AN ECONOMIC STUDY OF THE EASTERN BEET SUGAR INDUSTRY

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ABSTRACT

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by Robert Alton Young

Beet sugar production in the Eastern Region (Michigan, Ohio, Indiana, Illinois and Wisconsin) has in the last three decades been characterized by a decline in the level of production, both absolutely and relative to other areas. The purpose of this study has been to make an analysis of the factors influencing the industry in order to determine its future prospects. Changes which provided for increased supplies of sugar from the sugar beet section were made in the Sugar Act in 1962. This new situation raised questions concerning the possibilities of expansion of beet sugar output in the Eastern Region. Thus, this investigation was made with special reference toward evaluation of the feasibility of proposals for expanded production.

The method of analysis was to examine the economic, technical and institutional factors influencing the supply, demand and price of beet sugar in the Eastern Region. The analysis focused on conditions in Michigan and Ohio, for in none of the other states has a sugar beet processing industry survived.

A study of production response for sugar beets was made using the linear programming technique with variable prices. Production of sugar beets has undergone a major transformation in the past decade. The crop enjoys a strong competitive advantage over other typical crops.

on the heavy, level lake-bed soils in East Central Michigan and Northwest Ohio. However, high hauling costs limit this advantage to areas adjacent to beet factory locations. The linear programming analysis showed that supplies of beets would be expected to increase to the limits of present factory capacity. As large expansion in processing capacity through erection of new plants is of questionable profitability (see below), these supplies are likely to be adequate for prospective processing capacity.

Beet sugar processors have been faced with rising costs of labor and other resources. Sugar prices as controlled by the Department of Agriculture under authority of the Sugar Act have not risen as rapidly. Quality of the sugar beets has declined over the last decade as farmers have increased fertilizer use and adopted mechanical harvesting techniques. The factories in the Eastern Region are older and relatively small. However, the construction of new plants entails a capital outlay of 15 to 20 million dollars.

An analysis was made of the feasibility of construction of new sugar beet plants. Under Eastern Region conditions, it does not appear that the returns from such a venture would be sufficient to justify the investment.

Beet sugar producers in the Eastern Region supply only a small proportion of the huge Midwestern market for sweeteners. They are thus "price takers" and their level of returns is influenced by the behavior of the larger suppliers from coastal cane sugar refineries and Central and Western Region beet sugar producers. Increasing output of beet sugar in other regions has resulted in the surpluses from these areas being shipped into the Midwest. Price concessions have been required in order to penetrate these markets. A statistical analysis showed that these supplies have a measurable impact on returns to Eastern Region beet processors and growers. Basis prices in the region are often lower than elsewhere in the nation. This condition is partially offset by a freight advantage.

It was concluded that the outlook for the beet sugar industry in the Eastern Region is for neither a period of rapid growth nor for an immediate demise. A period of favorable prices and continued technological advances are in the offing for the sugar beet farmer. The sugar beet processor can expect a somewhat larger supply of beets to enable a more effective utilization of capacity. A period of favorable price levels should exist for several seasons until world supplies are brought into closer balance with consumption. These factors should help offset the continued increases in resource costs and the decline in the quality of the sugar beets.

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Any errors which remain in the manuscript are the responsibility of the author.

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CHAPTER I

INTRODUCTION

The Department of Agriculture classifies sugar beet producing regions as "Eastern," "Central" and "Western." The Eastern Region is comprised of Michigan, Ohio, Wisconsin, Illinois and Indiana.

The last decade or two has witnessed major transformations in the conditions under which the beet sugar industry in the United States operates. Some of these changes are technological; others are the result of economic shifts, and others may be termed political or institutional. Many of these have affected the whole of the industry, but a number are localized in the Eastern Region. As background for the problem, let us briefly sketch the nature of some of the changes.

Sugar Beet Production.--The sugar beet crop has long been known as a high cost, labor intensive enterprise. In the past two decades research work by the United States Department of Agriculture, the land grant colleges and experiment stations and the sugar industry has resulted in dramatic changes in the production technology of the sugar beet. Since the introduction and complete adoption of mechanical harvesting techniques, the heavy demands for migrant labor in the harvest periods are a thing of the past. Research in plant breeding and in mechanical and chemical weed control show great promise of similar elimination of hand labor for "spring work." Per-acre yields are also advancing due to more intensive use of resources, improved varieties, and shifts to more favorable locations. These yield increases are taking place more rapidly in the Eastern Region than elsewhere, so that state average yields per acre have on occasion in recent years exceeded those of some of the irrigated areas of states farther to the west.

Processing.--Major technological advances and increased capital investment are evident in the processing sector as well. However, the apparently optimistic outlook for the beet grower is not completely mirrored in the Eastern Region processors' situation. The last two decades have witnessed a decline in the region's sugar production both relative to other areas and absolutely. Michigan, once a major center of beet sugar production, has fallen from third among the states in the middle Thirties to a position of seventh in 1962. Factory numbers in that state have dropped from sixteen in 1940 to five in 1962. Ohio's rank has also declined somewhat, and the last remaining plant in Wisconsin did not slice beets in 1962. Even after this reduction in capacity some processors are unable to contract as much acreage as their capacity warrants. However, these figures do not tell all the story. Much of the decline in production and number of factories can be attributed to inappropriate location of factories relative to raw material supplies. The remaining factories appear to be in localities where beets enjoy a more favorable competitive position. New investment and fruits of research have increased the daily and annual slicing capacity so that the output of the present eight plants slightly exceeds that of the 22 plants in Michigan and Ohio in 1925.

Marketing.--Sugar produced in Michigan and Ohio supplies only a small portion of the total consumption of these states. About 35 percent of all sugar delivered in Michigan is of local origin, and

the figure is typically between 10 and 15 percent for Ohio. The five states of the region absorb nearly one-fourth of sugar deliveries in the U.S. Less than 8 percent of this huge market is accounted for by the Eastern Beet Sugar Industry. Location in such a deficit market is favorable to Eastern Region producers, but other factors operate to reduce this advantage. In recent years there have been supplies of Central and Western beet sugar in excess of the demand in those regions. Surplus sugar has come East to Chicago and the nearby areas, and price concessions have been necessary in order to penetrate this market which is also supplied by cane refiners on the Atlantic and Gulf Coasts. Competition is intensified in Southern Lower Michigan by a freight rate structure which is more favorable from certain Rocky Mountain points to that area than to Chicago. The Southwestern Lower Michigan sugar market has come to be known as the "coffin corner" in the trade.

On the demand side of the marketing picture, the major consumers of sugar are now the "industrial users"; the food canning and freezing, baking, dairy products, candy and beverage industries now absorb over 60 percent of the United States' annual consumption of sugar. These new markets pose new problems to the sellers of sugar. They demand a wider range of products which must meet more exacting specifications.

Policy.--On the political front, the sugar industry operates under what is probably the most complex and extensive set of regulations of any agricultural commodity. A number of important changes have been put into effect in the Federal sugar regulations, particularly as they relate to the future growth of the domestic beet industry's share of the sugar market. The presence of an unfriendly regime in Cuba, long a major supplier of sugar for the United States, has required that other sources of supply be found. Among the steps in this direction has been a change in the provisions of the sugar legislation which will enable the erection of several new beet sugar factories in the United States.

Need

Sugar beets and beet sugar do not account for a large portion of the farm income of the Eastern Region or even of the producing states in the Region. However, for the several thousand farmers who grow beets in Michigan and Ohio, the beet sugar processing industry is a major market, and in the communities in which the processing facilities are located, the industry is an important part of the local economy.

The changing economic and technical conditions focused attention on the value of an economic study of the industry. In 1961, largely through the foresight of personnel at Michigan State University, the present study was initiated with the purpose of making an economic investigation of a number of the problems confronting the Eastern Beet Sugar Industry. Since that time, the study has taken on a new and immediate significance. Because of the potential effects of further shut-downs of plants to the farmers and localities concerned, individuals and groups at local and state levels have also become concerned that the down-trend in beet sugar factory numbers might be continuing.

More recently, the provisions in the 1962 Federal sugar legislation for additional sugar beet acreage and plant capacity have resulted in proposals for construction of new processing facilities in the Eastern Beet Area. The capital outlay envisioned in these proposals is of the order of 15 to 20 million dollars. It is obvious that unwise investment could entail capital losses of large magnitude. The alternative of expanding existing facilities also has its proponents. It is therefore important that a careful analysis of the factors influencing the outcome of all alternative courses of action be available to the parties concerned.

Problem Framework

The foregoing brief discussion of the industry points up some important characteristics of the Eastern Beet Sugar Industry. The small proportion of the market which it can supply dictates that producers in the region are "price-takers." The market is mainly influenced by supplies from cane refiners on the Atlantic and Gulf Coasts and from beet sugar producers to the West.

The conceptual framework appropriate to the subsequent analysis is the theory of interregional trade, which is the modern refinement of the theory of comparative advantage. The pure theory may be summarized as follows:

> There are a set of regions with different resource endowments trading in some homogeneous good. Positive transportation costs exist between regions. Composite supply and demand schedules are visualized for each region for the product in question.
>
> An equilibrium solution would indicate (a) the net price in each region, (b) the quantity of exports and imports of the

good in each region, and (c) the volume and direction of trade in the good between each possible pair of regions.[1]

Preliminary Considerations

Geographical Area - Empirical estimation of supply and demand relations for sugar for each of the several regions of the United States is an enterprise beyond the scope of this study. The analysis will be confined to a consideration of such relationships for the areas presently producing sugar beets in the five states of the Eastern Beet Sugar Region.[2]

Marketing Stage - The price-making forces may be examined at a number of steps in the channels from farm to consumer. In this case, the forces affecting both the price of sugar beets and the price of sugar will betreated.

Supply

In the static theory of the firm, the supply relation for a given product is determined by (a) the price of the product, (b) the cost of resources required in its production, and (c) the production function (the relationship between resources and output), given, of

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[1]After S. Enke, "Equilibrium Among Spatially Separated Markets," Econometrica, Vol. 19, No. 1, January, 1951. See also Ronald Mighell and John D. Black, Interregional Competition in Agriculture, Cambridge, Mass., Harvard University Press, 1951, Chapter 2.

[2]Since the field studies for this project were completed, some interest in the beet industry has been evidenced in Eastern Region states not now producing beets (Indiana, Illinois and also New York). The data in this study relating to sugar beet production applies only to Michigan and Ohio areas presently growing beets. This information has some relevance to conditions elsewhere in the region but should be interpreted with considerable care for such applications.

course, the usual assumptions of a profit-maximizing firm under conditions of perfect knowledge.[1]

Uncertainty, fixed factors, capital rationing, nonmonetary goals, multi-product firms and complementary and supplementary relationships are complicating factors which must be taken into account.

These general principles apply to both the farm and the processing firms in the present case. Accordingly, the analysis of the supply side of the equation shall consider technical production relationships and the price and supplies of resources for both the production of sugar beets and competing enterprises and for the processing of the beet crop.

Institutional restraints on sugar supplies are of major importance in the present case. A thorough examination of Federal sugar policy thus is necessary for the understanding of sugar supplies and prices.

Demand

Final demand for a product is considered to be determined by consumer preferences and incomes. In the case under consideration, it has been noted that a large proportion of sugar purchases are for industrial uses. This demand is "derived" from the demand for the various sugar containing final products. The nature and elasticities of these markets differ. Accordingly, the characteristics of each of these markets require separate attention.

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[1]Heady, Earl O., "Uses and Concepts in Supply Analysis," in Earl O. Heady, et. al., eds., Agricultural Supply Functions, Ames, Iowa, Iowa State University Press, 1961.

Objectives and Plan of Work

The objective of this thesis is, then, to present the results of a study of the economic factors influencing the Eastern Beet Sugar Industry. In view of the current requirements, the analysis will be carried out in terms of the problems of and potential for expansion of the acreages of sugar beets and plant capacity in the region.

These objectives will be approached in the following steps:

1. In Chapter II, the historical and economic background will be described, and the development and operation of the federal sugar programs will be discussed.

2. In Chapters III and IV, an analysis will be made of the projected future competitive position and expected supply relationships for sugar beets in the region.

3. Chapter V will examine certain economic relations in the processing sector as they relate to supply and price of sugar.

4. The characteristics of the sugar market will be described in Chapter VI and an analysis made of the special conditions affecting the marketing of sugar in the areas where Eastern beet sugar is sold.

5. In Chapter VII, the estimates and analysis of previous steps will be integrated and conclusions drawn about the prospective position of the Eastern Beet Sugar Industry.

CHAPTER II

HISTORIC, ECONOMIC AND POLITICAL BACKGROUND

A. General - About Sweeteners

The class of compounds which the chemists call "sugars" or "saccharides" are members of the larger group of organic compounds termed carbohydrates (that is, compounds whose molecules are formed from atoms of carbon, hydrogen and oxygen). Sugar molecules have a unique structure and arrangement of the atoms of these elements. The simplest sugars, which are called monosaccharides, usually have five to seven carbon atoms in a molecule and about two hydrogen and one oxygen atom for each of carbon. A common example of the monosaccharide is dextrose (also called glucose) which has the formula $C_6H_{12}O_6$. Monosaccharides may combine to form higher sugars ("oligosaccharides"). The disaccharide of formula $C_{12}H_{22}O_{11}$, termed "sucrose," is the product which is commonly called "sugar." It is a usually stable combination of the two monosaccharides, dextrose and levulose. Henceforth, unless otherwise specified, in this discussion the term "sugar" will be used to refer to sucrose in its various forms.

The only commercially important sources of sucrose are the sugar beet and sugar cane plants. As the sucrose is in the plant in pure form, the process of recovery is one of extraction, rather than of chemical modification. The refined product of either process is chemically identical and only an exhaustive laboratory analysis of

the tiny amount of residual impurities can differentiate between the two. Refined cane sugar consumed in the United States is usually the result of two processings. The sugar cane stalks are crushed at a cane mill, and there a "raw sugar" of about 97 percent purity is recovered. The final refining usually is accomplished in large refineries located in various large seaboard cities.

The sucrose is usually produced in crystalline form, although some cane refineries are equipped to produce a liquid sugar which does not pass through the crystalline stage. In the crystalline form it may be ground up to become powdered sugar or it may be redissolved to become a liquid sugar. The "brown" or "soft" sugars are composed of very fine crystals of sucrose with highly refined sirups added to give the special flavor and consistency. When a sugar in water solution is treated by heating in the presence of acids or certain enzymes, the sucrose breaks down into its two components, dextrose and levulose. The resulting solution has less of a tendency to crystallize than sugar and is valued in certain industrial uses such as candy-making and beverage-bottling. This process of breaking down sucrose is called "inversion," and the resulting product is known as "invert sugar."

Other saccharides of commercial importance are those refined from the hydrolysis of starch (usually cornstarch). Dextrose (identical to one of the components of sucrose) is a monosaccharide produced by a complete hydrolysis or conversion. It is not considered to be as sweet as sucrose but has other useful properties. Partial hydrolysis of cornstarch can result in a product known as "corn sirup." It contains chiefly dextrose, maltose and higher saccharides. Several grades are

produced, depending largely upon the total reducing sugar content of the sirup. This sirup also may be dehydrated to produce "corn sirup solids" which has many uses in industrial food manufacturing.

Certain other organic compounds have been found to have sweetening properties. Saccharin and certain cyclamates are the most common examples. These compounds substitute for saccharides in dietary uses since they have no caloric content but a relatively large sweetening power. Hence, they are termed "non-caloric" sweeteners.

Uses of Sweeteners

The main function of sweeteners is as a flavoring. Besides having an attractive taste in themselves, they enhance and bring out the flavors of other foods with which they may be combined. They can also serve as a preservative, as in jams or jellies. In baking, sugar provides food for yeasts, and the desirable brown color on the crusts of baked goods comes from the carmelization of sugar from the heat of the oven.

B. Beet Sugar Production in the Eastern Region

The first attempts at beet production for sugar in the United States occurred in the 1830's in Pennsylvania and later in Massachusetts and Michigan. Several other efforts got underway in the next three decades before the California Beet Sugar Manufacturing Company commenced operations at Alvarado, California, in 1870. This factory is called the first successful beet sugar plant in the United States, for a factory (since completely rebuilt) is presently operating on the original site.

In the meantime, a number of other factories were established, leaning upon the European experience for both equipment and knowledge. The industry during this developmental stage was given important encouragement from the Department of Agriculture. James Wilson, who was Secretary of Agriculture under three Presidents, and Dr. Harvey W. Wiley, Chief Chemist of the Department for nearly 40 years, instituted research programs to determine the best locations and methods for beet production and worked unceasingly to encourage new capital investment in beet sugar factories. The revenue tariffs on sugar in the Nineteenth Century provided some protection from cane sugar imports to the fledgling beet sugar industry. When these tariffs were repealed for a short period, a bounty replaced them. Under these influences a great number of beet sugar enterprises sprang up. Seventy-one factories were built during a 10-year period, 1897-1906.[1]

Wiley's studies indicated that the best climate for the sugar beet was in an area where the mean summer temperature falls between 67° and 72°F.[2] In 1898 he produced a map which delineated the most favored areas. The regions so designated included the areas near the Great Lakes, across the Northern Great Plains, below both Eastern and Western Slopes of the Rocky Mountains, and along the Pacific Coast in California. It is interesting to note that most of the sugar beet

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[1]United States Department of Agriculture, Sugar Division, Beet Sugar Factories in the United States. Washington, D.C., 1961.

[2]U.S. House of Representatives, 55th Congress, 2nd Session, Document No. 396, Special Report on the Beet Sugar Industry. Washington, D.C., Gov't. Printing Office, 1898.

operations remaining at the present time are located within the areas specified 65 years ago by Wiley.[1]

A sizeable portion of the industry's development in that period at the turn of the century was in the Great Lakes area, particularly in Michigan. (Of the 71 new beet sugar factories reported in the decade from 1897 to 1906, 22 were in Michigan and nine were in the other Great Lakes States.) The large expansion in Michigan was partly a reflection of a bounty of one cent per pound offered by the Michigan Legislature in 1897.[2]

Since the early burst of expansion in Michigan, the center of gravity of beet sugar production has been moving westward. As shown in Table 2.1, many factories in the region around the Great Lakes region have ceased operations. Meanwhile, new plants opened and existing plants expanded capacity in the Plains, Mountain and Western states. Table 2.2 shows that the decline in production in the Eastern Region has been even more striking when related to the growth in total production of beet sugar in the United States. California and Colorado have maintained their position of leadership in total sugar production while Idaho, Minnesota, Washington and Montana have moved up in the rankings ahead of Michigan. Beet production in Indiana and Wisconsin has ceased and only a relatively small acreage is still produced in Illinois.

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[1]See, United States Department of Agriculture, Farmer's Bulletin No. 2060, Sugar Beet Culture in the North Central States. Washington, D.C., 1954.

[2]For an interesting first-hand account of the origin and development of the beet sugar industry in the Great Lakes area, see Oviatt, C. R., "Sixty Years in Sugar," U.S. Department of Agriculture, ASCS, Sugar Reports, No. 128, December, 1962.

TABLE 2.1. BEET SUGAR FACTORIES IN OPERATION IN THE EASTERN REGION, 1900-1963[1]

Year	Michigan	Ohio	Wisconsin	Illinois	Indiana
1900	10	1	1	1	0
1905	20	1	3	1	0
1910	17	2	4	1	0
1915	16	5	4	1	1
1920	17	5	5	1	1
1925	17	5	4	1	0
1930	16	5	4	0	0
1935	16	5	2	0	0
1940	16	5	2	0	0
1945	14	4	1	0	0
1950	13	4	1	0	0
1955	9	3	1	0	0
1960	5	3	1	0	0
1963	5	3	0	0	0

[1]Derived primarily from U.S.D.A., Sugar Division. Beet Sugar Factories of the United States, Washington, D.C., 1961.

TABLE 2.2. ACREAGE AND PRODUCTION OF SUGAR BEETS, AND PRODUCTION OF REFINED BEET SUGAR, U.S. BY STATES, SELECTED YEARS

	1938a/			1946a/			1954a/			1962b/		
	Acreage Harvested	Sugar Beets Produced	Beet Sugar Produced	Acreage Harvested	Sugar Beets Produced	Beet Sugar Produced	Acreage Harvested	Sugar Beets Produced	Beet Sugar Produced	Acreage Harvested	Sugar Beets Produced	Beet Sugar Produced
	1000 acres	1000 tons	1000 cwt.	1000 acres	1000 tons	1000 cwt.	1000 acres	1000 tons	1000 cwt.	1000 acres	1000 tons	1000 cwt.
California	162	2,092	6,742	138	2,361	6,755	198	4,319	12,088	241	4,388	12,062
Colorado	137	2,001	6,103	153	1,920	5,375	115	1,654	5,072	171	2,739	9,321
Michigan	122	1,005	3,427	95	814	2,884	64	771	1,528	66	1,077	2,350
Montana	78	987	2,837	73	891	2,344	54	683	2,039	63	843	2,653
Nebraska	77	1,111	2,706	60	825	1,865	60	786	1,836	73	945	2,293
Idaho	71	1,122	2,856	76	1,274	2,877	89	1,569	3,952	127	2,453	5,851
Wyoming	53	684	2,121	36	420	1,159	36	475	1,341	49	614	1,631
Utah	52	814	2,212	41	568	1,397	33	534	1,530	24	412	1,215
Ohio	51	366	862	26	229	611	15	247	681	25	415	1,164
Minnesota	36	355	914	37	400	1,019	73	818	2,702	106	1,038	3,174
Washington	15	215	572	15	316	831	34	761	2,043	55	1,330	3,522
Wisconsin	14	163	320	13	125	164	11	135	245	0d/	0	0
All Other States c/	63	664	2,016	55	720	2,037	73	1,014	2,312	105	1,915	2,993
Total U.S.	931	11,579	33,688	818	10,863	29,318	855	13,766	37,349	1,105	18,169	48,229

a/ Source: Western Beet Sugar Producers, Inc., Beet Sugar Handbook, San Francisco, 1961.

b/ Source: Statistical Reporting Ser., U.S.D.A., Annual Crop Summary, December, 1962 and U.S. Beet Sugar Association.

c/ Includes both beet production and processing in Iowa, Oregon and South Dakota. Beets produced in North Dakota, Kansas and Illinois are processed in other states.

d/ The only remaining factory in Wisconsin ceased operations after the 1961 season.

C. Economic Characteristics of the Market for Sugar

Production and Supply

Cane sugar supplies about 55 percent of the total world market of 56 million tons of centrifugal sugar (see Table 2.3). The agricultural organizations which produce cane and beet sugar show a rather remarkable contrast. Both the cane stalk and the beet root are relatively perishable and bulky so that the sugar mills must be located in the growing areas. Sugar cane is usually grown in a monocultural system, with vast tracts around the raw sugar mills devoted entirely to the culture of cane.

Sugar beets, on the other hand, typically are included in a livestock-crop rotation agriculture in temperate climates. The crop is grown by individual farmers under contract to a factory. The necessity of growing beets as part of an extended crop rotation makes it unfeasible for a factory to own and operate an agricultural operation of the scope necessary to provide the raw material for a factory. A factory processing 2,000 tons of beets per day for 100 days must draw upon 50 to 75 thousand acres of adapted cropland (assuming 16 tons per acre yield and a rotation of 4 to 6 years duration). The by-products of the sugar beet harvest (beet tops) and of sugar extraction (beet pulp and molasses) all find value in livestock feeding operations.

Supply Response in Sugar

Examination of the history of the sugar industry where free market forces have been allowed to reign show that supplies of sugar have been very inelastic to increases in price within the production

TABLE 2.3. WORLD SUGAR PRODUCTION[a] (IN 1,000 OF METRIC TONS, RAW VALUE). CROP YEARS BEGINNING MARCH 1

	1958-59	1959-60	1960-61
Europe			
Beet	11,795	10,520	14,515
Cane	35	30	35
U.S.S.R.			
Beet	6,195	5,967	6,946
North and Central America including Caribbean			
Beet	2,165	2,260	2,375
Cane	11,950	12,405	13,690
Non-centrifugal Cane	315	310	265
South America			
Beet	70	85	65
Cane	6,175	6,100	6,250
Non-centrifugal Cane	875	860	930
Asia (including Mainland China and Oceania)			
Beet	970	1,135	1,310
Cane	8,170	8,675	9,080
Non-centrifugal Cane	6,245	5,850	5,805
Africa			
Cane	2,555	2,675	2,400
World Totals			
Beet	21,200	19,970	25,210
Cane	28,880	29,880	31,460
Total Centrifugal	50,080	49,850	56,670
Total Non-centrifugal	7,440	7,440	7,000

[a]Source: Food and Agricultural Organization, United Nations, Production Yearbook 1961, Rome, Italy, 1961.

period. However, the output is very responsive to higher prices over a period long enough for the financing and erection of the necessary milling and transportation equipment. This relationship has been particularly true in the case of cane sugar, due largely, no doubt, to the relatively plentiful supplies of adapted land and of labor in tropical regions. Wolf asserts that tropical countries can expand output without increasing costs for a considerable range, providing only that capital is available for mills.[1] Declining prices have not resulted in the equivalent reduction in output and the industry in such cases has suffered through long periods of low prices following overexpansions. The theoretical framework developed by Johnson and others provides an explanation of this behavior.[2] Briefly, this analysis shows that where resources cannot be disposed of at prices equal to their cost of acquisition, the profit maximizing firm will not reduce output for some range of falling prices. The size of this range depends upon the difference between acquisition and salvage prices of the relevant resources. The case of a sugar mill or a factory demonstrates this property to a striking degree. Processing facilities, and in the cane areas the standing cane crops, are resources which have little or no alternative use when sugar prices fall. When the demand for sugar, and hence the demand for these resources used in sugar production declines, the

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[1] Wolf, H. A., The United States Sugar Policy and Its Impact on Cuba. Doctoral dissertation, Univ. of Michigan, 1958, Univ. Microfilm, Ann Arbor, Michigan.

[2] See Johnson, Glenn L., "The State of Agricultural Supply Analysis," Journal of Farm Economics, Vol. 42, No. 2, May, 1960, and also Edwards, Clark, "Resource Fixity in Farm Organization," Journal of Farm Economics, Vol. 42, No. 4, November, 1960, and references cited.

salvage values can be quite low. Thus, it is implied that falling prices would have relatively little effect on output and general over-investment in sugar facilities are quite likely to be followed by long periods of chronic heavy stocks and depressed prices. The tendency toward government intervention in sugar industries precluded any extensive test of this proposition, for output has been reduced by decree in many countries where the free action of entrepreneurs has failed to do so.

The experience of Cuba in the 1920's is illustrative. Extremely high prices were followed by a short depression which occurred after the wartime levels, spurring large investments in cane milling equipment and plantations. Output jumped some 12 percent between 1923 and 1924 (using 1921-23 as a base period) and 28 percent more in 1925 as the new mills came into operation. In the meantime, the high price of 1923 encouraged increases in output elsewhere around the world which caused the price to collapse while the increases in production were occurring. The relatively large (28 percent) increase in output in 1925 had followed a year in which price had declined by over a third from the average level of 1923. Prices continued to decline, dropping down to 44 percent of the 1923 level in 1925 and remained down in 1926. Production in the meantime did not show a decline until 1926, nearly 2 years after the first price drop. As suggested by the theoretical analysis, this decline was minor relative to the price decline, being on the order of 7 percent. It took action by the Cuban Government to reduce output by a further 10 percent in the 1927 crop, although the price of sugar was but half of its value 4 years previously.[1]

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[1]Wolf, H. A., <u>United States Sugar Policy and Its Impact on Cuba</u>, <u>op. cit</u>.

