These values were inconclusive, in fact, it is different to get conclusive results for this low number of observations.

Complete directions for calculations and interpretations are given in Agriculture Handbook No. 94 by Joan Friedman and Richard J. Foote.[39]

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[39] Joan Friedman, and Richard J. Foote, Computational Methods for Handling Systems of Simultaneous Equations, United States Department of Agriculture, Agriculture Marketing Service, Agriculture Handbook No. 94, November, 1955, p. 78.

CHAPTER IV

SUMMARY AND CONCLUSION

SUMMARY

In this study several multiple regression equations were computed with the objective of predicting the Michigan March price for potatoes at the farm level. The limiting restriction placed upon this prediction was that the results would be available by the end of October. The purpose was to make a reliable prediction that could aid potato producers in making the decision of whether to store their crop or to sell it at harvest time. This prediction could also benefit potato buyers in their decision of when to procure potato stocks. However, the amount of participation by buyers and sellers would depend upon the reliability of the predicted price. Of course, some people would do the opposite of what was predicted for purposes of speculation; or they would not alter their traditional patterns, regardless of available information.

The observation period for this study included the years 1930-1958 for Equation I and Equation II, but it was divided into Period A (1930-1942) and Period B (1947-1958) for the remaining problems. Multiple regression equations were computed for each period and for the two periods combined. The reasons for omission of the years (1943-1946) were:

1. World War II was being fought at this time which created a shift in demand.

2. The government enacted the potato price support program which created an increase in production.

3. This division appeared to be a good separation for analyzing economic changes within the independent variables.

The Michigan March price and October price were average prices received by Michigan potato producers for first sales, regardless of potato varieties, grade, size, amounts sold, or location through-out the state. This information was available from secondary sources, as was all data used in this study. The Michigan October price was looked upon as the last supply-demand indicator of the market forces that could be assumed to continue into the March market. However, the Michigan potato price between October and March increased during 19 years, declined during nine years, and remained the same during 1933. The October to March price differential varied from an increase of $1.29 per bushel to a decrease of $1.20 per bushel. This large range provided plenty of area for prediction errors. The Michigan March price averaged $1.05 per bushel for Equation I and II, 65 cents for Period A, $1.35 for Period B, and 99 cents for Periods A and B combined, during the respective periods, the October price averaged 94 cents, 63 cents, $1.16, and 88 cents per bushel. The average price differential for the entire observation period was 11 cents per bushel.

The simple correlation coefficient between the March price and the October price was +.68 for the years 1930-1958, +.85 for Period A, +.26 for Period B, and +.66 for Period A and B combined.

This study was concerned with the problem of selecting independent variables that explained a high percentage of year to year variation in the Michigan March price. Several independent variables were fitted in multiple regression equations to determine which ones were statistically good predictors. Certain variables were expressed in various forms. For example, Michigan October price was tried both in actual data and as a relative of the Maine October price for the same year. A supply indicator was sought by looking at Michigan total production, United States total production, Michigan total production as a percentage of United States total production, and United States late summer and fall production per capita which was finally used because it was a better predictor. Equation V was computed in logarithms from the same data as Equation IV which was computed in natural numbers. This computational difference resulted in a higher correlation coefficient, lower standard error of estimate, but higher unexplained residuals for Equation V. In fact, the average error of prediction for Period B was 31 cents per bushel from Equation IV-A and B and 38 cents from Equation V-A and B.

Results of all the multiple regression equations computed and independent variables used are presented in Table 13. The table is nearly self explanatory providing the reader has a basic understanding of statistical techniques. In this analysis, the t test was concerned with one tail tests because the proper sign of the regression coefficient was indicated by the economic relationship between the dependent variable and the independent variable. If the sign was opposite of expectation, this variable could have been omitted. The alternative hypothesis was that the regression coefficient was numerically greater than zero in the direction of the expected sign.

The discussion now turns to some comparisons of results among different equations and their independent variables. The October index of prices received for Michigan farm products was the best predicting variable for Equations I through IV-A and B because its regression coefficient was statistically different from zero in most equations at the ten per cent level. However, this variable lost some of its importance for prediction in Equation V which was computed in logarithms, and the Michigan October price became an important variable. United States late summer and fall production per capita was perhaps the second best predicting variable because its regression coefficient was often different from zero at the ten per cent level. Real disposable income per capita was significant at the ten per

Table 13 - A summary of empirical estimates for equations computed for this study.

Equations	I	II	III-A	III-B	III-A&B	IV-A	IV-B	IV-A&B	V-A log	V-B log	V-A&B log	VI-B
Years	1930-1958	1930-1958	1930-1942	1947-1958	1930-1942 1947-1958	1930-1942	1947-1958	1930-1942 1947-1958	1930-1942	1947-1958	1930-1942 1947-1958	1947-1958
Variables												
Michigan October price	+.107[d]	+.303				+.720[b]	-.343	.008	.864[a]	.088	.609[a]	.006
	(.2814)[e]	(.2914)				(.3761)	(.6745)	(.3294)	(.3294)	(.6575)	(.2683)	(.5717)
Michigan October price/ Maine October price			-.137	+.368	-.080	-.250	-.071	-.091	-.492	.035	-.473[c]	
			(.2455)	(1.2244)	(.3057)	(.1913)	(1.0932)	(.2947)	(.3762)	(1.0384)	(.3222)	
Michigan total prod.	-.001											
	(.0022)											
U.S. total production	-.235											
	(.2488)											
Mich. total prod./ U.S. total prod.		+2.384	-.559	+29.430	+1.366							
		(9.4842)	(5.8881)	61.8699	(10.0310)							
Per capita consumption for U.S.	+.985											
	(.7830)											
Time		+.713										
		(3.1557)										
Mich. personal income		-.003										
		(.0055)										
Real disposable income per capita U.S.			-.116[c]	+.117	-.073	+.046	.087	-.075	.495	-.009	.309	
			(.0812)	(.3280)	(.0775)	(.1072)	(.3199)	(.0931)	(1.2309)	(3.2282)	(.9220)	
U.S. late summer & fall production per capita		-63.482[c]	-93.604[c]	-82.262	-90.287[a]	-28.115	-99.951	-88.340[b]	-1.247	-.925	-.896	-37.352
		(42.9020)	(56.7937)	(77.9959)	(39.0370)	(55.1493)	(92.4022)	(46.068)	(2.0245)	(1.4391)	(.8127)	(77.3212)
Oct. index of prices received for Mich. farm products	+.589[b]	+.463[c]	+.928[a]	+1.22	+.676[a]	-.157	1.528	.652[c]	-.326	1.492	.181	1.097
	(.2878)	(.3411)	(.3415)	(.9859)	(.2737)	(.6282)	(1.2823)	(.3929)	(.8618)	(2.4479)	(.6357)	(.9291)
Average of previous two March prices												-1.010[c]
												(.6615)
R^2	.6131	.6122	.7874	.3058	.6361	.8602	.3094	.6358	.9093	.2539	.7983	.4755
$\bar{R}$	.73	.71	.80	.55[f]	.74	.87	.56[f]	.73	.92	.50[f]	.86	.42
Sy.x	37	38	20	60	38	16	60	38	.0941	.1941	.1352	49

a - Significantly different from zero at 2.5% level
b - Significantly different from zero at 5% level
c - Significantly different from zero at 10% level
d - Regression coefficient
e - Standard error of regression coefficient
f - Unadjusted multiple correlation coefficient

R^2 - Multiple coefficient of determination
$\bar{R}$ - Adjusted multiple correlation coefficient $\bar{R} = \sqrt{1-(1-R^2)\left(\frac{N-1}{N-M}\right)}$
Sy.x - Standard error of estimate