Consumption and Demand

The most important determinants of sugar consumption are sugar prices and the income level of consumers. Data on per capita consumption show considerable variation among nations. These differences are largely explained by the income level of various countries. Viton and Pignalosa of the United Nations Food and Agricultural Organization (FAO) made an exhaustive study of the demand for sugar.[1] They applied statistical regression techniques to both cross-sectional and time series data, as well as summarizing previous efforts in this field. Some of their estimates of income and price elasticities are reproduced in Table 2.4. The estimates for countries classified as to income level showed that changes in income at a relatively low level of per capita income are likely to be associated with a more than proportional change in sugar consumption, while income changes are likely to have much less effect on consumption in the developed countries. It appears that in a highly developed economy, such as that of the United States, this relationship between incomes and consumption becomes relatively stable. In the estimates shown in Table 2.4 for three different periods in the United States, only minor changes have occurred in the income elasticities. These relationships are also evident in Table 2.5 which presents total and per capita consumption for various areas in the world. The measurement of price elasticity (the effect of change in price on consumption) also is illuminating. In low income countries, consumption is quite

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[1]Viton, A. and Pignalosa, F., "Trends and Prospects in World Sugar Consumption." Monthly Bull. of Agricultural Econ. and Statistics, Vol. IX, Nos. 1 and 2, 1960. FAO, Rome, Italy.

TABLE 2.4. SELECTED ESTIMATES OF PRICE AND INCOME ELASTICITY OF DEMAND FOR SUGAR[1]

	Price Elasticity	Income Elasticity
Groups of Countries Classified by Income[2]		
Low Income Countries	-1.08	1.23
Medium Income Countries	-0.86	0.74
High Income Countries	-0.37	0.40
United States, Selected Years[3]		
1921 - 1938	-0.30	0.34
1921 - 1938 plus 1946 - 1951	-0.26	0.27
1921 - 1938 plus 1946 - 1956	-0.28	0.27

[1]Viton and Pignalosa, op. cit. See also FAO, United Nations Commodity Bulletin Series No. 32, Trends and Forces in World Sugar Consumption, Rome, 1961, by the same authors.

[2]Data from postwar years. Income levels are defined such that Medium Income Countries are those with per capita income falling between $200 U.S. and $500 U.S. Low Income Countries have per capita incomes below this range, and High Income Countries above it.

[3]Time series analysis.

responsive to price change; the estimated percentage change in consumption being greater than the percentage change in price. However, in the higher income countries the change in price has relatively little effect on the quantity demanded. In the United States, as indicated in Table 2.4, the elasticity is estimated to be only about -0.27; that is, only a relatively small change in the quantity demanded is associated with a given change in price. These properties of the demand for sugar suggest that, particularly in high income countries, prices would be quite volatile, and relatively small deficits or surpluses in supplies would be reflected in rather large movements in price.

TABLE 2.5. WORLD CENTRIFUGAL SUGAR CONSUMPTION, 1959[1]

Area	Total Consumption (1,000 metric tons raw value)	Per Capita Consumption (pounds raw value)
Western Europe	10,721	74
North America	9,223	105
Central America	1,898	67
South America	4,550	74
Near East (Asia)	1,310	32
Far East	5,819	16
Africa	2,641	24
Oceania	713	101
East Europe and U.S.S.R.	8,556	62
Mainland China	1,300	4
World	46,728	36

[1]Source: FAO, United Nations, World Sugar Economy in Figures, 1880-1959, Rome, Italy, 1961, Table 12-A and Table 12-B.

D. The United States Government and the Sugar Industry

Early History--The Tariff Era

The main interest of the Federal Government in the sugar trade during the Eighteenth and Nineteenth Centuries was as a source of income. Inelastic demand and well defined trade channels made sugar an excellent vehicle for gaining revenues. It is reported that the sugar duties during the last century made up nearly 20 percent of all customs collections. A by-product of the tariff was the protection afforded to the infant sugar cane industry of Louisiana and later to the Kingdom of Hawaii. (This latter nation was given duty-free entry under terms of a treaty in 1876.)

In 1890, sugar duties were removed but a two cent bounty on domestic sugar afforded protection. In 1894, when the tariff was reinstated, the duty on sugar was explicitly intended to continue protection of the domestic industry, as well as for revenue.[1] Behind the tariff barriers and with the assistance and encouragement of the Department of Agriculture, the domestic beet sugar industry developed. The Spanish-American War brought new sources of sugar supplies into the United States' market as the new territories of Puerto Rico and the Phillipines received duty-free status, and Cuba was afforded a preferential tariff rate. The economies of these areas, as well as that of Hawaii, soon specialized in cane sugar production, and their economic well-being was dependent upon both United States' policies and demand for sugar. United States' policy since this time has always been formulated with explicit references to the responsibility for the well-being of these nations.

The industry enjoyed a period of relative stability and growth up to and through the First World War. However, soon after this time, the picture changed. In the early 1920's a period of favorable sugar prices induced large investments in cane producing and processing capacity, particularly in Cuba. Coincidentally, nationalistic policies carried out by several European countries brought recovery to the beet sugar industry in that region. Prices fell rapidly, the supplies continued to increase and subsequently declined only a relatively small amount, so stocks began to accumulate in exporting countries. The United States Congress responded to these conditions by raising the

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[1]See the United States House of Representatives, 53rd Congress, 2nd Session, Tariff Hearings before the Committee on Ways and Means, Document No. 43, Government Printing Office, Washington, D.C., 1893.

tariff three times in order to protect the domestic beet and cane industries. The Smoot-Hawley Tariff of 1930 raised the Cuban duty to two cents per pound of sugar, and to two and one-half cents per pound on sugar from so-called full-duty countries. (Cuban sugar had a 20 percent tariff preferential, which together with Cuba's advantage on shipping rates made Cuban duty the effective rate.) During the earlier part of the period, the tariff had successfully insulated the domestic industry in the world market. By the 1930's, with a world-wide collapse in demand from the depression, heavy stocks of sugar and continued excess capacity made even the Smoot-Hawley Tariff ineffective. Insular and continental sugar areas increased production sharply in the next few years, apparently because the high tariff made sugar a relatively attractive place to commit resources during the general depression, even though absolute prices were low. Cuban sugar exports were cut back severely, but not enough to maintain the market in the face of increasingly large insular supplies. The general effect upon the economy of Cuba was calamitous, and the situation eventually resulted in the Government of that country being overthrown in 1933.

The Jones-Costigan Act

In 1933, the Tariff Commission reported that the situation was "disastrous for both Cuban and American producers," and recommended to the President that the sugar supplies from all domestic and insular areas in Cuba be limited, and that duty on Cuban sugar be reduced.[1] The sugar

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[1] U.S. Tariff Commission, Report to the President on Sugar, Report No. 73, Washington, D.C., Government Printing Office, 1934.

industry and the Administration were unable to reach agreement on a program that year, but in 1934 President Roosevelt sent a message to Congress asking for legislation which would achieve the following objectives:

(1) To maintain the existing acreage of sugar beets and sugar cane in the Continental United States, but to limit further expansion;

(2) To increase returns to domestic growers;

(3) To stabilize production in the insular areas;

(4) To check the decline of imports of Cuban sugar as a means of restoring Cuba's power to purchase America's agricultural products.[1]

Most of the President's recommendations were contained in the Jones-Costigan Act, which was passed later that year as an amendment to the Agricultural Adjustment Act.

Provisions and Operation of Present Sugar Legislation[2]

Most of the general principles embodied in the original sugar legislation in 1934 remain in effect to the present time. The present law is known as the "Sugar Act of 1948," and it was amended in 1951,

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[1]Source: Quoted in Bernhardt, Joshua, The Sugar Industry and The Federal Government, Washington, 1948, Sugar Statistics Service, p. 159.

[2]A more detailed discussion than found in this section is in The U.S. Sugar Program, Sugar Reports 124, August, 1962. For even more extended analytic treatments of sugar legislation the reader may consult the following: Dalton, John E., Sugar, A Case Study in Government Control, New York: Macmillan and Company, 1937; Wolf, H. A., U.S. Sugar Policy and Its Impact on Cuba, op. cit.; Bernhardt, Joshua, The Sugar Industry and the Federal Government, op. cit.; Polopolus, Leondas, Structure and Performance of the United States Beet Sugar Industry Under Federal Protection and Control, unpublished doctoral dissertation, University of California, Berkeley, 1960; Turner, Jack T., The Marketing of Sugar, New York: Richard Irwin, Inc., 1956.

1956, 1960 and 1961. In 1962 it was again amended and extended through 1966. The following sections will discuss the major provisions of the present legislation and modifications as they have been made since 1934.

Total Quantity of Sugar to be Marketed

The Secretary is to determine the quantity of sugar which could be marketed during the following year. This quantity is to be such as to result in prices that are not excessive to consumers nor too low to protect the welfare of domestic producers. As a starting point, he is to consider the recent past consumption, state of current inventories, and the effects of expected changes in demand. In determining the price level, the relationship between the index of prices paid by farmers and the price of raw sugars is to be taken into consideration. The initial determination is made in December but can be adjusted throughout the year as changing conditions warrant.

Supply Quotas for Domestic and Foreign Producing Areas

The Secretary is authorized to establish supply quotas to domestic and foreign areas. The legislation has spelled out the precise formula by which these are to be distributed. In the early years, the quotas were based on fixed percentages of the estimated consumption. Growth of the total consumption was then prorated according to the original shares. In the Sugar Act of 1948, this approach was changed by assigning fixed quotas to the domestic areas (Mainland Beet area, Mainland Cane area, Hawaii, Puerto Rico and the Virgin Islands), and the Phillipines. Most of the balance went to Cuba except for a negligible amount to other foreign countries. Thus, Cuba received nearly all of the consumption increases and the domestic areas were prevented from any over-all growth. The 1952 Amendments did not change this provision, but in 1956, 55 percent of the growth of the market in excess of 8,350,000 short tons, raw value, was allotted to domestic areas. The 1962 enactments again changed the basis. Domestic areas are now assigned a basic quota of 5,810,000 tons, plus 65 percent of requirements in excess of 9,700,000 tons. The domestic beet and mainland cane areas share such increases in proportion to their basic quotas--roughly on a three-fourths to one fourth basis. Though Hawaii and Puerto Rico have failed to fill their quotas on occasion in recent years, a provision is included to increase their quotas if the size of future crops should warrant it.

Sugar beet acreage reserve for new producing localities.--The 1962 Amendment provided for reserves of acreage sufficient to yield 65 thousand short tons, raw value of sugar, to be committed for new beet sugar factory areas, or for expansion of existing factories. This provision represents a major departure from previous policy in regard to expansion of the beet sugar sector. In the period since the end of World War II, only four new plants for processing sugar beets have been erected in the United States, the most recent being in 1954.[1] At the present writing (1963), the Department of Agriculture has allocated acreage reserves to new processing facilities in California, Texas, North Dakota, South Dakota and Arizona for the crop years 1963 through 1965.[2] In case this reserve is not utilized for new factories,

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[1]Western Sugar Beet Producers Association, Beet Sugar Handbook, 2nd Edition, San Francisco, 1961.

[2]Federal Register, March 5, 1963. Commitment of National Sugar Beet Acreage Reserve, 1962 and Subsequent Crops, Sugar Determination 851.1, Amendment Three.

it is provided that it can be allocated for expansion of capacity in existing areas.

Global quotas.--The recent developments in political relations between the United States and Cuba have caused some changes to be made in the latter country's quota allotments. During the previous Cuban regimes, substantially all of the United States sugar needs were provided by the domestic areas, the Phillipines and Cuba. Since the break-off of diplomatic relations between Cuba and the United States, Cuba's former share, which was about one-third of the total quotas, has been allocated to a rather large number of friendly nations. The 1962 Amendments provide Cuba with approximately 1.5 million tons. The bill further stipulates, however, that when the United States is not in diplomatic relations with a particular country the quotas are not granted. Cuba's quota thus has been designated as a so-called "Global Quota," which may be filled by competitive imports from other foreign producers. These importations are subject to an import fee which approximates the premium the United States price is over the world price of raw sugar, when such a premium exists.

The 1962 Amendments also reduce the amount of off-shore "direct consumption" (refined) sugar which may be imported. Prior to 1960, about 650 thousand tons of direct consumption sugars entered the United States from off-shore (including domestic) producers. This amount has been reduced to about 250 thousand tons, the Phillipines being the only non-domestic supplier with more than a negligible amount of direct consumption sugars.

Establishing Marketing Allotments

If a domestic area should have supplies in excess of quotas, panicky selling might cause an unwarranted decline in price. In order to promote orderly marketing, the Secretary may allocate the quota among processors in each area based on past marketing history.

Assignment of Proportionate Shares

The Secretary may also divide the quota for a domestic area among the farmers producing beets or cane. This allotment, known as a "proportionate share," may be expressed in acres, tons of cane or beets, or in tons of sugar. This provision adjusts each area's production to its marketing quota and insures that each farmer's share is equitably distributed in the adjustment. The basis of the share is usually past history of production, but the Secretary is instructed to consider the interests of smaller growers and of new producers. Producers are not required to abide by the assigned share but must do so in order to receive "conditional payments." (See below.)

Other Provisions

In addition to the benefits from price maintenance and stabilization, legislation insures that the growers and workers are able to share in these gains. Growers' incomes are augmented through "conditional payments," which are made at a basic rate of $0.80 per ton of sugar produced, raw value. (This amounts to about $2.20 per ton of beets.) The rate decreases progressively after the first 350 short tons refined value, to a minimum of $0.30 per 100 pounds for tonnages in excess of 30,000 tons. Receipt of these conditional payments is contingent upon the grower of beets or cane (a) complying with the proportionate share restrictions, when such restrictions are in effect, (b) paying his hired workers in full and at not less than the minimum rate (which is also set by the Secretary of Agriculture), and (c) abiding by the minimum age restrictions for juvenile workers. The program also makes provision for compensation of growers for disaster losses. Payments can be made in case of reduced yields (deficiency payments) or in case of actual loss of the crop (abandonment payments).

Results of the Program

No attempt will be made here at evaluation of the sugar programs. No lack of such analysis is to be noted. (See references cited on page 25, footnote 2.)

The level and stability of the domestic sugar price under the sugar program has apparently achieved the stated objectives of maintaining the domestic industry. Prices to consumers have probably been somewhat higher than would have prevailed had the quota system not been in operation. As is shown in Table 2.6, the price of sugar is advancing about as rapidly as is the index of prices of all foods but not as rapidly as the index of disposable consumer income. Substantial premiums over existing world sugar prices were received by the insular cane areas of Puerto Rico and Hawaii, the Phillipine Islands and, until recently, by Cuba.

E. International Markets in Sugar

Timoshenko and Swerling have commented that the "gradual erosion of the 'free' market, characterized chiefly by the expansion of preferential

TABLE 2.6. WHOLESALE PRICES OF SUGAR COMPARED WITH INDICES OF PRICES OF ALL FOODS AND OF PER CAPITA DISPOSABLE INCOME, 1935-62[1]

Year	Wholesale Sugar Price Net Cash Northeast	Prices of All Foods Wholesale	Per Capita Disposable Income
	Cents per Pound	Index Numbers, 1935-39 = 100	
1935-39 (Average)	4.67	100	100
1940-44 (Average)	5.13	118	163
1945-49 (Average)	7.03	186	232
1950-54 (Average)	8.32	201	293
1955	8.42	212	323
1956	8.59	212	339
1957	8.97	218	351
1958	9.08	230	355
1959	9.14	219	370
1960	9.24	223	376
1961	9.21	222	385
1962	9.37[2]	224[2]	397[3]

[1]Source: Sugar Reports No. 126, October, 1962, Table 19.

[2]January-September only.

[3]January-July only.

cane sugar suppliers, has been the outstanding feature of the world sugar economy of the Twentieth Century."[1] They define the "free market" as that part of international trade in sugar which enjoys no special privilege or protection in the country of destination. The United States, which represents nearly 20 percent of the world's consumption, has almost entirely insulated its sugar market from world economic

[1]Timoshenko, V. P., Swerling, B. C., The World's Sugar, op. cit., p. 325.

forces since 1934. Another example of such policies is the United Kingdom which, through the Commonwealth Sugar Agreement, has arranged to acquire most of her import needs at a negotiated (premium) price from Commonwealth sources. As a consequence of arrangements of this nature, the free sugar market represents only a fraction (of the order of 10 to 20 percent) of total world production. It supplies only residual requirements of importing countries.

Prices in the free market tend to be rather unstable. This characteristic has been attributed to the low short-term elasticities of demand and supply, such that small changes in the balance of production and consumption in the residual market are associated with relatively large fluctuations in price. The narrowness and the residual nature of the world market also are important contributing factors. Timoshenko and Swerling also point out that importing countries respond to cheaper sugar by increasing protection afforded to domestic producers, rather than by increasing consumption.[1]

The volatility in world market prices was well demonstrated in early 1963, when reduced supplies to the free world from Communist Cuba and two years of short crops changed the supply picture such that world prices for raw sugar skyrocketed from a 20 year low of just above 2.0¢ per pound (F.O.B. and stowed, Greater Caribbean ports) in late January 1962, to a 40 year high of over 12¢ in May 1963.

International Agreements in Sugar

A new International Sugar Agreement was negotiated in 1953 in

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[1] *Ibid.*, p. 340.

order to cope with some of the problems of the "free" world market. It provided for export quotas, with the objective of keeping prices within a target "zone" of stabilized prices.[1] The refusal of certain of the signatories to the agreement (particularly the recent Cuban regime) to abide by the export quotas has made the Agreement ineffective.

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[1] *Ibid.*, p. 323.

CHAPTER III

SUGAR BEET PRODUCTION RESPONSE I - TECHNOLOGY AND RESOURCE BASE

A. Introductory

Objectives and Procedures

The stated purpose of this dissertation is to analyze the effects of changes in various technical, economic and political relationships on the prospects of the Eastern Beet Sugar Industry. This and the following chapter will contribute to these objectives by making an analysis of production response of sugar beets in the region.

"Production response" or "supply response" are economic terms which refer to the relationships between the total supply of a given product and the factors or forces influencing that supply. In the static theory of production, the supply relation is completely determined by (a) the production functions (the relationship between resources or factors and output) for the product in question and all relevant competing products, (b) prices of the products and the competing products, and (c) costs of inputs or resources, given the usual static assumptions of a profit maximizing competitive firm operating under conditions of perfect knowledge.[1]

This provides a useful conceptual starting point. However, the real world situation is much more complex, and accordingly, difficult to approximate. A number of factors reduce our ability to measure

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[1]See Heady, E. O., "Uses and Concepts in Supply Analysis," in Heady, E. O., et. al., eds., Agricultural Supply Functions. Ames, Iowa, Iowa State University Press, 1961, for a concise summary of the theory.

precisely the production response for a particular commodity. Among these are uncertainty and lack of knowledge, capital rationing, non-monetary objectives, technical changes, fixed factors, complementary and supplementary relationships among products, and many others.

The problem of production response is of both practical and methodological interest in the case of sugar beets. As was noted earlier, the acreage of sugar beets supplied to processors in the Eastern Region has not always been sufficient to fully utilize existing plant capacity. Hence, any proposals for expansion of the industry through investment in plant facilities must demonstrate that the present production relationships will undergo a sufficient shift to fully employ both present and prospective capacity.

Method of analysis.--A procedure commonly employed in production response analysis is the application of statistical regression procedures to time series data, to measure statistically the influence of selected variables upon output. However, the facts presented in justification of the study seem to rule out such an approach. These facts imply that the underlying structure being investigated is undergoing shifts, and to attempt to predict the future on the basis of historical relationships would be somewhat inappropriate.[1]

An alternative procedure is to construct a detailed static micro-economic model of representative farm situations, make the necessary assumptions, judgments and projections about factor supplies, competing

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[1]This type of approach was applied in Perreault, R. P., The Acreage Response of Michigan Farmers in East Central Counties to the Relative Prices of Sugar Beets and Field Beans. (Unpublished Ph.D. dissertation, Department of Agricultural Economics, Michigan State University, 1956.)

demands, technology, and institutions, and determine the effect of varying prices on output and return to resources under these assumptions. This technique has been applied using budgeting procedures by Mighell and Black[1] and by Schuh.[2]

In the last decade or so, the linear programming framework using variable pricing techniques has been increasingly applied to this sort of problem. This is a mathematical technique which finds the maxima (or minima) of a particular linear function under certain specified restraints. It is possible, under certain assumptions, to represent the elements of the static theory of the firm by a linear programming model. Solution of the model for given product prices determines the organization of resources and the amount to produce of each commodity which maximizes profit. Solving for several prices of a particular product provides estimates of the optimum output of that product under each of the various prices; that is, a supply response function.[3]

Time period of the analysis.--The static model developed is based on projections of technology, product prices and resource prices for the 5-year period, 1964-1968. For convenience, the projections are referred to as for the year 1966, the center of the period.

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[1]Mighell, R. L. and John D. Black, Interregional Competition in Agriculture, Harvard University Press, Cambridge, Mass., 1951.

[2]Schuh, G. E., The Supply of Milk in the Detroit Milk Shed as Affected by Cost of Production. Michigan Agricultural Experiment Station Technical Bulletin 259, East Lansing, 1957.

[3]See McKee, Dean E., and L. D. Loftsgard, "Programming Intra-Farm Normative Supply Functions," in Heady, E. O., et. al., eds., Agricultural Supply Functions, Iowa State University Press, Ames, 1961, for a discussion of the method.

The order of procedure in the remainder of this chapter is as follows:

(a) Some previous studies of production response in sugar beets will be briefly reviewed.

(b) The past, present and future trends in sugar beet production technology will be discussed.

(c) Estimates of current resource inventories on "typical" sugar beet farms will be presented.

Chapter IV will continue the discussion of production response with a presentation of the assumptions, results and interpretation of an analysis utilizing the linear programming technique.

Other measurements of supply response.--The Sugar Division of the Agricultural Stabilization and Conservation Service, Department of Agriculture, has from time to time published measurements of responses of planted acreage of sugar beets to relative prices of sugar and all other crops. The analysis is in graphic form, and no statistical measures are presented. However, the graphic analysis suggests fairly close relationship between sugar beet plantings, on the one hand, and the relative price of raw sugar (raw sugar price, New York, 6 months prior to time of sugar beet planting, divided by the index of prices received for All Farm Crops).[1]

The work by Perreault[2] for Eastern Michigan Counties is the

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[1]"Relationships Between Sugar Prices and Sugar Beet Plantings." Sugar Reports 101, September, 1960, Commodity Stabilization Service, U.S. Dept. of Agriculture, Washington, D.C.

[2]Perreault, Roger, The Acreage Response of Michigan Farmers in East Central Counties to the Relative Prices of Sugar Beets and Field Beans, op. cit.

only known study of supply response of sugar beets for the Eastern Region. Perreault, using a recursive statistical model, treated the planted acreage of sugar beets in the East Central Counties of Michigan as a function of (a) the intended acreage of field beans, (b) the price ratio of sugar beets and field beans the preceding year, (c) the price ratio of sugar beets to livestock products the preceding year, (d) the cost of fall beet labor per year adjusted by the percentage of the acreage mechanically harvested, and (e) a dummy variable representing weather conditions at planting time. The period under study was 1928-1954, with some years omitted. These variables explained about 56 percent of the variation in planted acreage of sugar beets, but only the ratio of prices of beets and field beans was found to be statistically significant at the 5 percent level. The analysis indicated that a 10 percent increase in the ratio of sugar beet to field bean price indices (1935-39 = 100) resulted in a 3.1 percent increase in planted acreage of sugar beets. Other variables were tested, including the yields of both sugar beets and field beans, the acreage of wheat, and the abandonment of sugar beets in the previous year. None of these were found to significantly affect the acreage of sugar beets planted. Although it was not possible to measure their effects, weather variations at planting time and uncertainties regarding labor supplies were major disturbances affecting the acreage planted to sugar beets.

The low proportion of variation in planted acreage explained ($\bar{R}^2 = .56$) suggests that there are many other factors, each with relatively small influence on planted acreage. Perreault hypothesizes that among these are extremely adverse harvest weather in the previous season, relative prices of crops other than beans, acreage allotments on other crops, and distance to the factory. The long period of price uncertainty before final settlement is one of a group of more subjective factors, which also includes the effectiveness of processor fieldmen in making contracts for acreage, and the unwillingness of producers to sacrifice leisure and other satisfactions for the additional income of beets when returns from other crops are at generally prosperous levels, or when opportunities for off-farm work are available.

B. Technical Aspects of Sugar Beet Production in the Eastern Region

General

Sugar beets have but one profitable market, the beet processing factory. The sugar beet factory has but one profitable use, the processing of raw beets for sugar. In order to protect the investment both parties have in the crop, marketing is effected under terms of a contract between grower and processor. The agreement makes provision for the number of acres, the conditions of delivery, method and time of payment, and numerous other details relating to seed, advances for expenses against the proceeds of the crop, labor procurement and the like. Some of the major provisions are discussed below. (There are some variations in contract terms between companies in the region so that all of the following statements may not apply in specific cases.)

The grower agrees to deliver to the processor all beets grown on the acreage contracted. Upon delivery, they are weighed and tared. (To arrive at a net tonnage, the gross weight is reduced by the amount of soil or other foreign matter in the load, and by deductions for improper removal of tops and crowns.) The processor agrees that all beets so delivered and accepted at the factory will be processed into sugar, beet pulp and molasses; such products to be sold at the company's discretion.

The company agrees to pay the grower a fixed proportion (usually about 50 percent in the Eastern Region) of the "net proceeds" from the sale of sugar, pulp and molasses. The "net proceeds" is defined as the amount received by the company (less any differential received from sugar packed in other than 100 pound bags) after deducting actual cost of outbound freight, brokerage, taxes (including the federal processing tax of $0.535 per cwt.) and certain other specified marketing expenses. The sugar per ton of beets may be determined by sampling each load, or more commonly, by the average of all sugar for each factory district.

The grower receives an initial payment, usually in December, which is based on "the highest rate the company deems justifiable," taking into consideration the expected production and returns from the sale of the products. Other payments may be made, and final settlement is usually due within 15 days after all products from that crop year are sold, or on some specified date (usually in October of the year following harvest) in the event all products are not sold by that time.

The share feature of sugar beet contracts appears to be unique to this crop. The arrangement originated in the Thirties when processors were caught between falling sugar prices and a fixed price contract for beets. The original intention was not that the 50-50 share remain permanent, but few changes have been made since that time.[1,2]

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[1]Oviatt, C. R., Sixty Years in Sugar, op. cit.

[2]An example of a typical Eastern region contract may be found in Jackson, Donald, Economics of Sugar Beet Marketing, ERS-49, U.S. Dept. of Agriculture, Washington, D.C., March, 1962, Appendix.

Agronomic Characteristics and Requirements

The primary raison d'etre of the sugar beet is the relatively large amount of sucrose stored in its roots. Sugar beets may be grown on a wide range of soils and in an equally wide range of climatic conditions. Actual location of production of any crop is, of course, determined by the interaction of a number of natural and economic factors such as climate, soils, topography, competing crop and livestock enterprises, and cost of transportation to and extent of potential markets.

Sucrose is produced in the leaf of the beet as a product of the process of photosynthesis. Most of it is subsequently stored in the beet root. The sucrose content of the root averages in the neighborhood of 14 to 16 percent at harvest time. High sugar content is of considerable importance to the processor, and thus to the grower, since a higher percentage of sugar can greatly increase the efficiency of the factory operation. Also important to the processor of beets is "purity," the percent of sucrose in the soluble solids of the beet. A high level of impurities reduces the proportion of available sugar in the beet which can be economically extracted. A high sucrose content is typically associated with a high degree of purity so that when large quantities of sucrose are in the beet, a relatively larger proportion of that present is extracted. A number of climatic, soil and management factors are known to affect both sugar content and purity and, hence, the most economic location of sugar beet production.