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cent level for Equation III-A but not in Equation III-B or Equation IV-A. Most of the equations had two or three regression coefficients that were statistically different from zero, but they were not for the same independent variables nor at the same level of significance in different equations. In Period B, none of the independent variables had regression coefficients statistically different from zero at the ten per cent level, except for the average of the two previous March prices in Equation VI-B. As a matter fact, the only consistency of the independent variables fitted in multiple regression Equations I through IV for the entire period was that 71-74 per cent of the year to year variation in the March price was explained. Also the standard error of estimate was consistently 37-38 cents per bushel. In contrast, Period A had an adjusted correlation coefficient of .80 and .87, the standard error of estimate was 20 and 16 cents per bushel, and the unexplained residuals were relatively small. Just the opposite was true for Period B, in which, the adjusted correlation coefficient became negative for one of two reasons: (1) the per cent of variation explained was too small, or (2) the degrees of freedom were insufficient. The unadjusted correlation coefficient was .55 and .56, the standard error of estimate was 60 cents per bushel, and the unexplained residuals were relatively large.

Equation VI-B had the only multiple coefficient of determination for Period B that did not become negative when adjusted for bias. Therefore, the reader should keep in mind that the correlation coefficient of .56 for Equation IV-B was unadjusted for degrees of freedom while the .42 for Equation VI-B was adjusted. Also, for Equation VI-B the standard error of estimate was reduced to 49 cents per bushel, whereas the standard error of estimate was 60 cents in Equation IV-B. The greatest improvement for Equation VI-B was that it had the lowest average error of prediction for Period B from all computed equations. This error was 29 cents per bushel.

Several economic changes appear to have taken place within Period A and Period B because the regression coefficients had different signs and magnitude. For example, Michigan October price had a +.720 regression coefficient during Period A and -.343 for Period B of Equation IV. This fact, in part, might be attributed to changes in viewpoints concerning the importance of storage. Potato storage may have been on an individual basis during Period A while storage during Period B became more specialized and commercialized. In fact, the whole potato industry has undergone increased specialization during Period B. Another explanation of the reversed situation might be that potato processing companies were willing to bid up prices in October to insure sufficient supplies later in the season. Processed potatoes accounted for more than 20 per cent of the total potatoes for food use since 1956.[40] The Michigan October price might be unduly depressed by large Michigan crops because farmers and buyers in Michigan are thinking that United States crop may be as large as the Michigan crop relative to some expected crop.

Another reversed situation concerned the October index of prices received for Michigan farm products. The regression coefficient was -.157 for Equation IV-A and +1.528 for Equation IV-B. An explanation for this situation was not readily obvious, however, there was the possibility that the index was not a causal factor but just happened to be highly correlated since all prices are correlated.

United States late summer and fall production per capita was the only independent variable that had a consistently negative regression coefficient through-out the analysis.

When Equation V-A and B was computed in logarithms, the adjusted correlation coefficient increased to 86 per cent. It was felt that these results had provided the basis for predicting the March price for 1960. However, an examination of the unexplained residuals indicated that the residuals for Period B had not been reduced.

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[40] National Potato Council,"U.S. Production, Utilization, and Use of Designated Potato Crop", Agricultural Marketing Service, and Other Sources, 1958.

In fact, the average error of prediction for Equation V-B was 31 cents per bushel and 38 cents for Equation V-A and B during Period B. The residuals for Equation V-A and B during Period A had an average error of prediction which was lower than those calculated from Equation V-A. Therefore, the results of Equation V provided little help in predicting future March prices.

The Durbin-Watson test was computed for the residuals of Equation IV-A and Equation IV-B. This was a test for serial correlation of unexplained residuals. The tests were inconclusive.

The Michigan March price was difficult to predict from any of the computed regression equations for the years 1934, 1939, 1952, 1953, 1954, 1957, and 1958. The criterion for making this statement was based on several predicting equations, in which the unexplained residuals were greater than 20 cents per bushel. The period 1943-1946 was excluded from the statement. The 1958 residual was consistently larger than 90 cents per bushel. Since the demand and supply of potatoes are both very inelastic, a small change in some independent variables could have a substantial effect on the predicted price. For example, in 1953 the price declined a $1.20 per bushel from October to March; Michigan production was down ten per cent, but late summer and fall production for the United States was up six per cent; the March price for 1953 was 53 per cent lower than the 1952 March price; and the Korean Conflict came to a halt but its economic influences were still to run their courses. Similar information could be put together for the other years that were difficult to predict.

CONCLUSION

If the author had to predict the 1960 Michigan March price of potatoes at the farm level based on information available during October 1959, the multiple regression Equation VI-B would be used. This equation was discussed in some detail on page 78. In this equation, the adjusted correlation coefficient was .42; the standard error of estimate was 49 cents per bushel; and the average error of prediction was 29 cents per bushel. Granted, these results were not extremely accurate for prediction purposes, but they were the best of any equation computed. Other equations computed for Period B were poor predictors because the multiple coefficient of determination became negative when adjusted for degrees of freedom, even though, Equation III-B had an average error of prediction of 31 cents per bushel and Equation IV-B had an error of 30 cents. Equations for Periods A and B combined would not be used because they had larger average errors of prediction for Period B than equations computed solely from Period B data. The problem of price prediction in Period B was not the same as Period A because the potato industry has undergone substantial economic changes and new economic problems have developed. In using Equation VI-B to predict the 1960 Michigan March price, a specific price would not be indicated. However, confidence intervals could be formulated with probabilities attached by utilizing the standard error of forecast. Computations of the standard error of forecast are outlined by Joan Friedman and Richard J. Foote.[41] The standard error of forecast would provide a little wider range than would the standard error of estimate since it takes into consideration the standard error of specific values.

After the prediction has been made, the analyst should constantly search for new information and short range forecasts for the purpose of modifying the prediction. If data were estimated for certain independent variables in the original prediction, then it should be modified accordingly as soon as the actual data becomes available. One bench mark is the January first estimate of storage stocks. Another is the amount of potatoes moving into the Diversion Program. Of course, the February price is a better indicator of the March price than the October price. Also additional economic changes

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[41] Joan Friedman and Richard J. Foote, Computational Methods For Handling Systems of Simultaneous Equation, Agriculture Handbook No. 94, United States Department of Agriculture, Agricultural Marketing Service, November, 1955, p. 17.

should be weighed for their influence on the March price. If the decision to store is based on the October prediction of the March price and the prediction appears to be out-of-line as early as January, the producer may reduce his losses by the rate of movement out of storage.

In this study, it was felt that three independent variables were found useful for predicting the Michigan March price during October. They were: (1) an average of the previous two March prices, (2) United States late summer and fall production per capita, and (3) the October index of prices received for Michigan farm products. If computations were made in logarithms, then the Michigan October price would be a good independent variable to substitute for the October index of prices received for Michigan farm products.

The author recognizes that the best predicting equation of this study leaves some answers to be desired; mainly, a higher percentage of year to year variation of the Michigan March price explained which would reduce the standard error of estimate and the standard error of forecast; so that, the confidence interval would be smaller in making a specific prediction. Therefore, the following areas are suggested for additional consideration. The analyst might look to the potato futures market. There is a quotation of March futures on the New York Mercantile Exchange for Maine grown, Contract No. 1 potatoes as of October 31. Since winter and early spring potato production is marketed during the time that storage stocks are, it might be a good idea to consider this as a variable. Another variable might be an index of transportation rates from early producing areas and major storage centers to Michigan. Of course, government programs should not be overlooked since they have diverted supplies of potatoes under Section 32, and the Diversion Program. Perhaps, the greatest contribution to predicting the Michigan March price in October lies in a detailed study of producer attitudes concerning potato storage; such as, what information do they use in deciding to store; what per cent of production is stored; what is the rate of marketing storage stocks; and what is the cost of storing a bushel of potatoes. The answers to these questions and the study of other factors which exert their influence during the period from October to March may enable the analyst to substantially improve the results reported here.