Climatic requirements.—A growing season of 150 to 200 days is required to achieve adequate beet tonnage and sugar content. Some observers indicate that the longer days in northern areas can offset the shorter growing period there. Rainfall requirements in non-irrigated areas are about 15 inches during the growing season.

The critical condition for the economical production of sugar beets is that the environment (be it controlled or natural) is such that a relatively high level of sucrose is stored in the beet root during the last several weeks before harvest. These conditions are provided naturally where there are relatively cool, rainless autumns. The growth of the beet is apparently inhibited by the cooler temperatures, but in the presence of adequate sunshine, sucrose will be produced and stored. Rainy, cloudy and warm weather in September and October (which are occasional hazards of beet production in Michigan and Ohio) are conducive to rapid growth of the beet, which draws off energy rather than increasing sucrose. In hot, arid climates, such as the Central Valley of California, sucrose storage is induced by limiting irrigation water in the late weeks before harvest of the crop.

The beet seed can sprout at air temperatures near to freezing, but it does so so slowly as to produce a weakened seedling susceptible to "damping off" or "black root" organisms. Temperatures above 45 degrees allow a healthy emergence. After a period of conditioning, the plants become nearly as cold hardy as small grains.[1]

Soil requirements.--The beet survives in a wide variety of soils. Beets are most often found on soils which are deep, well-drained, and have good moisture holding capacities. On these soils high yields are

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[1]Brandes, E. W. and G. H. Coons, "Climatic Relations of Sugar Cane and Sugar Beet," United States Dept. of Agriculture, Yearbook of Agriculture, 1941, Washington, D.C., Government Printing Office, 1941.

obtained without excessive management problems. In the Michigan and Ohio areas where irrigation is not typically practiced, the heavier mineral soils with high moisture holding capacities have an advantage over the lighter soils during periods of insufficient rainfall. Soils with properties which inhibit deep root penetration, such as high water tables, repellent soil structures or poor aeration, tend to produce beet roots of undesirable size and shape.

Climate in the Study Area

In the course of a discussion about difficulties with the beet crop in the spring, a man with long experience in the beet industry in Michigan was heard to remark, "This has certainly been an unusual spring." After a moment of reflection, he added, "But all springs in Michigan are unusual." The weather data in Table 3.1 are notable as much for their range as for their means.

The climate in Lower Michigan and Northwestern Ohio may be characterized as being humid and continental. Rainfall averages about 30 to 35 inches annually, with somewhat more than half occurring during the growing season. Length of the frost-free period averages around 150 days, but with considerable local variation. For example, the eastern portion of the Michigan factory districts in Sanilac, Huron and St. Clair Counties have a somewhat later spring and somewhat more rainfall. Most of the present growing areas are close to one of the Great Lakes and so enjoy some moderating influences and longer frost-free periods. The high variation in both rainfall and temperature data which are shown in Table 3.1 are important for the evaluation of the adaptability of the beet crop to the area. Bad weather in the planting or harvest seasons may delay or complicate these field operations.

TABLE 3.1 SELECTED TEMPERATURE AND PRECIPITATION DATA--THREE STATIONS IN EASTERN BEET AREA[a]

Month	Mean Temperature, °F.					
	Saginaw, Michigan (1926-55)		Sandusky, Mich. (1942-61)		Findlay, Ohio (1889-1960)	
	Monthly	Range of Means	Monthly	Range of Means	Monthly	Range of Means
December	27.2	21.2-34.0	26.9	22.5-32.6	30.1	20.5-42.0
January	23.5	15.7-34.2	23.3	16.7-30.4	28.5	12.6-38.6
February	23.7	12.4-30.0	24.4	19.0-31.3	29.1	18.5-38.6
WINTER	24.8		24.9		29.2	
March	32.3	26.2-45.1	52.9	22.4-46.1	37.2	24.4-49.4
April	44.8	37.9-52.6	45.6	39.8-52.3	48.2	40.8-51.6
May	56.3	50.0-62.3	55.4	50.8-60.9	59.7	52.9-69.4
SPRING	44.5		51.3		48.1	
June	66.9	62.0-71.9	66.5	61.1-71.1	70.2	63.7-77.4
July	71.8	67.4-76.1	70.3	67.4-75.6	74.2	68.0-80.4
August	69.6	65.0-75.0	69.7	66.2-74.2	72.3	66.0-78.2
SUMMER	69.4		68.8		72.2	
September	61.7	56.8-68.5	62.3	58.1-67.0	65.1	57.3-71.2
October	51.1	44.1-58.2	52.4	45.9-59.8	53.7	44.9-61.8
November	37.9	29.9-46.8	38.7	31.7-43.3	40.4	34.7-50.2
AUTUMN	50.2		51.1		53.1	
YEAR	47.3		47.4		50.7	

Excessively warm, humid weather prior to harvest has encouraged top growth at the expense of sugar storage and provided the preconditions for infestations of the fungus disease, Cercospora leaf spot.

Soils of the Study Area

Soils of Lower Michigan and Northwestern Ohio are generally formed from primary materials of glacial drifts.[1] Sugar beets have

[1] University of Wisconsin Agricultural Experiment Station, Bulletin No. 544, Soils of the North Central Region, June, 1960.

TABLE 3.1 - Continued

Month	Total Precipitation, Inches					
	Saginaw, Michigan (1926-55)		Sandusky, Michigan (1942-61)		Findlay, Ohio (1889-1960)	
	Monthly Mean	Range in Total	Monthly Mean	Range in Total	Monthly Mean	Range in Total
December	1.85	0.33-4.19	1.83	0.20-3.49	2.15	0.35-5.05
January	1.60	0.24-3.55	1.58	0.14-2.85	2.38	0.40-7.59
February	1.69	0.19-4.33	1.57	0.33-3.60	2.03	*-8.55
WINTER	5.14		4.98		6.56	
March	1.95	0.56-5.96	2.04	0.36-4.12	3.35	0.27-8.80
April	2.44	0.42-5.49	2.82	0.35-4.73	3.22	0.72-7.86
May	3.14	0.53-6.99	3.74	0.66-6.95	3.71	0.48-9.39
SPRING	7.53		8.60		10.28	
June	3.00	0.64-5.82	3.13	1.04-5.18	4.18	1.06-9.94
July	2.31	0.38-6.38	3.50	0.93-7.12	3.57	0.54-11.10
August	2.86	0.27-6.25	2.73	0.80-6.41	2.86	0.17-6.79
SUMMER	8.17		9.36		10.61	
September	2.92	0.80-8.15	2.38	0.65-4.76	2.57	0.29-11.82
October	2.49	0.17-7.78	2.46	0.37-6.84	2.74	0.46- 7.28
November	2.19	0.18-4.53	2.32	1.20-3.48	2.31	0.08- 5.67
AUTUMN	7.60		7.16		7.62	
YEAR	28.44	17.56-43.58	30.10	18.06-38.61	35.07	26.20-46.81

TABLE 3.1 Continued

Minimum Temperatures	Dates of Freezing Temperatures in Spring and Fall											
	Saginaw				Sandusky				Findlay			
	Last in Spr.		First in Fall		Last in Spr.		First in Fall		Last in Spr.		First in Fall	
	Aver.	Latest	Aver.	Earliest	Aver.	Latest	Aver.	Earliest	Aver.	Latest	Aver.	Earliest
32° or lower	5/5	5/28	10/11	9/12	5/17	6/4	10/6	9/17	5/3	b/	10/11	b/
28° or lower	4/23	5/13	10/28	9/29	5/2	5/22	10/21	9/26	b/	b/	b/	b/
	...	...	...	...	...	...	...	...	...	...	...	...
Frost-free days Average	158				141				160			

*Trace

a/Source: For Michigan: Michigan Weather Service and U.S. Weather Bureau, Cooperating, Climate of Michigan, by Stations, East Lansing, 1963. For Ohio: personal communication, L. T. Pierce, State Climatologist for Ohio, June 13, 1963.

b/Not available.

proven to be especially well adapted to certain of the Humic-Gley soils. This group of soils was formed on glacial material in the more humid areas of the North Central region on sites that were poorly drained but not wet enough for the formation of organic soils. These soils were deposited on what were then lake beds during the glacial periods. The Humic-Gley soils tend to be level, fertile, well supplied with organic matter, but rather poorly drained. With the application of practices directed toward maintenance of adequate drainage and tilth, they are among the most productive of soils. In the North Central region, large bodies of such soils are found in Eastern North Dakota, Western Minnesota, along the Southeastern portion of the Lower Peninsula of Michigan, and in the Northwest portion of Ohio.[1]

The Department of Soil Science, Michigan State University, has classified Michigan soils into a number of "Soil Management Groups," based on the properties of surface texture, slope and degree of erosion or stoniness of the soil profile to the depth of 3 to 5 feet. Soil management groups are identified by number denoting texture (ranging from 0 for clay to 5 for sands) and the letter, a, b, c, denoting good, imperfect, or poor natural drainage.[2] Expected yields of sugar beets and competing crops on selected soil management groups are shown in Table 3.2. It must be emphasized that these yield estimates refer to improved practices (including tile drainage) by a grower who has the necessary equipment and experience and under "average" weather conditions. No irrigation is assumed.

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[1] Ibid., p. 32.

[2] Cooperative Extension Service, Michigan State University, Fertilizer Recommendations for Michigan Crops, Extension Bulletin E-159, April, 1963.

TABLE 3.2. EXPECTED AVERAGE YIELDS PER ACRE, SUGAR BEETS AND COMPETING CROPS UNDER IMPROVED PRACTICES ON SELECTED SOIL MANAGEMENT GROUPS[a/],[b/]

Soil Management Groups	Crops						
	Sugar Beets	Dry Beans	Corn	Wheat	Oats	Alfalfa	Soybeans
	tons	bu.	bu.	bu.	bu.	tons	bu.
2c (Poorly drained clay loam and loams)	20	30	100	45	80	4.5	35
2a, 2b (Loams or clay loams, well or imperfectly drained)	15	28	90	40	70	3.8	30
1a, b, c (Clays and silty clays)	14	23	80	35	65	3.5	25
3c, 3/2c (Sandy loams, poorly drained or overlaying poorly drained clay loams)	16	24	80	35	65	3.5	25

[a/] Source: Michigan State University, Cooperative Extension Service, Extension Bulletin E-159, Fertilizer Recommendations for Michigan Crops, April, 1963.

[b/] Assistance and advice of L. S. Robertson, Extension Soil Scientist, Michigan State University, is acknowledged. Estimates are based on the Soil Science Department's experience with test plots on various soil management groups. Yield estimates assume recommended tillage, fertilizer, drainage and other practices by experienced manager. No irrigation is assumed.

As would be expected, most sugar beets are grown on the 2c soils. The reader is urged to note the difference in expected yields of sugar beets on 2c and other soils in comparison with such differences in yields of other crops in Table 3.2.

Technological Advances in Sugar Beet Production

A considerable amount of published work on sugar beet production practices is now available.[1] However, in order to set the stage for the specification of the predicted production relationships, we shall review in detail the more important aspects of technological advance, both accomplished and projected.

Soil management.--The size and shape of the beet can be adversely affected by improper drainage. Tile drain lines at 4 to 6 rod intervals in the heavy clay loams common in the Eastern Region are very effective in reducing damage from excess moisture, as well as favorably influencing the timeliness which certain field operations may be performed. The analysis of Cook, et. al.,[2] in Michigan indicates that the average yield of sugar beets on tiled land exceeded that from untiled land by 3.4 tons per acre over the three seasons, 1958, 1959 and 1960. This amounts to an additional return in excess of $40 per acre per year. The proportion of beets grown on untiled land in the region will probably be well below 10 percent in the current (1963) season.

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[1]See for example U.S. Dept. of Agriculture, Farmer's Bulletin No. 2060, Sugar Beet Culture in the North Central States, Washington, D.C., Gov't. Printing Office, 1954, and Cook, R. L., J. F. Davis, and M. C. Frakes, 1958-1960 Production Practices of Michigan Sugar Beet Farmers, Michigan Agr. Exp. Station Quarterly Bulletin Art. 44-38, Feb. 1962.

[2]Cook, R. L., et. al., 1958-60 Production Practices of Michigan Sugar Beet Growers, op. cit., Table 3.

Tillage.--"Minimum tillage" as developed by Michigan State University's soil scientists has had the happy result of increasing yields while reducing the number of field operations, thus reducing costs. Yield of sugar beets was shown to decline sharply as number of tillage operations (after plowing) exceeded two.[1]

Fertilizer.--Relatively large quantities of fertilizer are applied to the sugar beet crop. Typical recommended application rates might be in the range of 600 to 800 pounds of 5-20-10 analysis fertilizer per acre, plus additional nitrogen side dressings in amounts depending upon previous crop history and manuring applications.

It has been shown that a high rate of application in nitrogen fertilizer can have detrimental effects on sugar content and purity of the sugar beet.[2] The problem is complicated by an apparent effect of the level of soil moisture upon the relationship. A preliminary hypothesis by Snyder[3] suggests that relatively warm and rainy late season weather combined with current levels of nitrogen application (at a rate of 100 to 120 pounds per acre) serves as an explanation for low sugar contents in the 1959 and 1961 seasons in the Eastern area. Relatively lighter rainfalls and cooler temperatures in 1960 and 1962 were associated with more "normal" sugar contents in the beet deliveries those years, which suggests that recommended levels of nitrogen

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[1]*Ibid*., Table 8.

[2]See for example, Haddock, J. L., *et. al*., "The Influence of Cultural Practices on the Quality of Sugar Beets," *Journal of the American Society of Sugar Beet Technologists*, Vol. X, No. 4, Jan. 1959.

[3]Snyder, F. N., "The Influence of Nitrogen Fertilization on Yield and Sucrose," American Society of Sugar Beet Technologists, *Proceedings of the Twelfth Eastern Regional Meetings*, 1963 (forthcoming).

application should be tempered by possible large adverse effects of atypical weather conditions.

Stand establishment.--The seed of the sugar beet is characteristically a "multigerm" form; that is, each seed ball contains several viable germs. When such a seed germinates, several seedlings sprout from each seed ball. Experience over the years has shown that the beets should be spaced approximately a foot apart in the row. Therefore, hand field operations were required to bring the resulting groups of seedlings to appropriate stands. These operations are and were started when the beets were about 4 weeks old. The first step was "blocking" which was the removal of soil and beets from the row with a hoe, leaving beet-containing blocks at the desired interval. Then the weeds and excessive beets from this block were removed by hand and hoe, which was called "thinning" or "singling." Such operations required as much as 34 man hours per acre, in the 1946 study by Johnson and Wright.[1]

Experimental work has been done on a number of methods to reduce the heavy work load for thinning. The first approaches were aimed at mechanical modification of the seed ball to reduce the number of germs per segment of the plant. The resulting "segmented" seed was a major advance as the improved stand often permitted the worker to operate with a long handled hoe in an erect position rather than on his hands and knees. Another approach was that of genetically modifying the seed so that it would have the one germ. This was made possible by a discovery of plants with true "monogerm" characteristics in 1948. The

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[1]Johnson, C. E., and Wright, K. T., Reducing Sugar Beet Costs, Michigan Circular Bulletin 215, Michigan Agricultural Experiment Station, East Lansing, Michigan, 1949.

original stock lacked many of the necessary qualities of yield, sucrose content, and disease resistance, so a decade of laboratory and greenhouse development was required before the first commercial scale plantings of a satisfactory monogerm variety were made.

The successful modification of the beet seed has not resulted in the complete elimination of hand labor as had been hoped. Uncertainties from weather and low germination rates require the planting of several times the actual number of seeds that are needed in order to be assured of a uniform stand. The hand blocking and thinning operations are thus simplified but not yet completely eliminated. Table 3.3 illustrates the trend in efficiency of labor utilization.

TABLE 3.3. ACRESBLOCKED AND THINNED PER WORKER PER SEASON: FOUR MICHIGAN FACTORY DISTRICTS, 1955-62*

Year	Acres per Worker
1955	8.9
1956	8.7
1957	9.6
1958	10.4
1959	12.5
1960	12.7
1961	14.3
1962	16.5

*Data courtesy of Michigan Sugar Company, Saginaw, Michigan. Refers to foreign national adult males only.

Mechanical methods have been sought to perform these operations, and many successful field trials have been completed. However, from a farmer's viewpoint, the economics of these operations are not clear-cut, for inaccurate machine settings can result in thinning of the stand to a point which reduces yields below those achieved from hand methods. In such event, the reduced labor costs generated by the mechanical methods are quickly absorbed by reduced income.[1]

Farmers have been reluctant to adopt mechanical thinning practices in the Eastern Region. In the field survey conducted for the present study, only an insignificant minority reported any such operation in the 1960 season.

The most recent approaches to the problem of establishing an optimum stand have been in the direction of improvement in planting techniques and in germination. Frakes, et. al.,[2] present results of 1960 studies in Michigan which indicate that yield and sucrose content are not significantly different for beet spacings ranging from 50-150 beets per 100 feet of row. Precision planting of the monogerm seed at 80 inch intervals would result in a satisfactory stand for germination rates even below 50 percent. Precision planting equipment has been developed which can accurately space seeds and leave the seed in an environment most conducive to germination.[3]

Weed control.--Weeds compete with beets for soil nutrients,

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[1]See the results reported in Davis, I. F., and Metzler, W. H., Sugar Beet Labor in Northern Colorado, Colorado State Univ. Expt. Station, Tech. Bull. 63, Fort Collins, 1958, Table 29.

[2]Frakes, et. al., How to Grow Sugar Beets With No Labor, Eastern United States and Canada Regional Meetings, American Society of Sugar Beet Technologists, Proceedings, East Lansing, 1961.

[3]Barmington, R. B., "What's Happening to Beet Drills," Through the Leaves, Vol. L, No. 1, 1961, Great Western Sugar Company, Denver, Colorado.

moisture and sunshine as well as interfering in field operations. Weeds growing between the rows are controlled by the conventional cultivating techniques. Weeds within the row have been a more challenging problem. They have been dealt with by hand labor, first during the thinning operation, then in one, two or three hoeings subsequent to this. Experimental work in both chemical and mechanical procedures have developed a number of increasingly successful methods.[1]

One long-time sugar beet researcher has stated, "What we must do is to make the sugar beet as easy to grow as any field crop; that is, we want to change the sugar beet from a vegetable crop to a field crop." Some researchers in the agronomy of the sugar beet are predicting that the development of precision planting techniques and improved germination which permit the beet crop to be planted to a stand, when combined with in-the-row weed control methods, have eventual promise of eliminating the hand labor traditionally required in the sugar beet field.

Harvesting.--As noted earlier, the sugar beet delivered to the factory should have its leaves and crown cleanly removed, be free of dirt, stones and weeds. The crown is both relatively low in sugar and high in non-sugars; hence, improper or incomplete removal of crowns will adversely affect the rate of sugar per ton of beets which can be removed in subsequent factory operations. The "topping" of the beet previously was done by hand laborers who followed the "beet lifter" (which loosened the beets in the ground) and pulled the plant, sliced off the crown and tops with a knife, and piled the beets for later

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[1]Anderson, R. N., "Progress and Problems in Sugar Beet Weed Control," Crystallized Facts About Sugar, American Crystal Sugar Company, Vol. XVI, No. 1, 1962, Denver, Colorado.

loading into trucks or wagons. The 1946 study in Michigan by Johnson and Wright reported that the hand operations required 28 man hours per acre (or about 2.8 hours per ton) for pulling and topping and 4.0 man hours per acre (or about .5 man hours per ton) for loading.[1] These operations are now all performed by machines. Under normal conditions one man with a one-row harvester can perform the operations to place the topped beets into trucks at a rate of up to 8 to 10 tons per hour.

These advances have not been entirely unmixed blessings, as machine topping, when not properly applied, can leave more tops and crowns and dirt in the delivered loads than did the hand operation. Sugar content and purity in the beets that are sliced are thereby reduced, and heavy tares are charged against the delivered loads.

Other technological changes.--Disease control has often been a major problem with sugar beet crops. One of the most expensive diseases in the Eastern Region is "damping-off," or "black root" in seedlings. This is a fungus infection of the root commonly associated with cold, damp weather at the time the seeds germinate. U.S.D.A. plant breeders in Beltsville, Maryland, and East Lansing, Michigan, are reporting promising results in breeding resistance to black root into commercial varieties. Also a problem, particularly in Ohio in recent years, is Cercospora leaf spot, a fungus disease of the beet which thrives in warm, humid weather. Control has been accomplished largely by breeding resistance into varieties, but significant increases in both yield and sucrose content were obtained with spray applications of oil-fungicide mixtures in 1961 and 1962 crop seasons in Ohio.

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[1] Johnson and Wright, Reducing Sugar Beet Costs, op. cit.

Breeding for higher yields.--Research efforts are being directed toward increasing yields by hybridization. Indications are that both yield and sucrose content are improved in hybrid varieties. For example, 1962 tests at East Lansing showed yields of up to 25 tons per acre and sucrose contents exceeding 17 percent. Plant breeders are confidently predicting that yield increases on the order of 10 to 15 percent over present commercial varieties will be achieved with the new hybrids. Programs are underway to develop parental lines with the necessary disease resistance and quality for hybrid seed production.

Another promising approach in search for high yielding varieties is a relatively new technique of polyploidy, which refers to the increase (usually doubling) of the number of chromosomes in the plant by application of certain chemicals. The resulting tetraploid plants are sometimes back-crossed with the usual diploid varieties, resulting in a triploid. The new varieties developed in these methods appear to have considerable promise.

Some Michigan growers have reported striking yield results when four rows of beets are alternated with four rows of navy beans. Research is being conducted on this development to determine the best row widths, spacings and fertilizer applications.

Maturity dates.--Recent research by plant breeders has suggested that sugar beet strains can be bred which will produce satisfactory yields of roots and percentage of sucrose and purity as compared with present commercial varieties even when harvested as much as 4 weeks earlier. The successful conclusion of such a research program would add materially to the length of the harvest season and the processing campaign, thereby greatly increasing the efficiency of utilization of capital equipment of both grower and processor. (The difficulty of storing harvested beets in the periods of warm weather in September and early October in the Eastern Region would limit the acreages where this innovation would be effective to that which could be processed during that period.)

C. Resource Organization and Supplies

Field Survey - Procedures and Findings

A field survey of sugar beet growers in Michigan and Ohio was conducted in the latter part of 1961. Seventy-five Michigan growers who delivered beets to Michigan factories and three Michigan growers and 13 Ohio growers who delivered to Ohio factories were interviewed. The objective of the survey was to provide estimates relating to resource levels and organization and production practices on sugar beet farms.

Sampling procedures.--For the Michigan factory districts, the survey was coordinated with one of those conducted for a study of feed grain-livestock complex in that area.[1] The population surveyed included all farms located on certain specified soil associations in the Saginaw Valley and Thumb region of Michigan, whose gross farm sales exceeded $2,500, but excluding specialty farms such as poultry, fruit and truck farms. (These excluded types are seldom found in conjunction with sugar beet growing, so this distinction proved to be of negligible consequence.) The soil associations chosen were on the lake bed soils adjacent to Lake Huron and nearly coincides with the present boundaries of the beet

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[1]The results of that study are reported in Lard, Curtis F., Profitable Reorganization of Representative Farms in Lower Michigan and Northeastern Indiana With Special Emphasis on Feed Grain and Livestock, unpublished Ph.D. thesis, Dept. of Ag. Econ., Mich. State Univ., 1963.

growing area. The survey procedure was an area-segment type. A list of 76 townships meeting the soil and location criteria was made. Within each township, two segments of two (contiguous) square miles were to be drawn at random, and all farms meeting the population specifications therein enumerated. It was determined from census data that approximately eight townships would be required to meet the quotas of the survey. This number was insufficient to insure an adequate geographic dispersal by random drawing. Hence, the townships were ordered geographically and every ninth one selected (using a random drawing to select the starting point).

It was anticipated that the number of sugar beet growers would be insufficient to meet the pre-established quota of 75 in this initial sample. Hence, a procedure was devised to fill this quota while maintaining the property of statistical independence among observations. The procedure proved necessary as the initial area-segment survey encountered but 42 operators who grew sugar beets in 1960. The additional sampling proceeded as follows: a list of farmers who were sugar beet growers for the 1960 crop year was obtained from the Michigan office of the Agricultural Stabilization and Conservation Service.[1] A list of growers comprising every twentieth grower on the ASCS roster was obtained. Addresses of these growers were found and the list was ordered geographically. Using a random starting point, the growers were then contacted in this order until the quota was filled. In Ohio factory districts the procedure followed was identical to that used to fill the Michigan

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[1]The assistance of Edward Lunde and his staff is acknowledged.

quota except that the sugar companies provided the list of growers.[1]

Quotas by size.--In order to obtain a sufficiently large sample for each size group in the Michigan districts, a quota system for each such group was instituted. Sampling was random with the size of farm variable during the first portion of the survey. From these first 42 schedules it was estimated that the distribution of farms in the population under study by size was as follows:

Small (120 acres or less)	38 percent
Medium (121-180 acres)	36 percent
Large (181 or more acres)	26 percent

The quota for each size group was set at 25. However, an error was made in keeping the survey records so that when the final numbers of farms were tabulated, the precise quotas of 25 observations in each size category were not met. No attempt was made to sample by size in the Ohio districts.

Questionnaire and Interviewing Procedure

The survey questionnaire was quite extensive, so it will not be reproduced here.[2] It included questions of the following general types:

(a) resources--detailed answers regarding quantity and quality of physical and financial resources were obtained, including quantity and value of land, machinery and equipment, buildings and livestock,

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[1]Northern Ohio Sugar Company, Fremont and Findlay, Ohio, and Buckeye Sugars, Inc., Ottowa, Ohio.

[2]See Lard, Curtis F., op. cit., Appendix C, for a sample questionnaire.

livestock facilities, liquid capital in the form of cash or crop inventories, net worth, and operator, family and hired labor.

(b) production practices and input-output relationships--these questions dealt with the amounts of inputs, such as fertilizers and sprays, technology of input combination, such as loose housing-parlor or stanchion type dairy operations, and certain production measurements per unit of input, such as crop yield per acre, rate of gain, and milk production per cow.

(c) resource demand and supply relations--other questions were devoted to obtaining estimates relating to supplies and prices of inputs when such information would not be generally available elsewhere. Examples of such resources are credit from noninstitutional sources (such as family or neighbors) and land available for sale or for rent in the farmer's immediate neighborhood. Some questions were also related to the off-farm job opportunities for operator and family labor and of the potential supply of such labor to the nonfarm economy.

Interviewing.--The interviews for the Michigan factory districts were conducted in the summer of 1961. In order to have a complete crop year's data, the production figures obtained pertain to the 1960 crop year, and resource inventories were as of December 31, 1960. The Ohio area was surveyed in November 1961. Data taken were thus for the 1961 crop year and resource inventories as of the date of the survey.

Survey Results

The enumerated farms were classified into three size categories and three type categories. The type-of-farm classification was based on the "major enterprise" as measured by comparison of gross sales. The major enterprise types encountered were dairy, livestock (hogs and/or beef cattle) and field crops. The three sizes of farms were (1) 120 acres or less, (2) 121 to 180 acres, and (3) 181 or more acres, which will be termed "small," "medium," and "large" for convenience. The distribution of farms and resulting classification is presented in Table 3.4. In both areas, sugar beet farmers were mostly in the field crop category--85 percent in Michigan and 68 percent in Ohio. The balance, however, have a tendency to be livestock farmers in Ohio and to be dairy farmers in Michigan. The most striking difference between the areas seems to be the acres of land operated in the farm units. Nearly 90 percent of the Ohio farms fall into the "large" classification of over 180 acres, as compared to 26 percent reported for the Michigan sample. Important differences were also noted in the cropping programs and enterprise organization in the two areas. As illustrated in Table 3.5, in the Michigan districts the major competing crop is seen to be dry edible beans (usually the small white or pea bean). Farming in the Ohio districts might be typified as "Corn Belt" in variety. All farms reported corn and soybeans, and many had some sort of hog or beef production enterprise.