BIBLIOGRAPHY

1. Bean, L. H., "The Farmers Response to Price", Journal of Farm Economics, Vol. 11, No. 3, July, 1929.

2. Benedict, M. and Stine, O. C., The Agricultural Commodity Programs, The Twentieth Century Fund, New York, 1956.

3. Bere, R. L. and Cravens, M. E., Trends in the Potato Industry with Emphasis on Ohio 1909 to 1956, Ohio Agricultural Experiment Station, Wooster, Ohio, Research Bulletin 811, July, 1958.

4. Cothern, James H., "The Importance and Impact of the 1955 and 1956 Government Potato Diversion Program on the Potato Industry", Thesis for the Degree of Master of Science, Michigan State University, 1957.

5. Dalrymple, Dana, Predicting August Potato Prices at Planting Time, A Cooperative Publication from the Storrs Agricultural Experiment Station and the Agricultural Extension Service, University of Connecticut, Storrs, Connecticut, Progress Report 29, February, 1959.

6. Foote, R. J., Analytical Tools for Studying Demand and Price Structures, United States Department of Agriculture, Agricultural Marketing Service, Agriculture Handbook No. 146, August, 1958.

7. Foote, R. J. and Fox, Karl A., Seasonal Variation: Methods of Measurement and Tests of Significance, United States Department of Agriculture, Bureau of Agricultural Economics, Agriculture Handbook No. 48, September, 1952.

8. Friedman, Joan and Foote, R. J., Computational Methods for Handling Systems of Simultaneous Equations, United States Department of Agriculture, Agricultural Marketing Service, Agriculture Handbook No. 94, November, 1955.

9. Gray, Roger W., Sorenson, Vernon L., and Cochrane, Willard W., *An Economic Analysis of the Impact of Government Programs on the Potato Industry*, University of Minnesota Agricultural Experiment Station, Technical Bulletin 211, June, 1954.

10. Hee, Olman, "Highlights of Changes in Acreage for Seasonal Potato Crops", *The Vegetable Situation*, United States Department of Agriculture, April, 1958.

11. Hee, Olman, "The Effect of Price on Acreage and Yield of Potatoes", *Agricultural Economics Research*, United States Department of Agriculture, Agricultural Marketing Service and Agricultural Research Service, Vol. X, No. 4, October, 1958.

12. Meinken, Kenneth W., *Factors That Affect Price and Distribution of New Jersey Potatoes*, New Jersey Agricultural Experiment Station Rutgers, The State University New Brunswick, in Cooperation with Maine Agricultural Experimental Station, Bulletin 786, June, 1957.

13. Merchant, C. H. and Wallers, A. G., *Shifts and Trends in the Potato Industry in the Northeastern United States*, Maine Agricultural Experiment Station, Bulletin 566, November, 1957.

14. Motts, George N., *Marketing Michigan Potatoes*, Extension Bulletin 331, Michigan State College Cooperative Extension Service, September, 1954.

15. Pubols, B. H. and Klaman, S. B., *Farmers Response to Price in the Production of Potatoes*, 1922 - 1941, Bureau of Agricultural Economics, United States Department of Agriculture, 1945.

16. Schickele, Rainier, *Agricultural Policy*, Mc Graw Hill, New York, 1954.

17. Shuffett, Milton D., *The Demand and Price Structure for Selected Vegetables*, United States Department of Agriculture, Technical Bulletin No. 1105, December, 1954.

18. Walker, Helen M. and Lev, Joseph, *Statistical Inference*, Henry Hold and Company, New York, 1953.

19. Waugh, Frederick V., Forecasting Price of New Jersey White Potatoes and Sweet Potatoes, New Jersey State Department of Agriculture, Circular No. 78, July, 1924.

20. Working, Holbrook, Factors Affecting the Price of Minnesota Potatoes, University of Minnesota, Agricultural Experiment Station, Technical Bulletin No. 29, October, 1925.

21. Wright, K. T., "Potato Growing and Harvesting Costs, and Returns in Michigan 1957", Agricultural Economics Department, Michigan State University, East Lansing, April, 1958.

22. National Potato Council, "U.S. Production, Utilization, and Use of Designated Potato Crop", Agricultural Marketing Service, and Other Sources, 1958.

23. United States Department of Agriculture, Agricultural Statistics 1957 and Others, U.S.D.A., Washington, D. C., 1957.

24. United States Department of Agriculture, The Vegetable Situation, U.S.D.A., A.M.S., Washington, D. C., 1957.

25. United States Department of Agriculture, Agricultural Prices, U.S.D.A., A.M.S., Washington, D. C., 1958.

26. Michigan Department of Agriculture, Michigan Agricultural Statistics, Lansing, Michigan, July, 1958, and Others.

27. United States Department of Commerce, "Personal Income by States Since 1929", A Supplement to the Survey of Current Business, Washington, D. C., 1956.

28. United States Department of Agriculture, Supplement for 1957 to Consumption of Food in the U.S. 1909-52, U.S.D.A., A.M.S., August, 1958.

29. United States Department of Agriculture, The Vegetable Situation, U.S.D.A., A.M.S., Washington, D. C., April, 1958.

APPENDIX

MICHIGAN POTATO PRICES AVERAGE MID-MONTH RECEIVED BY FARMERS, RATIOS, INDEXES OF PRICE RECEIVED, 1909 TO DATE. REVISED AUGUST, 1958.

YEARS	MICH. MARCH PRICE	MICH. OCTOBER PRICE	OCTOBER INDEX OF PRICES REC'D MICHIGAN FARM PRODUCTS
	Cents/bu.	Cents/bu.	(1910-14) = 100
1929	30	145	167
1930	125	110	133
1931	75	33	85
1932	27	26	70
1933	26	70	81
1934	90	33	95
1935	24	43	104
1936	55	89	123
1937	110	45	117
1938	49	45	103
1939	47	55	102
1940	70	60	106
1941	55	60	139
1942	95	100	168
1943	140	140	209
1944	130	155	202
1945	165	110	214
1946	140	120	271
1947	115	165	297
1948	175	115	278
1949	145	105	230
1950	120	66	240
1951	105	139	275
1952	225	225	268
1953	105	81	236
1954	66	111	228
1955	120	81	221
1956	129	75	223
1957	78	111	229
1958	240	81	224

SOURCE: U.S.D.A., Agricultural Prices, various issues.

POTATO PRODUCTION FOR MICHIGAN, UNITED STATES, AND U.S. LATE SUMMER AND FALL, 1929 TO 1957.

YEARS	MICH. TOTAL PRODUCTION[1]	U.S. TOTAL PRODUCTION[2]	U.S. LATE SUMMER & FALL PRODUCTION[3]
	Mil. bu.	Mil. bu.	Mil. bu.
1929	16.0	333.4	267
1930	14.6	343.8	272
1931	24.6	384.3	304
1932	30.3	374.7	309
1933	23.3	343.2	284
1934	36.2	406.5	334
1935	27.6	378.9	305
1936	25.0	324.0	265
1937	25.0	376.4	293
1938	25.5	355.8	273
1939	21.0	342.4	268
1940	17.5	376.9	295
1941	20.0	335.7	278
1942	16.6	368.9	285
1943	22.4	458.9	358
1944	18.4	383.9	303
1945	17.8	419.4	320
1946	17.9	487.3	370
1947	11.0	389.0	298
1948	14.6	449.9	353
1949	15.3	402.4	327
1950	15.3	429.9	352
1951	11.5	320.5	262
1952	11.3	349.1	288
1953	12.2	380.1	307
1954	12.0	356.0	298
1955	9.4	378.4	300
1956	13.4	405.4	335
1957	11.1	399.2	310

[1] Michigan Department of Agriculture, Michigan Agricultural Statistics.
[2] U.S.D.A., Agricultural Statistics.
[3] U.S.D.A., The Vegetable Situation, April, 1958, p. 30, and Others.