TABLE 3.4. CLASSIFICATION OF SURVEY FARMS BY SIZE AND TYPE

	Field Crop	Dairy	Livestock	Total*
		Michigan Area		
Small (120 acres or less)	24	4	1	29
Medium (121-180 acres)	21	1	0	22
Large (181 acres or more)	19	2	3	24
Total	64	7	4	75
		Ohio Area		
Small (120 acres or less)	0	0	0	0
Medium (121-180 acres)	2	0	0	2
Large (181 acres or more)	9	1	4	14
Total	11	1	4	16

*Note that the size distribution given here is non-random, due to the sampling quotas used for farm size. Errors in field survey records resulted in the size groups failing to meet the quotas of 25 in each group. See text for discussion.

TABLE 3.5. LAND USE ON SURVEYED FARMS: AVERAGE ACRES PER FARM BY CROPS

Classification	Crop-land Owned	Crop-land Rented	Total Crop-land	Sugar Beets	Corn	Edible Dry Beans	Soy-beans	Wheat	Other Small Grains	Specialty Field Crop[c]	Hay & Pas-ture	Idle
	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres
MICHIGAN DISTRICTS - 1960 CROP YEAR												
Small Field Crop (24 farms)[a]	61	14	75	14 (24)	5 (17)	33 (23)	d/ (1)	13 (22)	5 (16)	2 (3)	4 (6)	0 (0)
Medium Field Crop (21 farms)	100	40	140	23 (21)	10 (13)	64 (21)	0 (0)	21 (20)	10 (17)	3 (4)	6 (8)	2 (4)
Large Field Crop (19 farms)	146	100	246	42 (19)	28 (13)	88 (18)	0	35 (19)	14 (15)	12 (6)	22 (10)	5 (5)
All Field Crop (63 farms)	99	48	147	26 (63)	13 (43)	59 (62)	d/ (1)	22 (61)	9 (48)	5 (13)	10 (24)	2 (9)
All Farms (75 farms)	110	44	154	25 (75)	16 (49)	55 (69)	d/ (1)	22 (70)	10 (59)	5 (14)	18 (34)	4 (9)
OHIO DISTRICTS - 1961 CROP YEAR												
All Ohio Farms (16 farms)	91	185	276	35 (16)	58 (16)	0	66 (16)	39 (16)	14 (15)	8 (4)	20 (14)	23[b] (10)

a/ Numbers in parentheses refer to number of surveyed farms in that classification reporting any acreage of the enterprise.

b/ Includes land retired by 1961 Feed Grain Program.

c/ Includes corn, beans, peas and tomatoes for processing, crops grown for certified seed and potatoes.

d/ Less than 0.5.

Four "typical farm situations" were selected for further analysis on the basis of the distributions reported in the survey. For the Michigan districts, dairy and livestock farms did not represent a sufficient proportion of the population to warrant further analysis. Hence, the three sizes of "Field Crop" farms were designated as representative of the Michigan districts. All the useable interviews for the Ohio districts were grouped to form a representative farm situation.

The representative farm situations were defined in terms of the mean resource endowments of each category, as shown in Table 3.6.

Resource Supplies

Land.--New technologies and more intensive resource use will no doubt continue to aid the trend toward larger yields per acre of beets. However, the most important potential source of increased output of sugar beets in the Eastern Region is from the additional commitment of land. Additional land resources which are well adapted for sugar beets can come from two sources, given the number of farms. The proportion of a given farm's cropland devoted to sugar beets may increase, or the proportion of farmers growing beets can increase. The results of the field survey indicate that the proportion of cropland on sugar beet farms actually devoted to sugar beets was 16.2 percent (about one sixth) in the Michigan districts and 12.5 percent (about one eighth) in Ohio. The proportion of farms located on the appropriate soils is a little more difficult to ascertain. The estimates from field survey work done by Ohio State University[1] and from the 1959 Census of Agriculture indicate

[1]From field survey data provided by Dr. Francis Walker, Department of Agricultural Economics, Ohio State University, personal communication, October 30, 1962.

TABLE 3.6. RESOURCES ON REPRESENTATIVE FARM SITUATIONS

	Units	Michigan Districts			Ohio Districts
		Small Field Crop (24 farms)	Medium Field Crop (21 farms)	Large Field Crop (19 farms)	All Ohio Farms
Land:					
Total land operated	Acres	86	155	271	295
Cropland operated	"	75	140	246	276
Cropland owned	"	61	100	146	91
Cropland rented	"	14	40	100	185
Labor:					
Operator labor	Man equiv.	1.00	1.03	1.40	1.08
Family labor	"	.30	.32	.48	.24
Age of operator	Years	46	46	42	42
Education of oper.	"	7.5	8.7	9.3	10.9
Crop Machinery:					
Tractors owned--(2 & 3 plow)	Number	1.80	1.95	2.00	1.55
Tractors owned--(4 & 5 plow)	"	.38	0.48	1.47	1.18
Sugar beet harvester--(one row)	"	.13	0.42	0.75	.25
Sugar beet harvester--(two row)	"	.09	0.05	0.15	.06
Trucks (1.5 tons or larger)	"	.55	.96	1.50	.88
Livestock & Equipment:					
Dairy cows	Head (cow)	1	1	6	2
Milking capacity	"	2	2	8	2
Farrowing capacity	Head (sow)	3	3	2	3
Hog feeding capacity	Head (feed. pigs)	15	18	20	33
Beef steer feed.cap.	An. units	5	12	17	37
Silo capacity	Tons	7	32	50	73
Financial:					
Real estate assets	$1,000	46.7	51.1	78.7	50.8
Chattel assets (mach. & livestock)	"	7.2	7.7	17.7	14.2
Liquid assets	"	3.2	5.4	10.6	13.2
Total assets	"	57.1	64.2	107.0	78.2
Liabilities, real est.	"	4.0	5.9	13.1	2.5
Liabilities, mach. & livestock	"	0.5	0.5	1.7	1.9
Liabilities, other	"	0.1	0.3	0.8	2.5
Total liabilities	"	4.6	6.7	15.5	6.9
Net worth	"	52.5	57.5	91.5	71.3

that less than 5 percent of the farms in sugar beet producing counties in Northwest Ohio are sugar beet growers. It appears that there are ample adapted soil resources in the Ohio districts, and expansion in this area is but an economic matter of bidding this land away from alternative uses.

In the Michigan districts, the field survey of the Saginaw Valley-Thumb cash-cropping region by Lard encountered 42 farms (out of 100 farmers interviewed) who were beet growers.[1] The 1959 Census of Agriculture reported 2,425 beet farmers out of 7,610 Class I through Class V farms (or 32 percent) in the four main Michigan sugar beet producing counties (Bay, Saginaw, Tuscola, Huron). This is regarded as being consistent with the survey estimate of 40 percent of farmers on the better quality lake bed soils being beet farmers, since there are large areas in each of these counties which are on the lighter textured, sandy soils.

In terms only of this rough physical inventory of adapted soils, there is no reason why substantially more acreages of beets could not be grown in either the Michigan or Ohio districts. Later analysis will show that other factors in addition to soil resources are important in the choice of whether or not sugar beets are included in the crop rotation.

Labor.--The relatively heavy labor requirements and their seasonal distribution continue to be ranked among the major problems in the sugar beet industry. With the harvest period effectively mechanized, the main

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[1]Lard, C. F., op. cit.

focus of attention is on the spring labor requirements for stand reduction and weed control. These operations, particularly thinning, must be performed within a relatively short period for maximum effectiveness. The thinning operation usually begins some 4 weeks after planting, in middle or late May, and the weed hoeing extends into July. This period is one of heavy labor demands on the operator's time and management capacity from other enterprises. Planting and weed control operations must be carried out in the corn, soybean and dry bean crops. Furthermore, the man hours required to cover an acre are quite large. Even the "hoe trimming" operation, which is replacing "blocking and thinning" in fields planted with monogerm seed, requires up to 11 hours, and the hoeings require some 5 hours per acre. Even though this is a major improvement from the 30 or more hours reported by Johnson and Wright,[1] when the present-day larger acreages are involved it is still more labor than most families have available.

The heavy seasonal requirements have been met by the importation of migrant field workers. These workers are mostly domestic in origin, although in previous years there have been some Mexican National workers imported.

The beet sugar companies usually undertake the responsibility for recruitment and allocation of the workers. Some of the expenses, such as housing, are charged to the grower, but the company typically bears the cost of recruitment and much of the cost of transportation of the migrants (usually from Texas). Thus, the processor, too, has a real interest in the reduction of spring labor requirements.

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[1]Johnson and Wright, Reducing Sugar Beet Costs, op. cit., p. 16.

The introduction and adoption of monogerm seed and the other techniques discussed earlier in this chapter have had a marked effect upon the demand for labor. One measure of these effects is the "acres blocked and thinned per worker" presented in Table 3.3. Most of the benefits of this increased efficiency have been conferred on the worker through increased wage rates. It has been the policy of at least one company not to change the contract rate per acre in their district. The workers absorb all benefits in this case. The minimum wage rates for field workers specified by the Department of Agriculture for 1963 under the Sugar Act provisions are $1.05 per hour, up from $0.95 in 1962.[1]

There have been some indications at this writing (June, 1963) that the agreement with Mexico regarding the importation of field workers from that country might be discontinued. In such event, the effects on supply and cost of migrant field labor for Eastern beet growers are difficult to assess. There will be no direct effect, since the Mexican National workers are not now important (none in Michigan beet fields in 1963). However, the removal of this source of supply of labor may have some influence on the availability of and wage rate for the remaining pool of domestic migrant workers.

Capital and credit.--The net worth of sugar beet growers reported in Table 3.6 indicates that the typical farm situation does not suffer from a shortage of capital. Most of the capital is tied up in real

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[1] Sugar Determination 862.3, reprinted from Federal Register of April 24, 1963. For a more general discussion of farm labor, see Elterich, J., et. al., Perspective on Michigan's Farm Labor Problems, Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, 1963.

estate. The typical farmer had very small liabilities in proportion to his assets. Lending agencies are willing to provide much more credit than the farmer appears to wish to obtain. In addition, the processing companies typically provide both credit (as well as a number of other services) to growers under contract. The grower can have a number of his operations such as thinning and hoeing labor and contract harvesting and hauling paid for and charged against the crop. The amounts plus interest are deducted from the first crop payment.

The results of fitting Cobb-Douglas equations to income and expense data for sugar beet growers suggest that the average grower could well afford to transfer capital from real estate into cash expenditures. Lard reports that Michigan cash crop (including sugar beet) growers earned an average of $2.60 for every dollar of cash expenses in 1960.[1] This provides a return per dollar substantially above the cost of borrowing at 5.5 percent for real estate mortgage or 7 percent for chattel mortgage.

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[1]Lard, Curtis F., Michigan State University, unpublished data.

CHAPTER IV

SUGAR BEET PRODUCTION RESPONSE II - THE ANALYTICAL MODEL

A. Static Model of Production Response in Sugar Beets

The discussion of the previous chapter has covered the technical relationships of Eastern Region sugar beet production and some aspects of the present organization and supplies of resources. The former provide the basis for projecting a production relation for sugar beets. The latter allowed us to specify representative farm situations for the subsequent analysis.

In this section, the assumptions and specifications of the linear programming model will be discussed in some detail. This will entail the prediction of both resource and product prices for beets and the relevant competing crops, as well as technical production relationships for all of these. Such projections necessarily involve us in a multiplicity of hazards and possible errors. Primarily, of course, there is the problem of accurately predicting prices and production techniques for a future period. Furthermore, in order to simplify the problem to manageable proportions, we assume that one set of input-output relationships, one set of product and resource prices, and but a few sets of resource organizations will adequately portray the situation for a region. We thereby ignore a cluster of problems; in particular, intra-regional soil and climate variability, the effects of scale of operation on resource use and

costs, differences in the goals and capabilities of managers, and behavior in the face of imperfect knowledge.

However, with full recognition of these limitations of the analysis, we shall proceed, for such restrictions on realism are necessary in order to reduce the problem to a manageable scope. After the static analysis is presented, some of the more obvious limitations will be discussed.

The Linear Programming Model - Theoretical and Empirical Assumptions

Basic elements of a linear programming model.--The linear programming model may be applied to problems relating to the optimal organization of the resources of the firm operating under a free price system. In this interpretation, usually called "activity analysis," we visualize an entrepreneur who has at his disposal fixed amounts of a number of different resources. These resources can be combined to produce varied quantities of several different products. It is known how much of the i^{th} resource is required to produce a unit of the j^{th} product, and how much profit is made for each unit of each product. If such a problem can be expressed in the linear programming framework, then a solution in terms of the optimal quantities produced of each of the j products can be found which will maximize profits.

The major elements of a linear programming problem include:

(1) a linear function

$$c_1x_1 + c_2x_2 + \dots + c_nx_n$$

to be maximized subject to a set of restrictions given in (2) and (3) below. This function is called the

"objective" or "criterion" function. Coefficients of the $\underline{j}^{th}$ variable of this function in the activity analysis interpretation are "net revenues" or "net profits" to a unit of output of the $\underline{j}^{th}$ product.

(2) a set of linear equations which give the total amount of the $\underline{i}^{th}$ resource to be used

$$a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n$$

The $a_{\underline{ij}}$ are called "input-output" coefficients, since they represent the number of units of the $\underline{i}^{th}$ resource needed to product a unit of product j.

(3) the total use of the $\underline{i}^{th}$ resource must not exceed the amount available, so we have a linear inequality in the form:

$$a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{i_n}x_n \leq bi$$

The $\underline{b_i}$ represents the amount of the $\underline{i}^{th}$ resource on hand and are usually called "restrictions."

To achieve precise results from the application of linear programming, the problem under study must meet or approximate the assumptions of the mathematic model. These assumptions are as follows:[1]

1. Additivity and linearity of activities or processes.
2. Divisibility of processes and resources.
3. Limited resources.

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[1]Heady, E. O. and Candler, W., Linear Programming Methods, Iowa State Univ. Press, Ames, Iowa, 1959, p. 17.

4. Production taking place in a finite number of alternative processes.
5. Single-valued expectations (that is, resource supplies, input-output coefficients and prices are known with certainty).

In order to express a problem in the activity analysis framework, it must also be assumed that the entrepreneur maximizes a profit function which can be expressed in a linear form. None of these assumptions are precisely met in most activity analysis applications, including the present problem. Of particular concern are the assumptions of the single-valued expectations and the linearity and additivity of the activities. However, it should be noted that any alternative microeconomic approach, such as budgeting, suffers from similar difficulties and is much more limited in the range of alternatives and the degree of complexity which can be undertaken in a reasonable length of time. The adaptability of the linear programming routine to a solution on a high-speed computer greatly simplifies the search for a solution to a complex problem.

Furthermore, a model can be modified in a number of ways to more nearly approach the conditions of the particular problem under study. For example, additional activities can be added to approximate segments of a nonlinear relationship, or behavioral responses to imperfect knowledge or risk can sometimes be handled by special restrictions on resource use. Such modifications are made, however, at a definite cost in additional complexity and computing.

The model of a representative sugar beet farm constructed for this problem was rather large and complex. The final system of equations included 72 equations (resource restrictions) in 121 variables (activities). The large number of activities can be attributed mainly to certain methodological considerations. The definition of a fixed asset proposed by G. L. Johnson[1] suggests that resources are fixed endogenously at levels where the MVP of the resource falls between its acquisition and salvage prices. In order to incorporate this concept into a linear programming framework, one or more acquisition and salvage activities were incorporated into the model for each of a large number of resource categories. The methodological import of the model will be reported elsewhere. The present discussion is confined to the implications of this solution for supplies and the future competitive position of the sugar beet enterprise on the farms of the Eastern Region.

Empirical Specification of the Model

Empirical data assembled for the linear programming problem included:

(a) technical input-output coefficients

(b) net revenue coefficients for the objective function

(c) resource restrictions.

Technical input-output relationships.--Input-output coefficients were developed through a "synthetic" procedure. Survey results were combined with experience and judgment of specialists from the Departments of Farm Crops, Soil Science, Agricultural Engineering, Animal

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[1]See for example, Johnson, G. L., "Supply Functions--Some Facts and Notions," in Heady, E. O., et. al., Agricultural Adjustment Problems in a Growing Economy, Ames, Iowa, Iowa State College Press, 1958, p. 74.

Husbandry, Dairy, and Agricultural Economics of Michigan State University, as well as from representatives from the sugar industry. Judgments were obtained as to expected production techniques and levels of various inputs and outputs for the future periods under consideration. From these recommendations a "table of operations and inputs" was constructed for each crop enterprise. (These tables are included as appendix tables 3, 4, 5, 6, 7, 8 and 9 in Appendix II.) Data for livestock production and equipment and for machinery were obtained from a wide variety of published and unpublished sources.[1]

Net revenue coefficients.--The first step in this procedure was to estimate expected input and product prices. These were determined on the basis of recent past trends and relationships, taking into account Government programs where relevant. Input costs were based on 1961 data, projected on the basis of recently observed trends. (For example, fertilizer and seed prices were not assumed to change from the 1961 levels, while cost of items such as land, machinery and building materials were projected to 1966 using relevant U.S. Government or specially constructed indices.) The net revenue budgets reproduced in Table 4.1 were then derived from prices and the previously mentioned input tables.

Initial resource levels.--These were derived from the field

[1]Many of these references are listed in Hinton, R. A., Some Original Sources of Selected Budgeting Information from the North Central States, 1946-59. Research Report No. 35, Agr. Econ. Dept., Univ. of Ill., 1960, and Hinton, R. A., Improving Livestock, Labor and Capital Information for Farm Development and Management, Res. Report No. 34, Agr. Econ. Dept., Univ. of Ill., 1960.

survey data as reported earlier. Survey results and secondary data were used to specify technical and institutional restrictions on resource use. (Examples of each of the latter two types of restraints are the maximum proportions of the cropland in intertilled crops and in the amount of wheat allotment.)

Empirical Assumptions of the Model

The actual model used in the analysis will not be presented in its entirety from lack of space.[1] We will, however, discuss some of the empirical assumptions of the model and present some of the more important net revenue budgets and the input-output coefficients which were developed in the course of the analysis.

Crop Activities and Restrictions

See Tables 4.1 and 4.2 for assumptions as to inputs and costs and returns for crop enterprises. Appendix Tables 3 through 9 show the explicit technical assumptions.

General.--Maximum acreage of intertilled row crops was assumed to be 75 percent of the available cropland.

Sugar beets.--Sugar beets were projected to yield 18 tons per acre in 1966 and to return $12.85 per ton (yield net after tare; return including Government payments of $2.20 per ton). The yield assumption is a projection of the post-war trend. (Introduction of hybrid varieties on a large scale would make this projection too conservative.) Acres

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[1]For readers interested in the technical aspects of the problem, a model substantially equivalent to the one employed here and constructed cooperatively with this one is presented and described in Lard, op. cit.

TABLE 4.1. PROJECTED COSTS AND RETURNS PER ACRE TO SUGAR BEETS AND COMPETING CROPS, MICHIGAN AND OHIO DISTRICTS, 1966

Item	Michigan Districts						
	Sugar Beets	Edible Dry Beans	Corn for Grain	Corn for Silage	Oats	Wheat	Alfalfa Hay
INCOME							
Yield per acre	18T	18cwt	100bu	18T	80bu	55bu	3.0T
Price per unit $	12.85*	6.00	1.04	6.50	0.65	1.78	18.00
Gross income $	231.30	108.00	104.00	117.00	52.00	97.90	54.00
VARIABLE CASH EXPENSES	$	$	$	$	$	$	$
Seed	1.50	2.45	2.40	2.40	3.74	4.83	1.86
Fertilizer	25.20	6.30	13.65	13.65	7.82	15.45	7.02
Other materials (sprays, etc.)	7.00	1.50	1.00	1.00	0.50	----	----
Machinery (pre-harvest)	2.49	2.49	2.81	2.81	2.09	1.04	----
Machinery (harvest)	6.45	1.58	2.98	1.80	0.63	0.63	3.73
Hauling (truck or wag.)	3.80	0.37	1.17	2.95	0.71	0.53	0.37
Beet labor	13.50	----	----	----	----	----	----
Other	1.75	----	5.00	----	----	----	----
Sub-total variable cash expenses	61.69	14.69	29.01	24.61	15.69	22.58	14.03
Return over variable cash expenses	169.61	93.31	74.99	92.39	36.31	75.32	39.97
OVERHEAD COSTS							
Cash Expenses							
Machinery (dep., etc.)	31.16	12.34	10.72	12.16	9.60	7.67	16.45
Miscellaneous (phone, travel, etc.)	8.42	4.08	3.84	4.08	1.84	3.60	2.00
Real estate taxes	5.75	5.75	5.75	5.75	5.75	5.75	5.75
Sub-total cash overhead	45.33	22.17	20.31	21.89	17.19	17.02	24.20
Total cash expenses	107.02	36.86	49.32	46.50	32.88	39.60	40.65
Return over all cash expenses	124.28	71.13	54.68	70.50	19.12	58.30	15.77
CHARGES FOR LAND INVESTMENT AND OPERATOR & FAMILY LABOR							
Land charges @ 5.5%	31.63	31.63	31.63	31.63	31.63	31.63	31.63
Labor charges @ 2.00/hr.	25.50	16.00	11.30	21.20	6.80	4.80	15.70
Sub-total	57.13	47.63	42.93	52.83	38.43	35.43	37.33
TOTAL CHARGES	164.15	84.49	92.25	109.33	71.31	75.03	77.98
RETURN TO RISK AND MANAGEMENT	67.15	23.51	11.75	17.67	(-19.31)	22.87	(-23.98)

*Price for sugar beets includes government payments.

TABLE 4.1. Continued

Item	Ohio Districts (where different)				
	Corn for Grain	Corn for Silage	Oats	Soybeans	Wheat
INCOME					
Yield per acre	110 bu	19.5 T	70 bu	37 bu	45 bu
Price per unit $	1.04	6.50	0.65	2.25	1.84
Gross income $	114.40	126.75	45.50	83.25	82.80
VARIABLE CASH EXPENSES	$	$	$	$	$
Seed	2.40	2.40	3.94	3.50	4.83
Fertilizer	14.80	14.80	7.82	7.12	14.15
Other materials (sprays, etc.)	1.00	1.00	0.50	----	----
Machinery (pre-harvest)	2.81	2.81	2.09	3.35	1.79
Machinery (harvest)	3.17	1.90	0.63	1.40	0.63
Hauling (truck or wagon)	1.29	3.22	0.59	0.40	0.45
Beet labor	----	----	----	----	----
Other	5.50	----	----	----	----
Sub-total variable cash expenses	30.97	26.13	15.57	15.72	21.85
Return over variable cash expenses	83.43	100.82	29.93	67.53	60.95
OVERHEAD COSTS					
Cash Expenses					
Machinery (depreciation, etc.)	10.85	12.87	9.55	11.82	7.53
Miscellaneous (phone, travel, etc.)	3.96	4.35	1.62	2.95	2.90
Real estate taxes	4.95	4.95	4.95	4.95	4.95
Sub-total cash overhead	19.76	22.17	16.12	19.72	15.38
Total cash expenses	50.73	48.30	31.69	35.44	34.23
Return over all cash expenses	63.67	68.70	13.81	47.81	45.57
CHARGES FOR LAND INVESTMENT AND OPERATOR AND FAMILY LABOR					
Land charges (@ 5.5%)	27.28	27.28	27.28	27.28	27.28
Labor charges (@ 2.00/hr.)	11.60	22.60	6.70	9.30	4.80
Sub-total	38.88	49.88	33.98	36.58	32.08
TOTAL CHARGES	89.61	98.18	65.67	72.02	69.31
RETURN TO RISK AND MANAGEMENT	24.79	28.57	(-20.17)	11.23	13.49

TABLE 4.2. SELECTED PHYSICAL INPUTS PER ACRE; SUGAR BEETS AND COMPETING CROPS, MICHIGAN AND OHIO DISTRICTS, PROJECTION TO 1966

Item	Unit	Michigan Districts							Ohio Districts (where different)				
		Sugar Beets	Edible Dry Beans	Corn for Grain	Corn for Silage	Oats	Wheat	Alfalfa Hay	Corn for Grain	Corn for Silage	Oats	Soybeans	Wheat
Seed	lb.	1.5	35	12	12	72	105	8	12	12	72	70	105
Fertilizer N	lb.	80	10	50	50	20	60	0	66	66	20	20	50
P_2O_5	lb.	120	40	60	60	40	60	60	66	66	40	30	50
K_2O	lb.	60	20	30	30	20	30	20	33	33	20	30	25
Tractor (2 plow)	hours	2.10	2.80	2.70	2.90	1.15	1.25	4.85	2.70	3.20	1.10	2.00	1.25
Tractor (3 plow)	hours	3.30	1.30	2.95	3.10	1.60	.70	0	3.05	3.50	1.60	1.58	0.70
Operator labor equivalents	man hrs.	12.75*	8.00	5.65	10.60	3.40	2.40	7.85	5.80	11.30	3.35	4.65	2.40

*For sugar beets, labor hours excludes migrant labor hired for thinning and hoeing of beets.

in the sugar beet crop were limited to that previously contracted, which typically was about one sixth of the available cropland based on the farm survey data. It was assumed that monogerm seed would be used as well as one pre-emergent spraying for weeds. Migrant labor was assumed to be hired for one "hoe-trim" thinning and one weed hoeing. All other labor was assumed to be performed by the operator and family or by hiring of seasonal labor where necessary. Hauling costs were estimated on the basis of eight miles.

Dry edible beans.--The "pea" or "navy" bean is the most important crop competing with sugar beets in the Michigan districts in terms of both acreage and net returns. A government price support program of the loan-purchase agreement type has been in effect in recent years. The basic support rate is from $6.40 to $6.90 per cwt. for the 1963 crop. New varieties are expected to contribute to the improvement of both bean yields and quality in future years. The dry bean crop was projected to yield 18 cwt. per acre at a price of $6 per cwt. Labor requirements for hand hoeing and chopping make this crop second only to beets as a heavy user of labor, but most farms utilize only family labor for these tasks in contrast to the practices for sugar beets. The acreage restriction for dry beans in the model was 50 percent of cropland.

Soybeans.--In the Ohio districts, soybeans are in the rotation rather than dry beans, although corn is a more attractive alternative there under the projected price and yield relationships. Soybeans are restricted to 50 percent of the cropland in the model. The projections were for a 37 bushel per acre yield at a price of $2.25 per bushel.

Wheat.--Crop acreage of wheat was limited to that of the allotment level as reported in the farm field surveys. It was assumed that the type of support program in effect in 1963 would continue to be in effect during the projected period. (This assumption may prove to be erroneous.) The soft white winter wheat most commonly grown in Michigan was projected to yield 55 bushels on the sugar beet soils and return $1.78 per bushel. The soft red winter wheat of the Ohio area was projected to yield 45 bushels and return $1.84 per bushel.

Corn.--Corn acreage was restricted to 50 percent of the cropland. Yields were projected to 100 bushels in Michigan and 110 in Ohio. The continuation of an acreage diversion program of the form in operation in 1962 was assumed. However, representation of the various alternatives in the model was difficult and expensive in terms of additional equations. It was therefore assumed that the operator would not comply with this type of diversion program. Net price to the farmer for shelled corn was projected to be $1.04.