POTATOES: PER CAPITA CONSUMPTION, U.S. LATE SUMMER AND FALL PRODUCTION PER CAPITA, AND MICHIGAN PRODUCTION AS A PERCENTAGE OF U.S. PRODUCTION.

YEARS	PER CAPITA CONSUMPTION OF POTATOES[1]	U.S. LATE SUMMER & FALL PRODUCTION PER CAPITA[2]	MICH. PRODUCTION AS A PERCENTAGE OF U.S. PROD.[3]
	Lbs.	Bu.	Per cent
1929	159	2.19	4.79
1930	132	2.21	4.25
1931	136	2.45	6.39
1932	134	2.47	8.07
1933	132	2.26	6.79
1934	135	2.64	8.89
1935	142	2.39	7.27
1936	130	2.07	7.71
1937	126	2.27	6.63
1938	129	2.10	7.17
1939	122	2.05	6.12
1940	123	2.23	4.65
1941	128	2.08	5.96
1942	127	2.11	4.48
1943	125	2.62	4.88
1944	136	2.19	4.78
1945	122	2.29	4.24
1946	123	2.62	3.66
1947	127	2.07	2.83
1948	105	2.41	3.23
1949	110	2.19	3.80
1950	106	2.32	3.55
1951	113	1.70	3.58
1952	101	1.83	2.96
1953	106	1.92	2.82
1954	106	1.83	3.38
1955	106	1.81	2.48
1956	100	1.99	3.30
1957	109	1.81	2.78

1 U.S.D.A., The Vegetable Situation, July, 1958.
2 Computed by author from U.S.D.A. data.
3 Computed by author from U.S.D.A. data.

U.S. REAL DISPOSABLE INCOME PER CAPITA, MICHIGAN PERSONAL INCOME, AND MICHIGAN OCTOBER FARM PRICE AS A PERCENTAGE OF MAINE OCTOBER FARM PRICE, 1929 TO 1957.

YEARS	U.S. REAL DISPOSABLE INCOME PER CAPITA[1]	MICHIGAN PERSONAL INCOME[2]	MICH. OCT. FARM PRICE AS A PERCENTAGE OF MAINE OCT. FARM PRICE[3]
	Dollars	Mil.dol.	Per cent
1929	930	3,803	107
1930	846	3,186	147
1931	792	2,593	165
1932	668	1,882	124
1933	658	1,668	117
1934	719	2,167	165
1935	782	2,554	113
1936	872	3,014	119
1937	897	3,389	180
1938	839	2,891	102
1939	906	3,215	92
1940	962	3,610	186
1941	1108	4,522	100
1942	1250	5,812	154
1943	1320	7,269	147
1944	1410	7,570	135
1945	1348	7,215	122
1946	1362	7,743	133
1947	1237	8,832	150
1948	1256	9,579	96
1949	1249	9,522	124
1950	1332	10,803	110
1951	1327	12,103	132
1952	1339	12,902	118
1953	1383	14,516	162
1954	1378	14,172	131
1955	1450	15,632	169
1956	1486	16,206	132
1957	1483	16,706	154

1 U.S.D.A., Supplement for 1957 to Consumption of Food in the U.S., 1909 to 1952, August, 1958.

2 U.S. Department of Commerce, "Personal Income by States Since 1929", A Supplement to the Survey of Current Business, 1956, and Others.

3 Computed From Data in U.S.D.A., Agricultural Prices.