Oats.--Oats represented all small grains (oats, barley, buckwheat and rye) in the model. Acreage was restricted to 50 percent of the cropland. Price was projected to $.65 per bushel, while yields were estimated at 80 bushels for Michigan and 70 bushels per acre for the Ohio districts.

Hay and pasture.--No limit was set on acreage of rotation meadow. Such meadow is assumed to yield 3 tons of hay per acre on the basis of 3 cuttings per season. Net price for baled hay was projected to be $18 per ton.

Livestock Activities

Grade A dairy.--Production per cow for the dairy activities was projected to be 11,500 pounds (3.5 percent butterfat) of milk to sell at a price of $4.22 per hundredweight. To the total milk income of $485.30 is added $71.72 of sales of cull cows and calves for a gross income of $557.02. Cash expenses (marketing, protein supplement, veterinary, etc.) were estimated at $88.97 per cow, leaving a net return to farm produced feed, equipment, labor, management and risk of $468.05 per cow. Replacement heifers and calves were assumed to be a total of 0.90 head per mature cow. Feed inputs per cow (plus replacements) were: corn equivalents, 38 hundredweight; hay, 3.28 tons; corn silage, 5.40 tons; pasture (in hay equivalents), 2.77 tons; soybean oil meal (40 percent), 5.75 hundredweight.

Dairying was of minor importance in the representative farms, which were all of the Field Crop type. It was therefore assumed that any investment in additional dairy capacity would be in a parlor-loose housing system.

Estimates of labor use were based on work at the University of Minnesota.[1] Estimated labor requirements were 62.81 hours per cow (again including replacements) for the herringbone parlor system selected.

Provision was made for increasing the capacity of farms for dairy production by investment in additional cows, housing, milking parlor and equipment capacity.

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[1]See references in Hinton, Some Selected Sources of Budgeting Information in the North Central Region, op. cit.

Beef feeding.--A number of different techniques and methods were represented in the beef feeding activities. Two basic systems were used: 700 pound yearlings on feed for 180 days and 430 pound calves on feed for 360 days. For each basic system, alternatives using local dairy breed steers and alternatives using beef-type steers were included. For each of these classes, several types of feeding programs were considered, such as all silage for roughage; all hay for roughage; and pasture and hay or silage for roughage. Finally, an alternative utilizing mechanical feed handling with low labor requirements was available for certain of the drylot beef steer activities.

The twice-a-year system utilizing yearling steers which was selected as the most profitable alternative by the program will be described as an illustrative example. These steers were assumed to gain 2.0 pounds per day for a total of 360 pounds in the 180 days. Their ration consisted of 21.5 hundredweights of corn equivalents, 0.21 tons of hay equivalents and 160 pounds of protein supplement (40 percent). Labor requirements, on the basis of 100-head lots, were estimated at 5.3 hours per head. The steers were assumed to weigh 700 pounds and cost $23.75 per cwt. delivered to the farm. They were sold at 1,060 pounds at $23.50 per cwt. after transportation and marketing costs.

The model also included activities to represent acquisition of additional housing and feeding capacity for steers.

Hog activities.--Hog production alternatives were of three classes: confinement farrowing and feeding, confinement farrowing with portable (pasture) feeding, and portable farrowing and feeding. The

subsequent analysis showed the land to be too valuable in crops in these areas for the pasture alternative. The confinement system allowed for farrowing in each quarter of the year. It was assumed that a sow would have one litter of eight pigs. The sow, weighing 400 pounds, would then be sold some time after the pigs were weaned, with one gilt from the litter saved as a replacement. The pigs were assumed to be grown out and sold at 215 pounds 180 days after farrowing. Feed requirements for sow and litter up to the time of sale were: 61.7 hundredweight of corn equivalents and 12.3 hundredweight of soybean oil meal (40 percent). Labor requirements varied with season but averaged about 13.8 man hours per litter.

The price projection for No. 1 farrows and gilts, Michigan basis, was $13.73 per hundredweight, and the enterprise returned a net revenue of $199.45 per litter to home-produced feed, labor and capital. As with the other livestock enterprises, activities were included to represent investment in additional farrowing housing and feeding capacity.

Capital and credit activities.--Initial cash holdings were estimated from survey returns based on estimates of cash in bank plus saleable crop inventories (see Table 3.6). Activities were included so that additional financing for operations and investments could be obtained against present real estate and chattel assets, as well as from dealers for the purchase of machinery and from private sources. Interest rates were 5.5 percent on real estate mortgage credit, 7 percent on chattel credit, 12 percent on dealer credit, and 4.7 percent on credit from private sources. Credit on owned real estate was limited to 50 percent of the net value of real estate assets. Restrictions on chattel credit varied with the class of assets; machinery could be borrowed against up to 40 percent of the present value, while feeder steers could be financed up to 100 percent of value, as long as sufficient home grown feed was available. The model was designed so that borrowing against presently owned assets could be used to finance either operations or new investments in land, buildings or equipment.

Labor activities.--The model provided that the family labor force could be augmented without limit by hiring of seasonal workers in any of the six time periods. It was assumed that one hour of hired labor replaced .67 of an hour of operator labor. The cost of replacing an hour of operator labor thus came to $2.02 based on a projected wage of $1.35 per hour for local seasonal workers.

Initial restrictions on operator and family labor were based on reported availability, adjusted for age, sex and health, as determined by the survey.

Activities representing off-farm employment for the operator in each of the six time periods were also included. Net wage (after deduction of travel costs) was projected to be $1.99 per hour. Family labor could be "sold" at a net of $1.58 per hour. Restrictions on the quantities of labor sold were based on the average weeks of off-farm labor obtained in the year covered by the field survey.

Machinery acquisition.--The model provided for acquisition and disposal of machinery services for tillage, harvesting of small grains and beans, harvesting of corn and corn silage, harvesting of forage, and harvesting and hauling of sugar beets. The estimates of initial capacity for each representative farm were obtained from the average amount of various types of equipment reported in the survey.

Annual overhead cost for sugar beet harvesting equipment was projected to be $11.65 per acre. This estimate was reached by subtracting the variable cost of harvesting and a charge for labor from the projected custom rate of $20 per acre.[1] Sugar beet hauling was assumed to be on the basis of an 8 mile trip to the factory. Hauling capacity overhead cost was estimated at $15.50 per acre.

Land acquisition activities.--The linear programming model provided alternatives whereby investment capital could be diverted into purchase of land on a mortgage or under a land contract, as well as for the renting of land. In order to approximate the empirical assumption that the supply of land is not perfectly elastic, it was assumed that 40 acres could be purchased at one price and 40 more at a higher price. The prices in Michigan were estimated to be $575 and $690 per acre in the 1966 period, and the prices in Ohio were projected to be $495 and $590. The lower of these prices was reached by projecting the average of survey responses regarding value of land owned on the basis of the Department of Agriculture's index of land prices. Land could be purchased either on a mortgage basis requiring 50 percent down payment and 50 percent mortgage financing, or on a land contract basis where only a 20 percent down payment was required. A question in the field survey questionnaire provided a basis for estimating both the price and quantities of land available for sale and for

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[1]This method of estimation was used for all machinery acquisition activities in order to meet the difficulties involved in estimating investment costs for durables which are used in more than one crop, such as tractors or combine harvesters. The technique represents a "market valuation." Checking this approach against the more conventional technique of summing depreciation, taxes and insurance and dividing by acres worked per year for single-use durables (beet harvesters, corn pickers) showed that the two methods achieved very close results.

rent in the neighborhood of each responding farmer. On this basis it was estimated that each farm operator could purchase 40 acres of land at the projected price of $575. Up to half of this 40 acres could be purchased on a land contract. In addition to acquisition through purchase, it was estimated that an additional 80 acres could be acquired through rental arrangements (40 at each of the two prices). The cash rental rate was estimated on the basis of current share rental arrangements, projected prices and yields, and present distribution by acres of crops on the farm. Land rental cost was estimated at $33.50 and $39.15 for the Michigan districts and $29.40 and $35.50 for the Ohio districts.

B. Results of the Static Linear Programming Analysis

General

The method of solution of the model was in a sense determined by the particular computing facilities that were available. The computer used was the Model 1604 produced by the Control Data Corporation. At the time the computing equipment was required, the available linear programming routine was somewhat limited in capability. Its variable price feature provided solution at any specific price or net revenue combination desired. A more advanced "parametric" technique would indicate corner points or changes in the optimum solution through a specified range of prices.

Solutions were obtained for each of the four representative farm situations (see resource organization of the representative farm in Table 3.6, supra) under a number of different price combinations.

In addition to the prices shown in Table 4.1, solutions were computed for prices approximately 20 percent above and 20 percent below these projections for each of the three crops: sugar beets, beans and wheat. Solutions which were computed for one Michigan district representative farm and for the Ohio district representative farm under several of the more likely price combinations are presented in Tables 4.3, 4.4 and 4.5, respectively. The implications of these results for each enterprise are discussed below in terms of the effect of changing price relationships, changing resource base, and changing enterprise alternatives.

Michigan Districts

The results are presented only for the size farm which was termed "medium" in the Michigan district. The model was solved under two situations. "Case I" will be applied to the situation where livestock alternatives were not considered (which corresponds roughly to the present organization in these strata) and "Case II" to the situation where beef, hog and dairy enterprises were also allowed as alternatives. From the results of the analysis, it will also be possible to show what the effect of a different resource base might be on the optimal solution.

The results for Case I (no livestock) are presented in Table 4.3. (Not all the 27 price combinations which were computed are displayed in these tables. Those combinations chosen for display are the ones judged most significant in their implications or those most likely to occur.)

In Case I, where there was no livestock alternative, there was no effect on proportion of cropland in sugar beets under any price of

TABLE 4.3. PROJECTED OPTIMAL RESOURCE ORGANIZATION AND INVESTMENTS--MEDIUM FIELD CROP FARM <u>WITHOUT</u> LIVESTOCK, SAGINAW VALLEY--"THUMB," MICHIGAN, 1966 (CASE I)

	Unit					
Price Combination No.		(1)	(2)	(3)	(4)	(5)
Price of Sugar Beets	$ per ton	12.85	12.85	12.85	12.85	10.60
Price of Dry Beans	$ per cwt.	7.20	7.20	6.00	6.00	7.20
Price of Corn	$ per bu.	1.24	1.04	1.24	1.04	1.24
ENTERPRISE ORGANIZATION						
Sugar Beets	Acre	34	34	34	32	34
Edible Dry Beans	Acre	145	145	63	134	145
Corn	Acre	37	37	119	35	37
Wheat	Acre	43	43	43	40	43
Oats	Acre	27	27	27	26	27
Rotation Meadow	Acre	0	0	0	0	0
RESOURCES ACQUIRED						
Seasonal Labor	Man hours	590	590	360	409	590
Land-purchase	Acre	80	80	80	61	80
Land-rental	Acre	80	80	80	80	80
CREDIT						
Real Estate Mortgage Borrowed	$1,000	34.7	34.7	34.4	38.4	34.7
Chattel Mortgage Borrowed	$1,000	3.4	3.4	3.4	0	3.4
All Other Credit Borrowed	$1,000	22.6	22.6	22.6	2.4	22.6
OFF-FARM EMPLOYMENT	Hours	594	594	594	594	594

beets from $10.60 to $15.10 per ton. This was true even when the price of either dry beans or corn, or both, were at levels 20 percent above that judged most likely to occur, and when the farm did not own the specialized beet equipment. The organization represented by price combination (4) in Table 4.3, which are the "most likely" prices, appears to closely approximate the present organization as determined by the survey data (see Table 3.5).

The main differences from present organization of the optimum solution presented in Table 4.3 are the additional acres acquired by renting and through purchase. In this case, the capital resources on the present farms are extensive enough to support an operation of over twice the present size, under the assumption that up to 50 percent of real estate assets may be mortgaged. Off-farm work was utilized to the limit allowed, since there were no livestock enterprises to compete in the winter months. Labor is hired in the summer season to meet the demands of the extra cropland.

Case II.--(Livestock activities included.) In this model, the beef feeding, hog and dairy enterprises were included. The results for five price combinations are presented in Table 4.4.

Crop enterprises.--As in Case I, when sugar beets are priced at the expected level of $12.85 per ton, there is no change in the proportion of crop acreage grown in beets. (The differences in acreages between Cases I and II are due to the different quantities of land acquired under the various price combinations.) However, when sugar beet prices are lowered to $10.60 per ton and bean and corn prices are favorable, the most profitable combination of enterprises does not include sugar beets. This change from the previous case is a consequence

TABLE 4.4. PROJECTED OPTIMAL RESOURCE ORGANIZATION AND INVESTMENTS--MEDIUM FIELD CROP FARM WITH LIVESTOCK, SAGINAW VALLEY-"THUMB," MICHIGAN, 1966 (CASE II)

	Unit					
Price Combination No.		(1)	(2)	(3)	(4)	(5)
Price of Sugar Beets	$ per ton	12.85	12.85	12.85	12.85	10.60
Price of Dry Beans	$ per cwt.	7.20	7.20	6.00	6.00	7.20
Price of Corn	$ per bu.	1.24	1.04	1.24	1.04	1.24
ENTERPRISE ORGANIZATION						
Cropping Program						
Sugar beets	Acre	33	31	30	30	0
Edible dry beans	Acre	143	128	30	30	139
Corn	Acre	39	33	121	119	69
Wheat	Acre	43	38	36	36	41
Oats	Acre	29	9	5	0	28
Rotation meadow	Acre	0	17	19	24	0
Livestock Program						
Grade A Dairy	Head	2	2	2	2	2
Yearling steer feeding	Head	122	208	303	312	202
Hogs	Litter	2	2	2	2	2
RESOURCES ACQUIRED						
One-Use Inputs						
Corn	Bu.	0	5,011	0	802	0
Hay	Tons	32	0	0	2	49
Seasonal labor	Man hrs.	910	1,039	1,088	1,120	1,013
Durable Resource Investments						
Land-purchase	Acre	76	40	25	20	65
Land-rental	Acre	80	80	80	80	80
Milking capacity	Head	0	0	0	0	0
Beef feeding capacity	Head	43	86	134	138	82
Hog farrow. & feed. capacity	Litter	0	0	0	0	0
Credit						
Real estate mort. borrowed	$1,000	31.6	26.9	23.4	22.1	28.6
Chattel mort. borrowed	$1,000	12.0	15.7	15.7	15.7	15.7
All other credit borrowed	$1,000	22.6	11.6	11.6	11.6	22.6
Off-farm employment	Hours	558	481	438	427	421

of the added value of corn acreage when corn can be fed on the farm. Furthermore, when the model is solved for a resource base which has no inventory of special beet equipment (that is, harvesting and hauling equipment must be purchased), with beet, bean and corn prices at $10.60, $6.00 and $1.04, respectively, the beet enterprise becomes somewhat marginal (i.e., the estimated MVP of an additional acre of sugar beets is near zero).

The value of corn to the livestock enterprise also changes the competitive relationship between corn and dry beans. Compare Tables 4.3 and 4.4. With livestock included, corn takes over most of the acreage at these prices at the expense of dry beans.

Livestock enterprises.--The most profitable use of labor, feed and capital was in a yearling steer operation. However, investments would be necessary to embark on such an enterprise, for very little beef feeding equipment is currently available in this area.

Hogs.--The hog enterprise appears to be profitable at these prices if there are farrowing and feeding facilities present. It did not appear to pay to invest in additional capacity beyond that small amount presently available.[1]

Dairy.--The dairy enterprise also was not sufficiently profitable to warrant additional investment, although present capacity is utilized in the model.

Resources acquired.--As compared with Case I, the demand for capital and labor in the beef enterprise reduced the optimal land

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[1]For a detailed analysis of the interrelationships between the corn and livestock enterprises for this region, see Lard, op. cit.

acquisition. Credit use was modified accordingly, with less mortgage credit acquired, but with considerably more chattel credit used for financing the feeder steers.

Off-farm employment was not quite so attractive in the presence of the demand for labor from livestock in the winter. Capital limited the size of the winter feeding operations, so there still was time for several weeks of off-farm work remaining, even with the large beef enterprise.

Ohio Districts

Some of the results for the Ohio district representative farm situation are presented in Table 4.5. As in the Michigan districts, the sugar beet crop appears to have a strong competitive advantage over typical alternative crops. Soybeans are less profitable in Ohio than dry edible beans are in Michigan. Hence, even under the highest prices for soybeans and corn and a lower price for sugar beets, the beet crop is not forced out of the solution as was the case in the Michigan situations. The profitability should be sufficient to bid in new growers, since the marginal value of an additional acre of sugar beets considerably exceeds the cost of new equipment.

Implications of the Analysis

Remarks on the Appropriateness (or lack thereof) of the Assumptions

Predictions about prospective resource organization based on the results of the static analysis must be tempered by judgments as to the degree to which the assumptions of the static model are or will be approximated by existing conditions. A number of these deserve comment.

TABLE 4.5. PROJECTED OPTIMAL RESOURCE ORGANIZATION AND INVESTMENTS--FIELD CROP FARM, NORTHWESTERN OHIO, 1966

	Unit					
Price Combination No.		(1)	(2)	(3)	(4)	(5)
Price of Sugar Beets	$ per ton	12.85	12.85	12.85	12.85	10.60
Price of Soybeans	$ per bu.	2.20	2.20	2.60	2.60	2.60
Price of Corn	$ per bu.	1.04	1.24	1.24	1.04	1.24
ENTERPRISE ORGANIZATION						
Cropping Program						
Sugar beets	Acres	45	49	49	45	49
Soybeans	Acres	135	149	149	135	149
Corn	Acres	89	100	100	89	100
Wheat	Acres	51	57	57	51	57
Oats	Acres	5	21	21	5	21
Alfalfa	Acres	32	19	19	32	19
Livestock Program						
Grade A dairy	Head	2	2	2	2	2
Yearling steer feeding	Head	474	292	292	474	292
Hogs	Litter	8	4	4	8	4
RESOURCES ACQUIRED						
One-Use Inputs						
Corn	Bushel	9,333	0	0	9,333	0
Hay	Tons	21	0	0	21	0
Seasonal labor	Hours	2,458	2,135	2,135	2,458	2,135
Durable Resource Investments						
Land-purchase	Acres	0	45	45	0	45
Land-rental	Acres	80	80	80	80	80
Milking capacity	Head	0	0	0	0	0
Beef feeding capacity	Head	183	90	90	183	90
Hog farrowing and feeding capacity	Litter	0	0	0	0	0
Credit						
Real estate mortgage borrowed	$1,000	26.1	36.3	36.3	26.1	36.3
Chattel mortgage borrowed	$1,000	32.3	16.1	16.1	32.3	16.1
All other credit borrowed	$1,000	4.6	4.6	4.6	4.6	4.6
Off-farm employment	Hours	260	260	260	260	260

Resource supplies.--The projected optimal organizations imply a large demand for land and for labor. Although some allowance was made for an imperfectly elastic supply of land in the model, it is the opinion of the writer that the supply of land is much less elastic than the assumptions would indicate. Accordingly, the farm size is not likely to be doubled as is implied by the analysis.

Supplies of seasonal labor were assumed to be perfectly elastic in the analysis. This seemed to be a reasonably accurate assumption with respect to local summer help under the present organization. However, the increase in demand for labor implied by the added land and livestock operations moves the situation out of the range of the assumptions. Reliable labor is more difficult to locate in other seasons. (This is particularly true for the sugar beet harvest where relatively large amounts of labor competent and reliable enough to trust with the harvesting and hauling equipment are required.)

Capital rationing.--The model assumed that credit supplies would be based on the usual practices of institutional lenders. However, the survey data indicated that farmers in effect prefer a much lower ratio of debts to total assets than the limits imposed by lending agencies. Thus, the demand for resources, land in particular but also for labor and capital equipment, would be much less than implied by the model.

Demand for surplus farm labor in the nonfarm economy.--There is some doubt that the Field Crop farmers in Michigan districts will continue to have the opportunity to work seasonally off the farm as in the past. Temporary labor is more and more expensive to employers as fringe benefits become a larger portion of wages.

Risk, lack of knowledge and livestock enterprises.--The assumptions of the static model (perfectly elastic labor supplies, single valued expectations, and the particular set of relative prices of resources and products which were chosen) contributed to the apparent advantage of large scale beef feeding operations. Although a detailed analysis of this question is beyond the scope of the present study, the implications of the static model should be interpreted carefully. First of all, feeding of purchased steers is notably risky. Second, typical sugar beet farmers are not experienced with this operation. Third, the assumptions of the model in regard to costs of feeders and sale prices of fat steers, while consistent with the experience of the (relatively favorable) period 1961-62, are somewhat optimistic when compared to the previous 10 years experience in the Corn Belt feeding areas. In the writer's judgment, the degree of shift of resources by sugar beet farmers into beef feeder production implied by the static analysis is thus overstated.

Implications of the Static Model for Sugar Beet Production Response

The inference to be drawn from this static analysis is that the projected net returns to sugar beets provide this crop with a substantial net revenue advantage over principal competing crops. It further implies that the supply relationship will shift to fully utilize capacity available for processing. Returns are sufficient that profit maximizing firms with single-valued anticipations would be expected to commit new resources to sugar beet production.

This result is rather divergent from the recent experience where beet supplies were insufficient to fully utilize processing capacity.

(The short supply however is limited to a few factory districts and is not widespread so the point should not be overemphasized.) In order to test the static model, the problem was recomputed under assumptions about yields and prices approximating conditions in the immediate past growing seasons. The results of this analysis were similar to that reported previously for the projected conditions, i.e., the expected supplies of beets would exceed present capacity; however, the advantage from beets is not so large or clear-cut.[1] (This is equivalent to saying that the technical relationships projected here imply a greater change for sugar beets than for competing crops in 1966 relative to present conditions.)

To summarize: Static analysis indicates a shift in the supply response relation for sugar beets in the Eastern Region. Application of this model to previous conditions incorrectly forecasts (i.e., overestimates) supplies actually forthcoming under those conditions. It appears that the static model must be modified and supplemented before any strong conclusions are drawn.

In the next section, we shall consider a number of factors hypothesized to influence the production response of sugar beets.

C. Other Influences on Sugar Beet Production Response

The brief comments on theoretical considerations at the beginning of Chapter III provide a starting point for additional discussion of influences on supply or production response. Among the difficulties

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[1]Technical coefficients were not changed. There is thus some bias in that present conditions are favorably represented. This is not thought to be serious. The projected changes are mostly in increased yields and reduced cash expenses, both of which are expressed in the net revenues.

explicitly assumed away were nonmonetary goals, response to imperfect knowledge, and distance from delivery points.

Some of the above factors are amenable to analysis with the available data; a few directly, others in a more oblique fashion. In the remainder of this section, we will examine some of these problems.

The Effect of Distance from Delivery Point on New Revenues to Sugar Beets

The most important influence on the decision to grow or not to grow sugar beets, given appropriate soil and climatic conditions, is the distance from the farm to the factory. This proposition is well demonstrated in Tables 4.6 and 4.7 which report findings of the field survey described in Chapter III above. The population sampled was composed of farms located on the level lake bed soils where sugar beets are well adapted.

Beets are generally delivered to the factory by truck. However, there are several areas some distance from a factory from which the growers truck the beets to a railroad loading point, and they travel the remaining distance in railroad cars. In most, but not all of these cases, the grower pays the actual rail freight charges involved. Deliveries by truck are sometimes complicated by problems of insufficient capacity at the factory or receiving stations. During periods of good weather, the number of loads farmers would deliver must sometimes be restricted by temporary allocations of delivery privileges. Trucks may also at times be forced to wait for some time before being unloaded. These problems are on the way to being mitigated by additional investments in receiving facilities. Waiting times are thus being reduced resulting in a more efficient use of trucks.

TABLE 4.6. EFFECT OF DISTANCE TO SUGAR BEET FACTORY ON PROPORTION OF FARMS GROWING BEETS, 1960*

Distance to Haul Road Miles	Number of Observations	Number Growing Beets	Percent Growing Beets
0 - 5	19	16	84
6 - 10	5	4	80
11 - 15	29	15	52
16 - 20	15	4	27
21 - 25	12	3	25
26 - 30	0	0	0
More than 30	20	0	0
	Total 100		

*Source: Random Sample Survey of Economic Class I - V Farms, Saginaw Valley, Thumb Region, Michigan, 1961. (See Lard, Profitable Reorganization...op. cit., and Chapt. III, supra, for details of sampling procedure.)

TABLE 4.7. DISTRIBUTION OF SUGAR BEET FARMERS BY DISTANCE FROM DELIVERY POINT (FACTORY OR RAILROAD LOADING POINT) IN MICHIGAN AND OHIO, 1960*

Road Miles to Delivery Point	Number of Farms	Cumulative Percent
0 - 5	23	26
6 - 10	17	46
11 - 15	28	78
16 - 20	10	90
21 - 25	8	99
More than 25	1	100
	Total 87	

*Source: Random Sample Survey of Sugar Beet Growers, Michigan and Ohio districts, 1961. See Chapt. III, supra, for details as to sampling.

The effect of distance to the factory on net return to the farmer is from two sources. First, we have the actual additional cost per mile for labor, fuel, lube repairs, and "user cost." The second effect is also important but more difficult to measure. As the time required for a round trip increases, the size of the crew of trucks and drivers required increases also to efficiently utilize the capacity of the harvesting equipment. Individual farms seldom control this much labor or trucking capacity, and it may be difficult and expensive to acquire them.

The static analysis of the previous section assumed a single-valued cost for transportation of beets to the factory or delivery point. In the earlier discussion, it was assumed that the beets were hauled a distance of 8-10 miles. Although the hauling costs are masked by the way the data are presented, they approximate $1.50 per ton. On this basis, hauling costs amount to about 12 percent of the total revenues, which is a larger proportion than for fertilizer, or for hand labor, or for harvesting. In this section, effect of additional distances on costs and returns will be demonstrated.

We first make the (not unreasonable) assumption that costs involved in loading and unloading a truck are independent of distance to the delivery point, so the additional cost of an extra mile from the factory is just the additional cost of the truck and driver for the extra mile in each direction. Some assumptions as to costs are detailed below:

Variable costs of truck per mile:

Fuel and lube		$0.048
Repairs		0.050
"User" cost		0.102
	Sub-total	$0.20
Driver at $1.80/hour, 30 mph--additional cost per mile for labor		0.06
	Total	$0.26

For each additional mile to the loading point, trucks must travel two miles on a round trip for a variable cost of $0.52. Assume 7 tons per load:[1]

$$\text{Cost per ton per mile} = \frac{\$0.52}{7} = \$.0743$$

We assumed earlier that hauling costs were $1.50 per ton for distances up to 10 miles. For 20 miles, the cost would then be $2.24, and for 30 miles, $2.98 per ton.

For the 18 ton yield as projected, hauling costs are $27.00, $40.41 and $53.82 per acre for 10, 20 or 30 miles, respectively.

A better than average yield or efficiency of other operations must be obtained to offset the higher hauling costs for beets over the longer distances. Blosser's recent work in Ohio supports this proposition. He notes that the farms reporting higher yields also had a longer average haul.[2]

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[1]The "average" load will probably exceed this size, with the trend toward tandem rigs, although this size is thought to be more typical. The larger trucks would achieve a per ton cost somewhat lower than the above.

[2]Blosser, R. H., Costs and Returns from Producing Sugar Beets in Ohio, Research Bull. 923, Ohio Agr. Exp. Station, Wooster, Ohio, 1962.

The inference to be drawn from this analysis is that net revenue to sugar beets is strongly affected by distance to delivery point. (This explains the relationships exhibited in Tables 4.6 and 4.7.) The competitive advantage of sugar beets is reduced rapidly as the distance to the factory increases.

Furthermore, the rate at which the proportion of farmers growing beets declines at distance from the factory beyond 10 miles (see Table 4.6) suggests that factors other than just the hauling cost per mile (analyzed just above) are of considerable importance. The most obvious of these are the costs of obtaining relatively large supplies of higher quality labor and hauling equipment for the short period required for the beet harvest.

Variability of Income in Sugar Beet Production

One of the most commonly cited influences on sugar beet production response is that of risks in production and price. It is suggested that large risks are involved in the production of sugar beets which inhibit the response of growers to the favorable price and net income relationships which exist in the Eastern Region. This proposition is tested in the following discussion.

The government programs have removed most of the aggregate price fluctuations in sugar. There remain some regional influences on the level of and variability in net prices to beet sugar (which will be discussed in some detail in Chapter VI). The apparent variability in prices received by growers for sugar beets is due largely to quality differences. The price of beets is based on the recoverable sugar per ton of beets, which in turn depends on the sugar content and purity of the beet. These factors typically exhibit rather wide fluctuations in the Eastern Region. However, there is a marked inverse relationship between tons of beets per acre and recoverable sugar per ton of beets; that is, high yields are associated with low sugar content and _vice versa_. Thus, although either of these variables can and do fluctuate widely from year to year, the total sugar per acre, and hence, the gross income per acre, is much more stable (see Column 9, Tables 1 and 2, Appendix II).

Two measures of variability are used here. The first measure is the Coefficient of Variability,

$$V = \frac{\sigma}{\bar{X}} (100)$$

which is just the percent the standard deviation (σ) of a series is of its mean ($\bar{X}$). It measures the degree of variation from a long term average.

The other measure used is a form of "link relative." It has the more desirable properties of measuring year-to-year variability. The assumption that the degree of risk in the decision-maker's mind is measured by his experience with year-to-year variations seems to be a better approximation to the decision-maker's environment than a measurement of the deviation from a long term average. The link-relative measure of variation used here is constructed as follows. First, determine the percent each year's observation is of the preceding year's observation. That is, find the link relatives:

$$\frac{X_1}{X_0} (100) ; \frac{X_2}{X_1} (100) ; \frac{X_3}{X_2} (100) ; \frac{X_t}{X_{t-1}}, \text{ etc.}$$

where the subscript i of each observation refers to the i^{th} time period ($i = 0, 1, 2, \ldots n$). Some of the resulting values are less than 100. Take the reciprocal of these so that all numbers are greater than or equal to 100. The measure of variability used here is achieved by taking the unweighted means of the indices and subtracting 100 from this value. An index of 0 thus indicates no year-to-year variation.

The variability measurements were calculated for sugar beets in both Michigan and Ohio, and for comparative purposes, for dry beans and corn in Michigan. The basic data for corn and beans were for the East Central Counties (where most of Michigan's sugar beets are produced), in order to be on a comparable basis for at least the Michigan beet production. The variable chosen for the comparisons was gross income per acre. (Similar measures applied to either price or yield per acre series would reveal somewhat higher variability in the case of sugar beets. However, because of the aforementioned inverse relationship between price and yield, such measures are judged to be misleading.[1]

The results of the measurements are presented in Table 4.8. They do not support the hypothesis that income per acre from sugar beets is subject to significantly greater variability than are the principal competing crops. In fact, there is some evidence to indicate the relationship is changing to the advantage of the sugar beet crop. The 15 link-relatives were grouped into three consecutive 5-year periods for

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[1]There is also some doubt as to whether an aggregate series as used here can be an appropriate measure of year to year variability. One has the intuitive feeling that aggregation would tend to mask a considerable portion of the year-to-year variation experienced by individual farmers. No data are available to check this hypothesis.

each crop. For sugar beets in Michigan during the period 1947-51, the average year-to-year variability (link relative method) was 18.4 percent. In the second 5 years, this measure dropped to 15.4 percent, and the third 5 years to 8.4 percent. The comparisons are more striking for the Ohio series, which changed from 27.0 percent in the first 5-year period to 6.4 percent in the latest 5 years.[1] Similar comparisons for corn showed no trend, and an increasing variability was observed for dry beans.

TABLE 4.8. MEASURES OF VARIABILITY OF GROSS INCOME PER ACRE FOR SUGAR BEETS, DRY BEANS, CORN, 1946-61*

	Edible Dry Beans	Corn	Sugar Beets Michigan	Sugar Beets Ohio
Link Relative Index	12.1	20.0	14.2	13.9
Coefficient of Variation	13.6	18.0	16.8	12.9

*Data used for corn and dry beans were yield per harvested acre of East Central Counties, Michigan and State average prices, Michigan, 1946-61, as reported in Michigan Agricultural Statistics, Michigan Department of Agriculture, Lansing, various annual issues. Data for sugar beets was taken from U.S.D.A., Sugar Statistics, Vol. II, op. cit.

Another measure of risk which is of interest is the proportion of planted acres which are harvested, or conversely, the rate of abandonment. These figures are presented for sugar beets in the Eastern Region in Appendix II, Tables 1 and 2. It is interesting to note that these series also exhibit a trend toward less variability in the most recent periods.

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[1]Most of these variations were increases and therefore neither unexpected nor undesirable.

The proportion of acres abandoned is a somewhat less useful measure of variability than might appear at first glance. The acres of beets which are abandoned usually go into dry beans or soybeans, and very few resources are completely lost. In fact, some observers feel that much of the crop that is abandoned in Michigan would produce as good or better an income in beets as it would in beans, even though the stand of beets may appear a little sparse at bean planting time. The abandonment and deficiency payment provisions of the Sugar Act tend to reduce losses sustained by growers prior to harvest, albeit at some cost in "red tape."

Some consideration was also given to the alternative of measuring net income per acre instead of the gross figures. However, the variations in cost are thought to be considerably outweighed by variations in the yield and price series. Furthermore, there seems to be no convenient method of establishing a series on production costs.

Characteristics of Farm and Farmer

The statement is often heard that sugar beet growers are in some sense "a peculiar breed," different in attitudes and outlook than their neighbors. Should some such differences be demonstrated, it might have some implication for supply response. No part of the questionnaire was devoted to questions on individual attitudes or preferences, so no direct test of these notions can be applied.

There are some data which might throw some light on the question, however. The portion of the field survey conducted in conjunction with the Feed Grain Study[1] provided observations on 42 beet growers and 58

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[1]See p. 57, *supra*.

non-beet growers in the Michigan districts. Certain variables which were thought to be of possible influence on supply response were compared by standard statistical procedures. It was hypothesized that characteristics such as age, education, net worth, and work off the farm might influence goals or risk preference and hence, production response on sugar beets. Among the variables tested were age of operator, education of the operator, amount of operator and of family labor available at particular seasons, weeks worked at and income from off-farm jobs, investment in land and in equipment, and net worth. The beet grower group tended to have somewhat more family and operator labor, somewhat more machinery investment, somewhat higher net worth, and less land operated. However, there was no significant difference between the means of the two groups for these or for any other of the variables when tested statistically at even the 20 percent level.

Intra-regional Variability in Natural Environment

One of the necessary simplifying assumptions of the analysis was that a single technical relation could accurately represent the region. Some of the overcapacity problems of the region are known to be due to differences in natural and institutional environment from that hypothesized. For example, the weather data (Table 3.1) shows that the temperature and rainfall conditions in the planting season in Sanilac County, Michigan, are much different from that from other parts of the region. This same area is generally considered to have much poorer drainage than elsewhere in the Michigan districts. (Legal barriers to general drainage programs have recently been lifted, and there is hope that these conditions will change.) Other factory locations are thought to be less than optimal with respect to favorable soil associations. The data of Table 4.6 demonstrate that a few miles can make a rather large difference in beet supplies.

Other Factors

Perreault[1] suggested a list of factors which he hypothesized to be of small individual influence. Hypotheses about off-farm work, age, net worth and other variables have been examined with inconclusive results. A number of other hypotheses are suggestive but difficult to measure because of their subjective nature.

Large Capital Investment

It is hypothesized that the large investments involved in ownership of specialized planting, harvesting and hauling equipment is a deterrent to entry into the sugar beet business. It is quite true that investments are much larger, on the average, than for other crops (see Table 4.1, supra). Furthermore, this cost would be very much larger per acre for a small enterprise than for the average. However, other considerations suggest that this factor should not be weighted too heavily. An active market for custom services exists in the region. It is usually possible to hire these services without incurring the risk of costly excess machinery capacity.

Non-monetary Goals

If a farmer has goals other than that of maximizing profits, there are a number of reasons which might cause him to limit or refrain

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[1]Perreault, The Acreage Response of Michigan Farmers..., op. cit.

from the production of sugar beets. Among these might be included the producer's unwillingness to participate in the government program. Another notion frequently heard is that many farmers do not wish to lose the authority over their operations which is implicit in the language of the production contract. Other farmers are unable or unwilling to effectively supervise the migrant worker crews required in production of the crop. The production of the crop also may involve a large amount of strenuous labor, perhaps under unpleasant weather conditions during the harvest. (Similar conditions are not uncommon during the hunting season, yet the marginal utility of the latter is high enough for many to keep them from the beet fields.)

Specialized Technical Skills Required

Crop and soils specialists who have had a long association with sugar beet production emphasize that special technical skills are necessary for successful cultivation of the beet crop. It is implied that inexperienced growers might be unable to attain the average yields and resource uses that are projected here and therefore would not be likely to commit resources into beet production except at very favorable prices.

It is undoubtedly true that sugar beet production presents a number of problems which are different from and more complex than occur in production of competing field crops. Again, the amount of influence this factor exerts is difficult to measure. The previous discussions of trends in technology and the measurements of variability suggest that the importance of these difficulties is declining and that the trend may be expected to continue.

D. Summary and Conclusions from the Analysis of Production Response

In Chapters III and IV it has been shown that:

(a) Rapid technological advances have greatly increased yields and reduced costs in Eastern Region sugar beet production in the nearly two decades since World War II. Additional increases in yields and reduction in costs are anticipated in the years ahead.

(b) Although the sugar beet crop requires very large supplies of both migrant and family labor and substantial expenses for machinery, equipment and other inputs, its average return per acre on adapted soils is considerably more favorable than that for any major competing crop under present or projected price relationships.

(c) However, there is evidence to indicate that this strong competitive advantage of sugar beets over competing crops is limited to a particular subset of the lake-bed soils in the Eastern Region. When the yield relationships for soils other than the 2c classification (Table 3.2) are compared with the costs of production shown in Table 4.1, it is indicated that the advantage of beets nearly vanishes.

(d) Distance to the sugar factory is demonstrated to be a major factor influencing the individual farmer's choice of crops. The beet crop is relatively bulky so that hauling accounts for a large proportion of the production costs. Furthermore, the added trucks and drivers required to efficiently support the harvesting crew may often be expensive and difficult to acquire for the short harvest season. Thus, few farmers haul beets in excess of 20 miles.

(e) There are a number of other factors which make this crop somewhat of a special case. They are thought to affect production response but in a manner difficult to measure. Therefore, a static model of the profit-maximizing firm has some shortcomings as an analytical tool.

(f) The changes in technology of sugar beet production have reduced the importance of some of the special hard-to-measure characteristics. Thus, income variability has been reduced to the point where most of the year-to-year changes are upwards and thus not undesirable. Thinning labor is on the farm for only half the time of a few years ago. Harvest and delivery bottlenecks are being eliminated by increased factory receiving facilities. Resistant varieties improve the chances of having a satisfactory germination, stand and yield.

Implications

The implications of the model were that the supply of sugar beets would increase to a point to fully utilize existing and prospective processing capacity in the projected period.

In view of the considerations just noted and also because of the likelihood of favorable prices in sugar for the next few years, this projection seems realistic. This increase in output can be supplied from present producers by relatively small changes in the present rotations and the expected increase in yield per acre.

However, should processing capacity be increased substantially, as has been proposed, the answer is somewhat less clear. In a sense, such projections are extrapolations beyond the data. The static analysis indicates that new farmers would be bid into beet production. However, in view of the difficulties in accounting for the subjective factors discussed earlier, subjective judgments as to the behavior of the important variables are required.

In view of the data on transportation costs and personal opinions and judgments concerning the preferences and goals of farmers, this writer is not of the opinion that a large proportion (say over 20 percent) of the present non-beet growers on the adapted soil associations would supply beets under the projected price and technical relationships.

CHAPTER V

SUGAR BEET PROCESSING

Some background discussion on the development of the sugar beet processing industry in the United States and in the Eastern Region was presented in Chapter II. In Appendix I there is a chronological history of all sugar beet processing enterprises in the Eastern Region. This chronology shows that most plants in the region, including those presently in operation, were erected around the turn of the century. Of the 34 enterprises launched since 1897, only eight remain. These plants have, in general, increased daily and annual output to a large degree over the years. However, they are still, on the average, of smaller capacity than the average of plants elsewhere.

The present chapter will be devoted to an analysis of some economic aspects of the processing of sugar beets. Consideration will be given first to production techniques and input-output relationships for the industry. A later section will examine the relative attractiveness of alternative methods of expanding plant capacity.

A. The Production Process and Input-Output Relationships

The process of extracting sugar from the beet root involves the following steps:[1]

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[1]See McGinnis, R. A., ed., Beet Sugar Technology, Reinhold Publishing Corp., New York, 1951, for a detailed analysis of every phase of sugar beet processing.

(a) Washing and slicing the beet into thin strips called "cossettes."

(b) Removal of the sugar from the cossettes by diffusion (essentially, the cossettes are soaked in hot water, causing nearly all the sugar to move from the cossettes into the water).

(c) Partial purification of the resulting diffusion juice by successive treatment with calcium oxide (lime), carbon dioxide, and sulfur dioxide, and filtration of the resulting precipitates. (The lime and carbon dioxide are produced at the factory's lime kiln from limestone.)

(d) Concentration of the purified juice by boiling in evaporators.

(e) Crystallizing the sugar in the resulting sirup by boiling it in a partial vacuum until it is supersaturated so that crystals form.

(f) Separating the resulting mixture into crystals and sirup by centrifuging.

(g) Drying, sizing, packaging and storing the final product.

The sirup from the first centrifuging still contains a considerable amount of valuable sugar. It is boiled and crystallized twice more. The sugar resulting from second and third boilings is not of commercial quality, so it is remelted and re-enters the process. The sirup from the third centrifuging is called "molasses." The solids in molasses are around 60 percent sugar, but the recovery of this sugar by boiling and centrifuging is not economically feasible. Beet molasses is usually sold for livestock feed or for use in the production of yeasts and other microorganisms. It also may be subject to other types of process for extraction of the remaining sugar. The most common of these is called the Steffens process, which is used in a number of factories in the United States, although by none in the Eastern Region.

The other by-product, the exhausted cossettes or pulp, is pressed and usually dried for sale as cattle feed.

Waste disposal is a major problem of beet factories. McGinnis reports that the waste disposal problem from a 2,000 ton per day (non-Steffen) factory is roughly equivalent to that from a city of 125,000 population.[1]

The processing season (or "campaign") is about 100 days duration, beginning around October 1 when the beets have reached a sufficient size and sugar content. The harvest is largely completed by November 1. The length of the processing season in the Eastern Region depends upon the period which the beets may be stored in the factory pile. The beets lose sugar through respiration and from such factors as bacterial infections from physical damage or freezing and thawing. The amount of sugar extracted per ton of beets sliced thus declines as the season progresses.

The factory usually maintains some permanent force of about 100 the year around. These include the executive, supervisory and office personnel, a part of the factory work force (which performs the necessary inter-campaign maintenance), and an agricultural staff

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[1]McGinnis, Beet Sugar Technology, op. cit., p. 471.

who are responsible for the details of acquiring the beet crop. The remainder of the factory crews are hired only for the period of the campaign.

New technology.--Although the basic process for extracting sugar has not changed for many years, a large number of greatly improved methods and equipment have been developed. The most important of these is the continuous diffuser which eliminates as many as 15 men per shift in replacing the batch-style diffusion batteries. Continuous techniques for many other phases, including carbonation and centrifuging for intermediate sugars, have been developed. Automatic control systems for many operations have been introduced. A number of developments in beet storage have contributed materially to a lengthened campaign in recent years.

Input-Output Relationships and Measures of Efficiency

The list of physical inputs required for operation of a beet factory is too long to cover in detail here. Brief comments shall be offered on those of major importance.

Beets.--The amount and proportion of sugar extracted from the beets depends both upon the quality of the beet and the factory equipment and operating techniques. The amount of sugar extracted per ton depends primarily upon the percent of sugar in the beet. The proportion of the sugar in cossettes which is finally bagged is further dependent upon the purity of the beet (that is, the proportion of sucrose to total soluble solids in the beet) and the final purity of the molasses (the proportion of sucrose to total solids in the molasses). Cottrell states the point succinctly:

> For any particular combination of soluble non-sugars found in factory sirups there is a ratio of sugar to non-sugars which represents the limit beyond which sugar cannot be economically crystallized by ordinary factory processes....If for example, it is found impractical to crystallize sugar beyond a point where the purity of the final molasses is sixty, then it is evident that each 100 pounds of dry substance in molasses contains 60 pounds of sugar and 40 pounds of non-sugars.... every pound of non-sugars has prevented the crystallization of 1.5 parts of sugar.[1]

Losses of sugar other than that in the molasses generally amount to a quite small percentage of the sugar. According to Cottrell, they may be reduced to less than 0.03 percent of the weight of the beets in non-Steffen operations.[2]

Non-Steffen factories average about 80 percent recovery of the sugar in the cossettes. Factories equipped with the Steffens process for treating molasses can achieve an extraction rate of over 90 percent. The Steffens process is not universally used. More than half of the most recently established factories in the United States have not included it. The indications are that under the usual price relationships between sugar and molasses, the process does not make adequate returns on investment.[3] The comparison of extraction rates between regions thus must be made with care. The Eastern Region shows a much lower extraction rate as compared with other areas, at least partly because of the absence of any Steffens operations.

Moore has argued that the rate of recovery achieved will depend

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[1]Cottrell, R. H., Beet Sugar Economics, op. cit., p. 142.

[2]Ibid., p. 146.

[3]Personal communication, H. M. Bauserman, Stearns-Roger Mfg. Co., Denver, Colo., May 24, 1963.

upon the particular variant of the share contract in force at a given factory. The processors whose share allows him but 50 percent of any increment of sugar extracted would not find it to his advantage to extract as much sugar as would the processor who received the entire marginal unit.[1] The Eastern Region contract is of the former type. This may account for a part of the differences between regions, although the proposition would be extremely hard to test because of the variation in the primary factor influencing recovery rates, the amount of impurities in the beets.

<u>Labor</u>.--Generally speaking, the labor required per unit (whether measured inputs of beets or output of refined sugar) depends on the particular types of equipment installed in a factory and the scale of the operation, as well as on the quality of the beets. Kinsley reports a mean of .86 man hours per ton and a range of .62 to 1.29 man hours per ton of beets sliced in a study of six United States beet factories in 1952.[2]

<u>Water</u>.--Several million gallons of fresh water per day are required for fluming, washing, diffusion and for the boilers. The amount of fresh water used depends upon the degree of recirculation, particularly in the fluming.

<u>Fuel</u>.--Large quantities of steam are required at a number of different points in the extraction process. Accordingly, beet sugar

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[1]Moore, J. R., "Economic Implications of Share Contracts for Contracts for Sugar Beets," <u>Journal of Farm Economics</u>, Vol. XLIV, No. 2, May, 1962.

[2]Kinsley, R. T., <u>Case Study Data on Productivity and Factory Performance: Beet Sugar Refining</u>, BLS Report No. 6, U.S. Dept. of Labor, Washington, D.C., February, 1953.

factories are equipped with a large capacity boiler system for the production of steam to be used in the evaporators, vacuum pans, and various juice heaters. Steam is also usually used to generate the plant's electric power. A system designed for the most efficient use of steam can make rather large economies in fuel consumption. The average reported by Kinsley was about 220 pounds of coal to boilers (basis 10,000 BTU per pound of coal) per ton of beets, but the most efficient plant achieved a rate of less than 160 pounds.[1] Pulp dryer coal requires an additional 75 pounds of high grade coal per ton of beets (14,000 BTU per pound). Coke is the usual fuel in the lime kilns, although some use of natural gas is reported. Coke is required at a rate of 10 to 20 pounds per ton of beets.

Limestone.--A good grade of lime rock is required for conversion to calcium oxide. A typical quantity would be at a rate of 100 pounds per ton of beets processed.

Other.--Lesser quantities of a number of other materials are required in the extraction process, including sulfur, diatomaceous earth (for use as a filter aid), soda ash, filter cloth, activated carbon, bags and the like.

The efficient and profitable operation of a given beet factory depends, among other things, on an adequate volume of high quality beets. Both quality and volume have been and are problems of Eastern Region processors. The content of sugar and the extraction rates have been somewhat lower on the average than in other regions.[2]

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[1] Ibid., Table 8.

[2] Sugar Statistics, Vol. II, op. cit., Tables 20, 21 and 22.

More of a problem has been volume of beets supplied. It was shown in Chapters III and IV that a most important determinant of the relative profitability of the beet crop to the farmer was the quality and fertility of the soil. Furthermore, the importance of transportation costs for beets indicates that a processing plant must be located in immediate proximity to large bodies of favorable soils in order to obtain adequate supplies without incurring special costs or subsidies. The history of declining factory numbers in the Eastern Region appears to be in large part attributable to the location of many of the plant sites in areas where the soil characteristics do not provide a margin of advantage to the beet crop. A chronically low volume of production is financially disastrous to a firm with the high overhead costs for capital equipment and permanent staff involved in beet production.

B. Returns to Alternative Methods of Adding Plant Capacity

The recent interest in the possibilities of expanding beet sugar production in the Eastern Region suggests that some consideration be given to alternative methods for achieving such ends. The problem is of rather a complex nature, and the subsequent analysis may reflect a larger probability of error than the author considers desirable.

There exists no public information on the detailed costs of operating a beet factory. The operating firms naturally do not publish any such information. (The Sugar Division of the Department of Agriculture has this type of data for purposes of administering the Sugar Act but only on a confidential basis, and "outsiders" such as the author are not permitted access.)

The procedure followed here was to construct a fairly detailed budget of the operating requirements of three hypothetical sugar plants. To arrive at estimates of operating costs, assumptions were made as to the quantities and unit costs of various categories of inputs, including beets, labor and materials, and capital equipment. These assumptions are presented in Tables 5.1, 5.2 and 5.3. The resulting income and expenses will then be compared as to their rate of return on invested capital.

Certain specific and limiting assumptions are required for this analysis. The capital investment in a sugar plant must be recovered over the plant's operating life of 40 or more years. The cost of the various other resources, labor, coal, lime rock and various and sundry operating supplies may be expected to increase over time. The use of present prices, as was done in this analysis, is equivalent to the assumption that sugar prices and the efficiency of resource utilization will change at rates sufficient to precisely offset expected increases in costs for other purchased resources.

Case I.--In this instance, we assume a hypothetical plant with a capacity of 1,600 tons daily. It is proposed to remodel the existing facilities and equipment to reach a capacity of 2,400 tons. Assumptions as to the investment required are listed in Table 5.3. It is assumed that a continuous diffuser will be installed and equipment purchased to replace and add to existing yard, beet end and sugar end facilities. A bulk storage silo for 100,000 hundredweight is included. Labor and material input assumptions are shown in Tables 5.1 and 5.2, respectively. This plant would draw on 15,000 acres of beets at present yields.

TABLE 5.1. PRODUCTION AND RELATED LABOR REQUIREMENTS FOR THREE HYPOTHETICAL SUGAR BEET FACTORIES

Operation	Factory No. 1 2400 tons/day (partly modernized equipment)	Factory No. 2 3000 tons/day (modern equipment)	Factory No. 3 4500 tons/day (modern equipment)
	Men Required per 8 Hour Shift		
Beet End			
Handling (fumes, trash catchers, beet washers)	7	5	7
Slicing (picking table, knife filters, weighers)	4	5	8
Diffusion	1	1	1
Carbonators	2	1	1
Filters, Laundrymen	7	4	6
Evaporators	1	1	1
Utility	2	1	2
Foremen	1	1	1
Sugar End			
Boilers, Crystallizers, Helpers	2	3	4
Granulators	2	2	2
Centrifuges, Melters	4	3	4
Packaging, Warehouse	12	15	20
Utility	1	1	2
Foreman	1	1	1
Lime Kiln	4	3	3
Boiler House	4	3	3
Laboratory (chemists, samplers)	6	7	9
Pulp Dryers	6	8	10
Maintenance (machinists, mechanics, electricians)	9	7	10
General (sweepers, janitors, supply handlers, etc.)	6	6	6
Average per Shift	82	78	101
Average Production and Related Labor per Ton of Beets Sliced	.82	.62	.54

TABLE 5.2. PHYSICAL INPUT AND COST ASSUMPTIONS FOR HYPOTHETICAL BEET SUGAR FACTORIES

Item	Unit	Price per Unit	Factory No. 1 (existing factory remodeled) 2,400 tons/day	Factory No. 2 (New Factory) 3,000 tons/day	Factory No. 3 (New Factory) 4,500 tons/day
			Units per Ton of Beets Sliced		
Production and Related Labor	Man hour	2.48	.82	.62	.54
Coal to Boilers (10,000 BTU/lb.)	Ton	9.50	.11	.08	.08
Coal to Pulp Dryer (14,000 BTU/lb.)	Ton	13.50	.037	.037	.037
Lime Rock	Ton	4.25	.05	.05	.05
Coke	Ton	30.00	.0042	.0042	.0042

TABLE 5.3. CAPITAL INVESTMENTS FOR THREE HYPOTHETICAL FACTORIES

Item	Factory No. 1[a/] Remodeling by addition of 800 ton/day to existing 1,600 ton/day	Factory No. 2 New 3,000 ton/day	Factory No. 3 New 4,500 ton/day
		1,000 Dollars	
Factory yards and equipment (land, earthmoving, pilers and receiving equipment, water supply, waste lagoons, flumes, etc.)	250	4,000	5,000
Buildings (main building, including beet and sugar end, office and laboratory building, packaging area, machine shop and storeroom, lime kiln house, boiler and generator, pulp dryer and warehouse, sugar warehouse and bulk bins)	200	2,100	2,680
Equipment (including installation) (wash house, beet end, sugar end, lime kiln, boiler, generator, sugar packaging, laboratory, office, pulp dryer and misc.)	920	8,040	10,270
Temporary Construction Facilities	15	500	500
Engineering and Design	10	75	85
Contingencies and Other	75	760	970
TOTALS	1,470	15,475	19,595
Average Investment[b/]	4,400	11,750	15,800

a/ New investment only.

b/ One-half of value of depreciable capital plus value of land and operating capital.

Case II and Case III.--These are hypothetical new plants. Assuming that a site could be acquired suitably located with respect to supply of beets and water, on a rail spur and with sufficient acreage for waste disposal and beet storage areas, costs might be as in Tables 5.4 and 5.5. Each plant is assumed to have the following types of equipment: continuous diffuser, continuous first and second carbonation system, and automatic centrifugals. None of the special processes (Steffens, ion exchange, or continuous adsorption) are included in the cost of equipment. (Each of these improves quantity or quality of sugar extracted at an additional cost in capital and materials.) Bulk storage bins are included to the extent of 200,000 and 300,000 hundredweight, respectively. The labor requirements assumed do not reflect a particularly high level of automatic controls.[1] These plants would draw on 19,000 and 28,000 acres of beets, respectively, for 100 days of operation (current yields).

The additional investment in Case III as compared to Case II was estimated by a method reported by Chilton.[2]

The assumptions with respect to performance rates imply a somewhat greater efficiency in use of labor and fuel in Cases II and III than in the remodeled plant. It is assumed that extraction rates of sugar

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[1]Data on costs and input-output relationships which provided the basis for estimation for new plants were generously provided by H. M. Bauserman, Stearns-Roger Mfg. Co., Denver, Colorado, Personal Communications, April 1, 1963, and May 24, 1963.

[2]Chilton, C. E., "'Six-Tenths Factor' Applies to Complete Plant Costs," in Chilton, C. E., ed., Cost Estimation in the Process Industries. New York, McGraw-Hill Book Co., Inc., 1960, p. 282.

TABLE 5.4. INCOME AND EXPENSES PER TON OF BEETS SLICED--HYPOTHETICAL FACTORIES

	Factory No. 1 (Existing factory remodeled) 2,400 tons/day	Factory No. 2 (New factory) 3,000 tons/day	Factory No. 3 (New factory) 4,500 tons/day
Income - Net Proceeds	$ per Ton	$ per Ton	$ per Ton
Sugar 240 lbs. per ton @ $8.00 per cwt.	19.20	19.20	19.20
Dried Pulp 103 lbs. per ton @ $33.00 per ton	1.70	1.70	1.70
Molasses 96 lbs. per ton @ $22.50 per ton	1.08	1.08	1.08
	21.98	21.98	21.98
Expenses (not including marketing expenses)			
Payments to Growers (50%)	10.99	10.99	10.99
15% of excess of $7.50/Cwt.	.18	.18	.18
Sub-total	11.17	11.17	11.17
Production and Related Labor	2.03	1.54	1.34
Fuel to Boilers	1.05	0.76	0.76
Pulp Dryer Coal	0.54	0.54	0.54
Coke	0.13	0.13	0.13
Limestone	0.21	0.21	0.21
General Property Taxes	0.17	0.50	0.44
Depreciation	0.92	1.93	1.65
All Other Expenses	3.44	3.36	3.20
Total Expenses (excluding Federal income tax)	19.66	20.14	19.44
Income Less Expenses	2.32	1.84	2.54

TABLE 5.5. INCOME AND EXPENSE STATEMENT FOR HYPOTHETICAL FACTORIES--100 DAY CAMPAIGN

	Factory No. 1 (Existing factory) (some modernization) 2,400 tons/day	Factory No. 2 (New factory) 3,000 tons/day	Factory No. 3 (New factory) 4,500 tons/day
Income			
Net proceeds, sales of sugar @ $8.00/cwt.	$4,608,000	$5,760,000	$8,640,000
Net proceeds, beet pulp @ $33.00/ton	408,000	510,000	765,000
Net proceeds, molasses @ $22.50/ton	259,000	324,000	486,000
Net Sales	$5,275,000	$6,594,000	$9,891,000
Expenses			
Payments to Growers @ $11.17/ton	$2,681,000	$3,351,000	$5,027,000
Production and Related Labor (campaign)	487,000	462,000	603,000
Coal for Boilers	252,000	228,000	342,000
Coal for Pulp Dryer	129,000	161,000	242,000
Coke	30,000	38,000	56,000
Limestone	51,000	64,000	96,000
General Property Taxes	41,000	150,000	198,000
All Other Expenses	826,000	1,010,000	1,440,000
Cost of Goods Sold	$4,497,000	$5,464,000	$8,004,000
Total Income	778,000	1,130,000	1,887,000
Depreciation	221,000	580,000	742,000
Net Income (before interest, Federal income tax)	557,000	550,000	1,145,000
Rate of Return on Average Investment (before interest and income tax)	12.7%	4.7%	7.2%

per ton of beets sliced would not differ among the three plants.[1]

Income and Expenses for the Hypothetical Case

Tables 5.4 and 5.5 present an analysis of income and expenses for the three cases under certain assumptions as to costs, revenues and performance rates.

It is assumed that the beets are of 15 percent sugar content, and 80 percent is recovered (240 pounds per ton of beets). This sugar content is somewhat lower than average but in line with recent trends in the Eastern Region. Income per unit is based on net proceeds (which is gross income less marketing costs and federal processing taxes, as specified in the grower-processor contract).

Payment to growers is based on the typical Eastern contract, which allocates to the grower 50 percent of net proceeds from sales of sugar and byproducts plus an additional 15 percent of net proceeds for sugar above $7.50 per hundredweight. Quantity and cost of beets and other inputs are as in Table 5.2. The category of "all other expenses" includes the factory costs of acquiring beets (including agricultural department, fieldmen, labor procurement, and beet transportation), general administrative and overhead expense, insurance, state franchise and business taxes and general operating supplies (including maintenance). It does not include any charges for interest or depreciation. Wage rate, including fringe benefits, is $2.44 per hour.

The final figure represents gross pre-tax profits. Interest charges were not included in order to estimate a return on total capital.

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[1]As noted earlier, the amount of sugar entering the factory which is not recovered is either in molasses or in factory losses (the latter of which are of minor importance). Accordingly, there is no apparent reason to assume factory design has any particular influence on recovery rates.

The resulting estimate of rate of pre-tax returns to average investment is derived by dividing net income by average investment. (Average investment includes both property and operating capital.)

Implications

The results derived in Table 5.5 suggest the following conclusions:

1. A plant investment in replacing and adding to existing facilities is likely to provide an adequate return on investment. Such an expansion can be carried out with little risk of developing capacity exceeding the probable supply of beets (see Chapter IV).

2. Investments in the smaller new plant would be likely to achieve certain efficiencies in use of labor, materials and maintenance. However, the much larger expenses for depreciation tend to offset these other advantages. The resulting net returns, even for a larger scale enterprise, appear insufficient to attract capital.

3. The larger scale hypothetical new plant achieves additional and significant economies. However, because of the large investment per unit capacity, the rate of return, when 52 percent federal income taxes are deducted, appears to be modest at best.

The analysis of Chapter IV does not imply that a supply of beets sufficient to operate this larger plant at full capacity (28,000 acres) could be found anywhere in the Eastern Region without prior cessation of operation on one or more existing plants.

These conclusions would be different should conditions other than those assumed occur. For example, a capital contribution by growers, as is reported to have occurred elsewhere, could materially change the attractiveness of investment in new plants. An equivalent procedure would be to reduce the portion of the net proceeds returned to the grower under the terms of the contract. Changes in the price of sugar and in the quality of sugar beets are also possibilities which could change the rates of return. A longer processing season through improvements in beet storage techniques would have a similar effect by spreading overhead over a larger volume.

CHAPTER VI

MARKETING, DISTRIBUTION AND DEMAND

The purpose of the present chapter is to describe the characteristics and practices of the marketing and distribution of sugar with special reference to the Eastern Region. Another purpose is to analyze the forces determining prices and net returns to growers and processors of sugar beets.

A. Sources of Supply and Channels of Distribution

The total distribution of sugar in the United States approaches 10 million tons (raw value). (The legislative apportionment of these supplies was discussed in Chapter II.) About one third is supplied by mainland growers and another 20 percent from domestic off-shore sources, including Hawaii, Puerto Rico and the Virgin Islands. The balance, slightly less than half, is provided by shipments from a number of friendly countries. Prior to the recent and continuing unpleasantness with Cuba, that nation and the Phillipines (both of whom had preferential trade arrangements) were the main source of the balance. Table 6.1 shows the sources of supply for the calendar year 1962.

Primary Distributions

All sugar distributed in the U.S. originates from one of four classes of organizations which are called "primary distributors." These

TABLE 6.1. UNITED STATES SUGAR RECEIPTS AND PRODUCTION--BY SOURCE OF SUPPLY, 1962*

	Short Tons, Raw Value	Percent of Total	
Production			
Mainland Cane	763,192	7.9	
Domestic Beet	2,515,053	26.0	
Subtotal	3,278,245		33.9
Receipts of Refineries and Importers			
Offshore Domestic			
Hawaii	1,078,501	11.2	
Puerto Rico	756,814	7.8	
Virgin Islands	10,750	0.1	
Subtotal	1,846,065	19.1	
Offshore Foreign			
Cuba	0	0	
Dominican Republic	869,866	9.0	
Mexico	389,083	4.0	
Phillipines	1,210,158	12.6	
Brazil	397,839	4.1	
India	147,274	1.5	
Australia	160,915	1.7	
British West Indies	181,161	1.9	
Republic of China	109,304	1.1	
Peru	530,781	5.5	
Other Foreign Countries	533,252	5.5	
Subtotal	4,529,633	46.9	
Total Offshore	6,375,698		66.1
Grand Total	9,653,943		100.00

*Source: Sugar Reports No. 130, February, 1963, Tables 6, 7 and 9.

are: cane sugar refiners, domestic beet processors, mainland cane processors, and refined sugar importers.

Cane Sugar Refiners

These firms customarily refine purchased raw cane sugar. Their supplies of raw materials are the "off-shore raw sugars" and the domestic raw sugars from Florida and Lousiana. Most refineries are located in sea ports of the Atlantic, Gulf and Pacific coasts.

Domestic Beet Processors

These are the firms who produce refined sugar from sugar beets.

Mainland Cane Processors

These organizations customarily produce and distribute sugar which has been processed by them from sugar cane. (Most mainland cane sugar is produced in the form of raw sugar and subsequently sold to refiners for final processing, so this group is of negligible size.)

Importers

These firms distribute imported refined sugar. The 1962 Amendments to the Sugar Act have sharply reduced permissable imports, so this group is of declining importance. In Table 6.2 the proportions of the total distribution of sugar which comes from each of these sources are indicated.

TABLE 6.2. DISTRIBUTION OF DIRECT CONSUMPTION SUGAR BY PRIMARY DISTRIBUTORS, 1962[a/]

Item	Quantity Short Tons, Raw Value	Percent
Raw Cane Sugar Refineries	7,051,387	72.3
Beet Processors	2,415,674	24.8
Mainland Sugar Cane Processors[b/]	49,661	0.5
Importers	334,948	3.4
Total	9,851,670	101.0
Less Export and Livestock Feed	97,181	1.0
Continental Consumption[c/]	9,754,489	100.0

Table continued on following page.

Table 6.2 - Continued

[a]Source: Sugar Reports No. 130, February, 1963, Table 2.

[b]A number of cane processors who also refine purchased raw sugar are classified as refiners.

[c]Includes deliveries to armed forces at home and abroad.

Competing Products

A wide variety of products compete in the market for sweeteners, including honey, maple sugars and sirups and the various non-caloric sweeteners. The group of major importance other than sucrose is the corn sweeteners. Table 6.3 provides some indication of the magnitude of the consumption of this class of products. By way of comparison, the 1962 consumption estimate for corn sweeteners (about 28 million hundredweight) is about 16 percent of the deliveries of refined sugar (on a weight basis) and a somewhat smaller proportion on a value basis. Dextrose in the early 1960's has been quoted at a price in the neighborhood of 20 percent less than that of sugar (on a dry weight basis).[1]

Channels of Distribution

Most sugar, whether it is intended for industrial or household consumption, is handled through a broker. A number of firms specialize in the single commodity, sugar. They bring buyers and sellers together,

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[1]See P.M.A., U.S. Department of Agriculture, Competitive Relations Among Sugar and Corn Sweeteners, Ag. Info. Bull. 48, Washington, D.C., 1951, for a discussion of this general subject. Also a series has been published in 1963, bringing this study up to date. See for example, Ballinger, Roy A., and L. C. Larkin, Sweeteners Used by the Canning Industry: Their Competitive Position in the United States, AER 20, U.S.D.A., Washington, D.C., 1963. Other publications in this series will deal with Baking, Beverage, Confectionary and Dairy Product classifications.

TABLE 6.3. DOMESTIC SHIPMENTS OF CORN SWEETENERS, SELECTED YEARS[a/][b/]

Year	1,000 cwt., dry basis	Year	1,000 cwt., dry basis
1936	11,169	1957	20,869
1940	12,309	1958	22,897
1944	20,044	1959	23,861
1948	16,516	1960	24,732
1956	20,994	1961	25,431
		1962	27,942

[a/]Sources: 1936-48--adapted from PMA, Ag. Info. Bulletin No. 48, Competitive Relations Among Sugar and Corn Sweeteners, June, 1951. 1956-1962 Sugar Reports 93, 107, 131.

[b/]Includes Refined Corn Sugar (dextrose), Corn Sirups (mixed and unmixed, dry basis), Corn Sirup Solids, and Miscellaneous Corn Sweeteners.

as well as provide services to both, such as information, data and advice on market dealings.[1]

The sugar destined for the consumer market is sold by the primary distributor, usually operating through the services of a broker, into wholesale and retailing channels. Large retail chains often buy directly from a primary distributor, by-passing the wholesaler.

Sugar destined for the industrial market follows similar channels, except that few industrial users deal with a retail organization. The largest buyers typically deal directly with the primary distributor, although the details of the sales are handled through a broker.

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[1]Turner, Marketing of Sugar, op. cit., p. 122.

Types and Packages of Sugar

The expanded markets for sugar require an increasing number of grades, forms and packages for sugar. For example, Cottrell lists no less than 21 grades of sugar available in 100 pound bags. Most of these are pure sucrose in a wide variety of crystal sizes, ranging from several grades of powdered sugar to those of very coarse crystals. There are several brown or soft grades of sugar, ranging from light yellow to dark brown. Certain special grades for industrial uses are differentiated which must meet exacting specifications with respect to impurities.

In addition to these grades, there are the many forms of packages available. In the consumer packs (those of less than 50 pounds), there are various sizes of bags, cartons or individual service packs for powdered, granulated, brown or cube sugars.

For industrial users, the most common package is the 100 pound paper bag. However, in recent years, a trend toward bulk handling is evident, particularly for the larger user. Dry sugar in bulk can be utilized in plant operations with efficient mechanical handling equipment and storage bins. Large consumption is required in order to offset the initial heavy capital outlays. Special truck and rail cars are used for delivery. They are unloaded by gravity or screw conveyors.

Sugars in liquid forms are being utilized even more rapidly than the dry bulk techniques. Industrial consumers who eventually must have

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[1]Cottrell, Beet Sugar Economics, op. cit., p. 314.

the sugar in liquid solution, such as beverages, canned fruits and sirups find that large savings in labor and convenience are obtained. Liquid sugar is delivered in special tank trucks or rail cars and stored in large tanks. Metered pumps convey it directly into the production process with great economies in the requirements for labor. Liquid sugars are provided in a number of grades and concentrations. It also may be all or partly "inverted" (that is, the sucrose is all or partly broken down into its component monosaccharides by chemical means). Liquid sugar is also offered in mixtures with corn sirups.

Practices of Eastern Region Beet Processors With Respect to Grade and Form

Beet processors in the Eastern Region supply only a small portion of the sugar consumed there (see Table 6.4). Thus, they have been able to dispose of their products within a close proximity to the producing areas without resorting to the expense and complication of a wide range of grades and packages.

The general practices of producers vary widely among the primary distributors in Michigan and Ohio. One firms sells all its output in 100 pound bags, while on the other extreme, over 50 percent of other distributors' outputs are in consumer packs. (These last are a marked departure from the beet industry norms where 80 percent of production is sold in packages of more than 50 pounds.) Consumer size packages distributed by Eastern Region beet processors are usually confined to 5, 10 and 25 pound bags of white, granulated sugar. The market for brown and the small packages of granulated sugars is left to the cane distributors. Powdered sugars are included in some cases

TABLE 6.4. TOTAL AND PER CAPITA SUGAR DISTRIBUTION BY PRIMARY DISTRIBUTORS FOR CONSUMPTION IN THE U.S., SELECTED YEARS[a]

Calendar Year	Distribution of Sugar, Raw Value	
	1,000 Short Tons, Raw Values	Raw Value Pounds per Capita
1900	2,660	69.9
1905	3,154	74.9
1910	4,015	87.0
1915	4,556	91.7
1920	4,895	91.9
1925	6,548	114.0
1930	6,858	111.4
1935	6,634	104.3
1940	6,891	104.3
1945	6,041	86.3
1950[b]	8,279	109.2
1955	8,399	101.6
1956	8,904	105.9
1957	8,734	102.0
1958	9,030	103.8
1959	9,181	103.6
1960	9,261	102.9
1961	9,611	105.0

[a]Sources: Sugar Reports No. 126, October, 1962, Table 5. Sugar Statistics and Related Data, Vol. 1, U.S. Dept. of Agriculture, ASCS, Washington, D.C., 1961, Statistical Bulletin 293.

[b]Unusually large distribution due to outbreak of hostilities in Korea. Large quantities carried over to following year.

in the industrial lines of beet sugar producers but not usually in consumer size packages. For industrial users, there are, in addition to the 100 pound bags, sugars available from some, but not all, distributors in both liquid and dry bulk. (One firm is in the process of installing large bulk storage bins on its plant sites.) In general, the large number of crystal sizes and grades offered by cane refiners and the larger Western beet producers is not available from Eastern Region beet processors.

Seasonality in Supply

Most beet sugar is produced, as has been seen, in the months of October through January. The peaks in sugar demand, however, are typically in the summer months when food processing and beverage consumption are at their highest levels. Beet sugar sales follow roughly the same pattern as does the industry as a whole.

In order to alleviate storage problems, beet processors are tempted to move sugar into markets toward the end of the beet campaign. December was at one time the peak month of beet sugar deliveries. This tendency is not evident in the data on deliveries for the period 1960, 1961 and 1962, however. This perhaps reflects the increasing amount of bulk storage constructed by beet processors. Most processors try to distribute their stocks evenly throughout the year in order to be able to supply needs of established outlets at any time. During the price scare in May, 1963, one Eastern processor went so far as to refuse large orders at well above market prices in order to insure that he could provide for regular customers throughout the season.

B. Components of Demand for Sugar

The previous discussion of grades and classes of sugar mentioned some of the eventual consumers of sugar products. In this section, the characteristics of these outlets will be examined in more detail.

Consumption of sugar in the U.S. has become quite stable when measured on a per capita basis. This characteristic of demand is quite important in the successful administration of the Sugar Act. As shown in Table 6.4, the annual per capita consumption has settled down to a figure of about 104 pounds, raw value (or 97 pounds when measured on a refined basis).

The Trend Toward Industrial Consumption

As is well known, the income elasticity for services and "convenience" products has led to larger and larger sales of foods which are sold in partly or completely prepared forms. This, in turn, has had an effect on the sugar market, as the main sources of buying power have shifted. Table 6.5 demonstrates some of these changes. The gross deliveries to industrial users have nearly doubled over the 14-year period shown, while the consumption in nonindustrial uses was nearly identical in 1962 to the figure reported for 1949.

The industrial market is undergoing important changes as it grows. Larger volumes of sugar have made feasible the labor-saving bulk handling techniques for either liquid or crystalline forms of sugar. The industrial users' specifications for sugar have beome quite exacting. Trade associations of users, such as the soft drink and the canning industry, have set up standards for special sugar grades in cooperation with the sugar industry. These standards may specify limits on chemical or bacterial impurities. For example, minute amounts of particular residues occasionally found in both beet or cane sugars can cause a "floc" or cloudiness in clear soft drinks which reduces consumer acceptance to the product. Another example is the specific needs of the

TABLE 6.5. DELIVERIES OF SUGAR BY TYPE OF BUYER, 1949-62[a]

Year	1,000 Hundredweights (Refined Basis)				
	Industrial Uses[b]	Percent of Total	Non-Industrial Uses[c]	Percent of Total	Total
1949	57,227	41.8	79,701	58.2	136,928
1950	63,547	42.3	86,529	57.7	150,076
1951	61,323	44.2	77,556	55.8	138,879
1952	64,557	44.2	81,639	55.8	146,196
1953	70,687	46.5	81,450	53.5	152,137
1954	69,071	46.4	79,673	53.6	148,744
1955	73,984	48.2	79,614	51.8	153,598
1956	79,675	49.4	81,646	50.6	161,321
1957	81,237	51.1	77,768	48.9	159,005
1958	81,765	49.8	82,444	50.2	164,209
1959	86,966	52.2	79,750	47.8	166,716
1960	90,352	53.6	78,107	46.4	168,459
1961	94,437	53.8	81,065	46.2	175,502
1962	97,913	55.1	79,709	44.9	177,622

[a] Sources: Commodity Stabilization Service; U.S. Dept. of Agriculture, Statistical Bulletin 293, Sugar Statistics and Related Data, Vol. 1, and Sugar Reports, No. 131, March, 1963, Table 24.

[b] Includes delivery to Baker, Confectionary, Dairy Products, Beverages, Canning and Freezing and Non-Food industries.

[c] Includes Institution, Wholesalers, Retail Stores and all other uses.

canning industry. Certain bacteria, termed "thermophilic" which can survive the high temperatures in the preserving process must be eliminated from the sugar used.

These changes create certain difficulties for the producer of sugars. To obtain a liquid beet sugar, it must be remelted from dry sugar which adds somewhat to costs for this product. The large investment in bulk storage facilities for both dry and liquid sugars return little to the processor in the form of increased efficiencies in handling. They are necessary expenses in order to retain the firm's competitive position in his natural markets. The sugars produced to high specification are more costly, for they may require special agents, or they may reduce the rate of factory operation. The tendency to store sugar in bulk silos means that all sugars in the silo must meet the standards of practically all users. Thus, the sugar sold for household and other consumption meets specifications well beyond what is actually required.[1]

Competitive Trends in the Industrial Users Market

In view of the increasing importance of the industrial demand for sweeteners, a field survey of various types of users was conducted as a portion of this study. (Table 6.6 shows the types of buyers of sugar and the quantities taken by each.) Although the relatively larger portion of Eastern beet sugars marketed in consumer packs makes this analysis somewhat less important than anticipated for the present problem, some general impressions are of interest and will be recorded.

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[1]Cottrell, R. H., Speech delivered to meeting of California Beet Sugar Technologists, February 21, 1959.

TABLE 6.6. SUGAR DELIVERIES BY TYPE OF PRODUCT OR BUSINESS OF BUYER, CALENDAR YEAR, 1962*

	Beet	Cane	Imported, D.C.	Total
	1,000 cwt. (refined)			
Industrial				
Bakery, Cereal and Allied Products	7,155	14,707	548	22,411
Confectionery Related Products	4,395	12,229	628	17,252
Ice Cream and Dairy Products	2,537	5,285	136	7,958
Beverages	5,395	20,603	435	26,432
Canned, Bottled, Frozen Foods, Jams, Jellies, Preserves	7,610	8,208	1,112	16,930
Multiple and Other Food Uses	980	4,139	230	5,349
Non-Food Products	53	1,424	104	1,581
Sub-Total	28,125	66,595	3,193	97,913
Non-Industrial				
Hotels, Restaurants, Institutions	47	1,249	5	1,301
Wholesale, Groceries, Jobbers	11,040	37,741	2,054	50,835
Retail Grocers, Chain Stores	5,359	19,718	381	25,458
All Other Deliveries Including Government Agencies	590	1,521	5	2,116
Sub-Total	17,035	60,228	2,446	79,709
TOTAL DELIVERIES	45,161	126,822	5,639	177,622
Deliveries in Consumer Size Packs (less than 50 lbs.)	9,682	45,843	585	56,110
Deliveries in Bulk (unpackaged)	12,446	18,942	0	31,389

*Source: Sugar Reports, No. 131, March, 1963. Table 24. Represents approximately 97.2 percent of deliveries by primary distributors.

Some 40 firms were contacted in Michigan and Ohio; all but three of these granted interviews. The wide range of production techniques and scale of operations preclude any statistical testing of estimates. Accordingly, the results will be reported in the form of verbal impressions.

User Attitudes With Respect to Competing Products

Most respondents regarded beet and cane sugar as identical products. They thus purchased sugar solely on the basis of price, taking beet sugar at the usual discount when it was available. For very large customers, it appeared that cane sugar was not priced higher than beet sugar. Two classes of exceptions to the general use of beet sugar were noted. All liquid sugar users contacted utilized only industrial grades of cane sugars, since this type was available only from cane refiners throughout much of the region. For reasons cited earlier, local beet processors do not emphasize liquid sugar and tend to sell it only to avoid the loss of large accounts. The other exception involved two candy manufacturers who reported unsatisfactory results with beet sugar. When pressed for details, both admitted that these experiences dated back to the World War II period.

Corn refiners are obviously competing aggressively for the sweetener market. Unlike most sugar producers, they tend to differentiate their products with brand names. They appear to have a vigorous sales program backed by technical and research staffs. Evidence of their increasing penetration was observed in all categories of users.

Some questions were posed which aimed at determining effects of change in relative prices. Some of these were concerned with possible effect of various prices among sweeteners upon the amounts of each sweetener used. Other questions were to determine the probable response to changes in relative costs of sweeteners and other inputs. Most respondents asserted that they would not change recipes or formulae in the event of price changes in material. This apparent inelasticity of response to changing prices should be interpreted with some care. Many of the interviewees had no authority to vary recipes. It also appeared that most had never considered the question, never having experienced anything but stability in the price relationships of sweeteners. It would be much more illuminating to repeat the interviews now that changes in sugar prices have occurred.

Quality of Product

One case of incompletely refined beet sugar (from an Eastern Region plant) was encountered. The sugar in solution was cloudy and gave off a "beet" odor. No other respondent could recall any case of quality problems in any sweeteners in his experience in the past 5 years, which would seem to speak rather well for suppliers of sweeteners in general.

Seasonality

Beet sugar seemed to be available only seasonally on the eastern fringes of the area; this was not regarded as a problem, since adequate supplies of cane were always available.

Services

Technical services did not appear to be a competitive factor in the dry sugar market where most beet sugar is sold. However, liquid sugar sellers have made available special services to help acquire and hold customers. Some instances of assistance by liquid sugar distributors in financing the bulk storage tanks and distribution systems were encountered. The customer paid back the cost over a long period by adding a small amount to each delivery. This keeps the customer in the "fold," at least until the tank is paid for. Liquid sweeteners must be treated with special care, for they are subject to mold and bacterial contamination. Thus, some liquid sugar manufacturers make a practice of providing periodic cleanings and inspectionsof the storage and distribution facilities. This service also retains customers, for if the customer buys from more than one distributor, neither is likely to accept the responsibility for problems. Once the firm has acquired capital equipment for liquid sugar, the asset is "fixed," and he is likely to be a long-term customer for this form of sweetener.

Technical Advances in Storage and Utilization

Over a third of the firms contacted used bulk storage for all or part of their sugar needs. None of those with bulk storage used beet sugar, primarily because of its limited availability, as noted earlier. Not surprisingly, bulk handling was associated with large annual usages and with products requiring liquid sweeteners in their production process, i.e., soft drink bottlers and fruit processors.

C. Sugar Pricing and Prices

The price paid by a sugar consumer depends on a number of factors. The general level of sugar prices is influenced, within limits, by the administrative policy of the United States Department of Agriculture. A relatively large portion of the delivered cost of sugar is represented by transportation charges. Thus, the distance from a producing point affects delivered price to a consumer. Finally, local and regional competitive factors have resulted in geographic variations in sugar prices. We shall discuss the influences of these in some detail.

The General Level of Sugar Prices

As was mentioned in connection with the discussion of sugar policy in Chapter II, the general level of sugar prices is administered, within certain limits, by the Department of Agriculture on authority granted to the Secretary to determine the total supplies of sugar to be marketed. The language of the Sugar Act, as amended, allows the Department broad discretionary power in this matter. The determination shall be made so as to provide "such supply of sugar as will be consumed at prices which will not be excessive to consumers and which will fairly and equitably maintain and protect the welfare of the domestic industry...."[1]

The relationships between the United States' market price and the world market price, combined with Cuba's willingness to forego short-term gains in order to maintain long-term access to the United States' market, provided the means for this control. The residual nature of the world market for sugar resulted in world market prices being much lower than the prices prevailing in the United States' market. On the few occasions when rising international tensions (such as the Korean and Suez crises) sent world prices to levels above those in the

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[1]U.S. House of Representatives, 87th Congress, 2nd Session, Conference Report on Sugar Act Amendments of 1962, House Report No. 1957, Government Printing Office, Washington, D.C., June 29, 1962.

United States, the former Cuban regimes continued to supply sugar to the United States' market in quantities sufficient to avoid any undue influence on the United States' prices. However, since Cuban sugar has been replaced in the United States' market by a large number of suppliers, the price of sugar has followed that of the world market in the first instance encountered of rising world prices. Thus, under the present operation of the Sugar Act, the general level of sugar prices in the United States can be said to be dependent on that in world markets when the price in the latter is high.

In view of the elasticity of sugar supply over the longer run, it appears that the conditions of short supply in world markets experienced in 1963 cannot be considered to greatly influence the longer term outlook for the general price level of sugar in the United States. Hence, it is appropriate to return to the experience under the Sugar Act for guidance on long term price expectations.

The language of the Sugar Act quoted above provides the analyst with no clear notion of what might be expected for the general price level of sugar. The terms "excessive to consumers" and "welfare of the domestic industry" are subject to varying interpretations, depending somewhat upon one's point of view. The 1962 amendments to the law do explicitly mention that the relationship between price of raw sugar and the parity index is to be taken into account. Similar but not identical concepts (whole price of refined sugar and the B.L.S. Cost of Living Index) were in the previous law. A check on the trends in the relationship between these latter two variables over the past decade shows that the supplies to the United States' market have been such that the price of sugar has risen at a rate somewhat less rapid than that of the Consumer Price Index.[1]

Sugar Division officials, when queried on this subject, were loath to admit any specific policy with respect to the relationship between wholesale refined sugar price and the consumer price index. However, examination of the data in the decade 1952-62 suggests that a one point increase in the CPI is associated with a change of about 0.67 point in the index of wholesale refined sugar prices. The relationship does not appear to be random (i.e., this relation is approximated each year, rather than being an average of a period of years).[2]

In the 1962 amendments, as noted earlier, the variables to be considered were changed to the price of raw sugar, and the Parity Index (Index of Prices Paid by Farmers). The rate of increase in the Parity Index has been of similar magnitude of that of the Consumer Price Index.[3]

It is therefore concluded that the general level of sugar prices will over the longer run increase at a very moderate similar rate (excepting, of course, during periods of shortages in the world market).

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[1] Sugar Reports 126, October, 1962, Table 18. The Consumer Price Index stood at 128, while an index of wholesale sugar prices was at 120 for the year 1962. (1947-49 = 100 for both indexes.)

[2] Sugar Reports 126, October, 1962, Table 18.

[3] Ibid., Table 13.

The Basing-Point Method of Pricing

Commodities such as sugar which (a) are generally standardized or undifferentiated and (b) for which freight costs are a significant part of delivered price, are typically sold on a "basing-point" pricing system. This method of pricing insures that delivered prices of a standard commodity at any geographic point are equal for all distributors in the market. (With a standardized commodity, quoted prices must be equal, or the seller having a higher price will move none of his product.) A basing point is usually the location of one or more major sellers. This center of distribution will originate most of the sugar sold in the surrounding area and so will tend to "make the market." The price of sugar in the territory will be the quoted "basis price" at the distributing center, plus freight charges from the basing point to the destination. Sellers at any basing point tend to quote the same price. For each basing point there is a natural territory, for which freight rates are lower from the territory's basing point than from any other basing point.

The result of this system is that the price at any point in the territory is the basis price plus the freight rate from the basing point for any shipper, whether his sugar originates from within or without the region. This situation makes possible "freight earnings" or "freight absorption," depending on the location of the seller and the destination of the sugar.

Freight absorption occurs when sugar is sold outside the shipper's own basing point territory. His freight charges are by definition higher to any point in the other territory than from that territory's basing point. However, in order to meet the market price, he must not quote more than the other territory's basis price plus shipping charges from its basing point to the location in question. Assuming that basis prices for each territory are the same, as is usually the case, then he must "absorb" some of the freight charges from his own location to the point of sale.

Freight earnings can arise when a seller (usually a small producer who does not materially affect the market) can ship for less to a destination than can other sellers at the basing point. The seller bills the purchaser for the basis price plus the freight rate from the basing point (which is called the "prepay"). However, he only pays the actual freight from his own location to the destination. He can do this since he has no reason to quote a lower delivered price than that from the basing point. The difference saved between freight charges or "prepays" and actual shipping costs are "freight earnings."

Under what might be termed normal market conditions, Eastern beet producers enjoy freight earnings on sugar sold in their territory. They originate but a small proportion of the sugar in their territory, which is in the Baltimore basing-point territory. Thus, they earn the difference between shipping charges from Baltimore and actual cost of freight. Prepays into Michigan from Baltimore are on the order of 60 to 65 cents per cwt. Actual freight costs of Michigan producers may be but half of this. It is, of course, advantageous for these producers (or any other, for that matter) to confine their sales to markets near the factories. The seller is always faced with the choice between price concessions in the nearby market or absorbing larger freight costs to more distant points.

Price Discount on Beet Sugar

Beet sugar has traditionally quoted at prices below that for cane sugar in the same market. This differential is usually about $0.20 per cwt., basis 100 pound bags. Some of the reasons for this date back to a period when production techniques were such that the quality and purity of beet sugar was sometimes inferior to that of cane. This condition has for the most part been overcome. Another explanation offered is that beet sugars are not always available in the range of grades and packages that are desired, nor are they available over the complete season. In order to penetrate a market dominated by cane sugar, beet sugar price has been set at a point below that quoted for cane. In recent years, the differential has been eliminated in the Pacific Coast states but is usually quoted in the North Central market.[1]

Price differentials on consumer sized packages.--Interviews with persons in the sugar trade indicate that a two-price system may be developing in the industrial and consumer markets in this region. Differentials of industrial grades below consumer packs are often greater than the differences in costs of bagging. Brand preferences of consumers may make this possible. It is more difficult for sugars from other regions to penetrate the consumer market with unfamiliar brands and packages than to compete in the undifferentiated industrial market. It was noted earlier that the Michigan processors sell up to 60 percent of their output in consumer size packages. They are thus partially insulated from the competition in the industrial grades.

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[1]Sugar pricing is more complex than this brief discussion would imply. For treatment of taxes, cash discounts and other details, see Cottrell, R. H., Beet Sugar Economics, Caxton Printers, Inc., Caldwell, Idaho, 1952, Chapter XX or Turner, Jack T., Marketing of Sugar, Richard D. Irwin, Inc., Homewood, Illinois, 1955, Chapter XII.

Regional Markets and Sugar Prices

The price received for Eastern beet sugar is influenced to a great extent by the regional trade flows in sugar. The five states of the Eastern beet region (also termed the "East North Central" area in other contexts) consume nearly 25 percent of the deliveries in the Continental United States. (See Table 6.7.) The beet sugar production in this area supplies but a fraction of this demand. Hence, the supply must be shipped in from elsewhere. Examination of Table 6.7 shows that Mid-Atlantic and Louisiana cane mills and refiners, the California area (beet and cane refiners), and the Mountain area beet producers have surplus sugar which cannot be absorbed in their own regions. Some of the production from each of these surplus regions finds its way to the North Central deficit areas. Chicago, because of its large population, because of its being a major center of industries who use sugar, and because of its role as a market and transportation center, is the hub and focus of the North Central sugar market.

The ability of all of these regions to participate in the North Central sugar markets is influenced by the freight rate structure. Rail rates on carload lots of sugar have been adjusted by the various carriers in order that the Chicago and central markets are retained for shippers from their respective regions. Thus, for example, sugar from a California point enjoys freight rates to Chicago roughly equivalent to that from New Orleans, although the distance involved is much greater.[1]

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[1]See Fair, M. L. and E. W. Williams, Economics of Transportation, Revised edition, Harper and Bros., New York: 1959, for a discussion of the evolution of rail freight rates on sugar.

TABLE 6.7. RECEIPTS, PRODUCTION AND DISTRIBUTION OF SUGAR BY STATE AND REGIONS, OCTOBER 1961-SEPTEMBER, 1962[a]
1,000 CWT., REFINED VALUE

States and Regions	Production and Receipts	Distribution	Surplus or Deficit
Connecticut	-------	1,338	-1,338
Maine	-------	667	-667
Massachusetts	8,905	5,190	3,175
New Hampshire	-------	375	-375
Rhode Island	-------	510	-510
Vermont	-------	302	-302
NEW ENGLAND	8,905	8,382	523
New Jersey	-------	8,155	-8,155
New York	30,391	18,102	12,289
Pennsylvania	16,149	12,718	3,431
MID-ATLANTIC	46,540	38,975	7,565
Delaware	-------	298	-298
District of Columbia	-------	438	-438
Florida	4,619	3,966	653
Georgia	4,336	5,570	-1,234
Maryland	10,710	4,181	6,529
North Carolina	56	4,187	-4,131
South Carolina	56	1,848	-1,792
Virginia	318	3,201	-2,883
West Virginia	-------	1,007	-1,007
SOUTH ATLANTIC	20,095	24,696	-4,601
Alabama	75	2,744	-2,669
Arkansas	-------	1,216	-1,216
Kentucky	-------	2,702	-2,702
Louisiana[b]	40,289	3,900	36,389
Mississippi	-------	1,658	-1,658
Oklahoma	-------	1,554	-1,554
Tennessee	-------	3,783	-3,783
Texas	5,233	8,691	-3,458
SOUTHERN	45,597	26,248	19,349

States and Regions	Production and Receipts	Distribution	Surplus or Deficit
Illinois	------	19,248	-19,248
Indiana	------	4,893	-4,893
Michigan	2,318	6,600	-4,282
Ohio	830	8,817	-7,987
Wisconsin	190	3,703	-3,513
E. NORTH CENTRAL	3,338	43,261	-39,923
Iowa	467	2,184	-1,717
Kansas	------	1,432	-1,432
Minnesota	3,429	2,480	949
Missouri	------	4,628	-4,628
Nebraska	2,998	1,439	1,559
North Dakota	------	312	-312
South Dakota	328	517	-189
W. NORTH CENTRAL	7,222	12,992	-5,770
Arizona	------	665	-665
Colorado	8,023	1,281	6,742
Idaho	5,009	372	4,637
Montana	2,520	365	2,155
Nevada	------	129	-129
New Mexico	------	297	-297
Utah	952	703	249
Wyoming	1,840	93	1,747
MOUNTAIN	18,344	3,905	14,439
Alaska	------	47	-47
California	25,799	18,247	7,552
Oregon	2,164	1,932	232
Washington	3,197	2,552	645
PACIFIC	31,160	22,778	8,382
UNITED STATES	181,201	181,237	

TABLE 6.4. Continued

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[a]Sources: Production and Receipts, Mainland Cane Production from Sugar Reports 115, Table 5; Sugar Reports 118, Table 5, and Sugar Reports 127, Table 6.

Beet area production--U.S. Beet Sugar Association. Offshore raws (converted to refined basis) from Sugar Reports 120, Table 30, and Sugar Reports 133, Table 26.

Offshore Direct Consumption Sugars - Sugar Reports 120, Table 31, and Sugar Reports 133, Table 27.

Distribution--Sugar Reports 118, Table 16, and Sugar Reports 127, Table 16.

[b]Production and receipts include raw sugar shipped to inland points for refining.

The basis price for sugar in the Eastern beet and Chicago West territories has often times been somewhat lower than that quoted at seaboard refinery points in recent years. This is not surprising, in view of the competition of surplus sugars from all the surrounding regions. Thus, the sugar market of Chicago and vicinity has been called the "great dumping ground of homeless refined sugars,"[1] as sugar is shipped in by producers in other areas, in order to avoid ruining their home markets.[2]

The declines in Midwestern price have been generally attributed

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[1]Cottrell, Beet Sugar Economics, op. cit., p. 336.

[2]The behavior of this market appears to be explained by the notion of price discrimination in imperfect markets. The relatively high transportation costs to an extent insulate each producing area from others, and in the large competitive market in the North Central states each producer would face a demand of greater elasticity. It pays the firm to equate marginal cost with marginal revenue in each market, and the price would be lower in the more competitive market with the greater elasticity of demand. See Boulding, K. E., Economic Analysis, 3rd ed., Harper Bros., New York, 1955, p. 611.

to the competition of increasing supplies of beet sugar. Growth of output in the Western and Central states' beet areas has outpaced population growth, and these sugars have had to penetrate the Midwest in search of markets. Price concessions have been necessary in order to effect this penetration, in addition to the freight absorption required to market Western and Central beet sugar in the Midwest. Table 6.8 demonstrates the relationship between total beet sugar production and marketings of beet sugar in the East North Central states.

Another element which should not be overlooked is that the North Central Region is the point of origin of almost all corn sweeteners, which intensifies the competition for the sweetener market.

Effects on the Eastern Region

The effects of these competitive conditions on the basis price and net proceeds to beet sugar have been of considerable concern to the Eastern beet producer. A number of factors are thought to contribute to the particular effects on the region. First, the Eastern producers are price takers, even in their home markets. Hence, the competitive behavior of major cane and beet suppliers is the major influence on the market. Also, the structure of transportation rates is such that a more favorable freight absorption from other beet areas can be obtained for sugar sold in portions of Lower Michigan than in, for example, Illinois.[1] Thus, beet sugar is shipped into Southern Michigan in competition with

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[1]Kweskin, S. R. (Lamborn and Co., Sugar Brokers, Saginaw, Mich.), Marketing Michigan Beet Sugar, Speech at Sugar Beet Day, Michigan State University, January 28, 1958 (processed).

TABLE 6.8. BEET SUGAR PRODUCTION, U.S. AND BEET SUGAR DISTRIBUTION, EAST NORTH CENTRAL STATES, 1949-62

Crop Year (beginning Oct. 1)	Beet Sugar Production U.S. 1,000 tons[a]	Calendar Year	B. Sugar Deliveries East North Central States[b] 1,000 tons refined
1948	1,227	1949	453
1949	1,503	1950	573
1950	1,883	1951	568
1951	1,440	1952	437
1952	1,419	1953	554
1953	1,750	1954	595
1954	1,868	1955	579
1955	1,617	1956	621
1956	1,843	1957	762
1957	2,068	1958	829
1958	2,068	1959	823
1959	2,151	1960	779
1960	2,313	1961	1,010
1961	2,263	1962	902

[a] Source: Adapted from U.S.D.A., Sugar Division, Sugar Statistics and Related Data, Volume II, Washington, D.C., 1959, Table 2, and Sugar Reports 125, September, 1962, Table 29.

[b] East North Central States are Wisconsin, Illinois, Indiana, Michigan, Ohio--Source: U.S.D.A., Sugar Division, Sugar Statistics and Related Data, Volume I, 1961, Table 12, and Sugar Reports 130, February, 1963, Table 18.

local sellers. There is also the influence of truckers who avoid empty runs back from Chicago by purchasing sugar at cut rates and hauling it back to Michigan for a small margin. Furthermore, the long existence of a beet industry in the Eastern Region assures the acceptability of the beet product in this area, a consideration which does not always hold true in areas further East which have had little or no experience with beet sugar.

The actual effects of these forces on net proceeds are somewhat difficult to demonstrate. The actual price may be considerably below that listed, due to unannounced discounts and allowances. A Sugar Division official, in response to a query from the author concerning the reliability of the various price series on sugar, replied as follows:

> ....The extent and variety of unannounced discounts and allowances have increased markedly and the development of a comparably reliable adjusted price series for more recent years seems out of the question.[1]

For many years, the Michigan producers have quoted a lower price in the Southwestern Michigan "coffin corner" market. For example, a trade publication in late 1962 stated, "Michigan beet processors list $9.15 in the lower peninsula of Michigan, and $8.80 in the Southwest corner of the state."[2]

The United States Department of Agriculture price series for

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[1]Personal communication, July 25, 1962, Herbert G. Folken, Program Analysis Branch, Sugar Division, U.S. Dept. of Agriculture.

[2]Lamborn Sugar-Market Report, Vol. XL, No. 45; (weekly) Lamborn and Co., New York, Nov. 5, 1962.

Eastern beet sugar does not include the price required to meet competition in the Southwestern part of Michigan. Hence, this quotation reflects the extent of these influences only when the competitive area extends throughout Michigan's lower peninsula. This occurred, for example, in 1961 and the average basis price for Eastern beet sugar was below the Chicago-West figure for that year. (See Table 6.9.)[1]

Effect of competitive factors on net proceeds to Eastern beet producers.--The above difficulties with the official price series led to a search for other relationships. The variable of most interest to the beet industry is "net proceeds."[2] The Department of Agriculture does not compute a separate series on net proceeds for individual regions. However, an approximation for the Eastern Region was developed by use of other available data. The Department does publish series by regions on (a) payments to growers per ton of beets and (b) on recovery of refined sugar per ton of beets. These data and assumptions as to the typical Eastern region arrangements for sharing net proceeds provide a basis for an approximation.[3]

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[1]In that year, the initial U.S.D.A. consumption estimate (measured on a per capita basis) was somewhat larger than had been typical. Prices in all regions suffered, but the effect was greatest in the marketing area for Eastern beet sugar. See Table 6.9.

[2]The concept of "net proceeds" was introduced in Chapter III. It refers to the return per cwt.of sugar after specified marketing and shipping charges have been deducted. In effect, this is the net price shared by grower and processor.

[3]The resulting series is no more than an approximation. The basis for payment includes the share of by-products. The amount of pulp and molasses derived per ton of beets varies somewhat from year to year, as do their prices. Also, in some years special bonuses may be included in the payment to growers, which would be unaccounted for due to lack of data.

TABLE 6.9. SELECTED CANE AND BEET SUGAR WHOLESALE PRICES, WITH TAX, BY AREAS, ANNUAL AVERAGE, 1947-62 [a/b/]

Year	Raw Sugar New York Duty Paid	Refined Cane Sugar Wholesale Northeast	Refiners' Theoretical Margin Northeast	Refined Cane Sugar Wholesale Gulf	Refined Cane Sugar Wholesale Chicago West	Refined Beet Sugar Wholesale Chicago West	Refined Beet Sugar Wholesale Eastern
				Cents per Pound			
1947	6.21	8.29	2.08	-	-	-	-
1948	5.54	7.76	2.22	-	-	-	-
1949	5.81	7.97	2.18	8.01	8.01	7.86	7.81
1950	5.93	8.00	2.07	8.00	8.00	7.80	7.82
1951	6.06	8.38	2.32	8.38	8.38	8.12	8.18
1952	6.26	8.62	2.36	8.55	8.61	8.41	8.42
1953	6.29	8.72	2.43	8.60	8.60	8.42	8.56
1954	6.09	8.72	2.63	8.55	8.56	8.35	8.50
1955	5.95	8.59	2.64	8.50	8.49	8.29	8.39
1956	6.09	8.77	2.68	8.60	8.58	8.38	8.52
1957	6.24	9.15	2.91	8.95	8.82	8.62	8.63
1958	6.27	9.27	3.00	9.06	8.89	8.68	8.61
1959	6.24	9.33	3.09	9.28	8.88	8.67	8.71
1960	6.30	9.43	3.13	9.39	8.97	8.77	8.79
1961	6.30	9.40	3.10	9.23	8.76	8.59	8.36
1962	6.45	9.60	3.15	9.03	9.15	8.95	9.07

a/ Source: U.S. Dept. of Agriculture <u>Sugar Statistics</u>, Vol. 1, Sugar Reports 126, and Sugar Reports 130.

b/ Basis prices, 100 lb. bags, not delivered prices. To derive delivered price, add freight prepays and deduct any discounts and allowances.

An attempt was made to measure the various influences on this approximation to net proceeds by statistical techniques. It was hypothesized that net returns (which is denoted N) were influenced by (a) the general price level for sugar (denoted P_s), and (b) the supply of beet sugar (denoted Q_b), and (c) a random component (denoted u).

$$N = f\ (P_s,\ Q_b,\ u)$$

A number of variables were tested before arriving at a final combination. Due to the provisions of the Sugar Act, the general price level of sugar was assumed to be predetermined. Since the wholesale cane sugar price was the variable defined by the legislation until mid-1962, it was used as an independent variable to represent the general price level of sugar in the equation.

Several variables were tested as measurements of beet sugar supplies, including total beet sugar production and per capita and total beet sugar deliveries to the East North Central Region. The variable which contributed most to the explanation of the variation in the dependent variables was total deliveries to the East North Central Region. Each of these variables was fit by standard least squares techniques to equations of linear and logarithmic form. The logarithmic form explained the largest proportion of variance in the dependent variable.

The resulting equation, based on time series data for crop years 1949-1961 was:

$$\log N = \underset{(.26)}{.1944} + \underset{(.33)}{.9258} \log P_s - \underset{(.07)}{.1493} \log Q_b$$

$$R^2 = .46$$

(Numbers in parentheses are standard errors of the regression coefficients.)

The signs of the coefficients were as hypothesized. The regression coefficients were tested to determine if they were significantly different from zero. The _t_ statistic was calculated to be .74 for the intercept, 2.84 for the coefficient of sugar price, and 2.04 for the coefficient of beet sugar deliveries. Thus, the coefficient of sugar price is the only coefficient significant at the 5 percent level.[1]

Taking derivatives of the equations for the region (at the mean) it was found that a 100,000 ton increase in deliveries of beet sugar to the East North Central Region was associated with a $0.18 decline in net proceeds per cwt. in the Eastern Region and a $1,00 change in the wholesale price of refined sugar in New York was associated with a $0.71 change in net proceeds.

The necessity for utilizing an approximation probably accounts for some of the relatively low explanatory values encountered (R^2 = .46). The effect of these same independent variables on net proceeds to all beet sugar delivered in the United States was also measured as a matter of curiosity. The resulting regression coefficients were of similar magnitude to those estimated for the region but were all significant at the one percent level, and the coefficient of determination was relatively large (R^2 = .85).

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[1]The value of _t_ must exceed 1.81, 2.23 and 3.17 for significance at the 10 percent, 5 percent, and one percent levels, respectively. (Ten degrees of freedom.)

The statistical analysis indicates that the increasing supplies of Western beet sugar have an important influence on prices and net returns to Eastern beet sugar producers. The announcement of plans to construct additional facilities in Central and Western beet growing areas indicates that this problem is likely to become more serious in the future, unless beet sugar producers in those areas are able to enlarge their share of markets close to their producing areas.

Conclusions

In summary, then, the net proceeds from the sale of Eastern Region beet sugar are influenced by (a) the general level of sugar prices in the United States, (b) the average distance from the factory to point of delivery, (c) the quantities of sugar (particularly beet) which are marketed in the region, and (d) the proportion of sugar distributed in consumer markets.

The effects of these factors vary over time, largely with the supplies and competitive behavior of the larger elements in the market.

Implications for expansion.--The inferences to be drawn from the previous discussion is that expansion of output in Eastern areas at a rate faster than the normal growth of the market could be expected to decrease "net returns" per bag to some extent. The larger outputs would have to be sold in more distant markets at additional transportation costs. More intense competition would likely be encountered, particularly in the industrial sectors of these markets. Price concessions might be required to penetrate consumer markets in areas not presently familiar with the brands.

However, even a large increase in production in the Eastern Region (relative to present levels) would not change the region's role as price-takers in the large Midwestern sweetener market. The major influences on prices (aside from the government) will continue to be the competitive actions taken by the large suppliers to the market.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

Beet sugar production in the Eastern Region (Michigan, Ohio, Wisconsin, Illinois and Indiana) in the past three decades has been characterized by a decline in the level of production, both absolutely and relative to other areas. Michigan and Ohio contain the only remaining production locations in the Region. Recent developments, in particular rapid technological advances in sugar beets and changes in the federal statutes governing the sugar industry, have raised questions concerning the feasibility of expanding beet sugar production in the Region. The purpose of this study has been to examine the trends and changes in the economic, technical and institutional factors influencing the industry and which determine the advisability of expanding output. The analysis has focused on the present producing localities in the Eastern Region, although there is some relevance to the other states.

Institutional.--The domestic sugar industry operates under a complex system of governmental controls. The Sugar Act authorizes the Secretary of Agriculture to determine the supply of sugar which will result in prices which are fair to consumers and will serve to maintain the domestic industry. These goals are implemented by a quota system whereby each producing area, domestic or foreign, is assigned a quota which it may sell in the United States' market. For many years the quota arrangement operated effectively to stabilize prices at reasonable levels. This form of program can successfully stabilize prices only when world supplies are large relative to consumption, as has been the case during most of the past four decades. When the world stocks of sugar became relatively small in the early months of 1963, the United States' price of sugar followed the rapid advance in the international market, since nearly half of United States' needs are purchased from foreign sources. The short run inelasticity of sugar supply and long lead time required for adding processing capacity indicate that world supplies will be relatively short for at least two to three years.

Sugar beet production technology.--Sugar beet production in the Eastern Region, as elsewhere, has undergone a dramatic transformation in the period since World War II. Formerly the heavy seasonal demands of the crop for labor were met by importation of migrant field workers. However, the introduction and adoption of mechanical harvesters some years ago eliminated the need for the migrant labor in the beet harvest period. The development of monogerm seed varieties and mechanical stand reduction techniques have reduced by half the demand for field workers in the spring thinning period over the past six seasons. Chemical and mechanical means are reducing field labor for weed control. Technologists are predicting the eventual elimination of migrant labor requirements. Along with these reductions in costs, the returns per acre have increased as yields have approximately doubled since the period 1947-49. In recent years, this advance has been partially offset by lower receipts per ton due to lower sugar content and purity of the beets. The lower quality of the beets has been attributed to less accurate topping by mechanical harvesters and high levels of nitrogen fertilizer application by growers.

Resource limitations.--A study of resource requirements for sugar beet production indicates that the supply of well adapted soils is sufficient for a relatively large expansion of sugar beet acreage. However, the distribution of these soils with respect to present or potential factory locations, when the costs of transporting beets are considered, is likely to discourage large additional acreages in the Region. No other resource appears to be limiting, but their prices are expected to continue to rise.

Production response.--An Analysis of Eastern Region production responses for sugar beets using linear programming with variable prices indicated that under reasonable projected prices, prospective technologies and reasonable resource costs, sugar beets enjoy a substantial competitive advantage over other typical crops. This implies that supplies of beets are likely to expand to the limit of present factory capacity. As large expansions in factory capacity are of questionable profitability (see below), sugar beet supplies are likely to be adequate for prospective processing capacity. These results are qualified by analysis of other factors influencing sugar beet production response. The evidence indicates that the costs of transporting beets to a factory or loading point is of major importance in determining whether the beets are to be included in the cropping system. Relative prices of sugar beets and other crops (particularly dry beans and corn) and the presence of "fixed" specialized durables (trucks and harvesters) are also important determinants of production response. Other factors hypothesized to influence production response in sugar beets do not appear to be significant. Variability in total returns per harvested acre and proportion of acreage abandoned have both shown marked declines in recent years. The degree of variability in returns to sugar beet production is no greater than that for competing crops.

Processing of sugar beets.--Sugar beet processing utilizes an expensive plant for a relatively short processing season. A year around staff is maintained for administration and inter-campaign maintenance and to aid farmers. This burden of overhead costs cannot be met unless a full volume of beets is available relative to processing capacity. The relatively large cost of transporting beets indicates that factories must be located in the midst of large bodies of adapted soils in order to achieve a satisfactory supply of beets. The decline in number of factories in recent years in the Eastern Region can largely be attributed to the inability of unfavorably located plants to increase annual volume of beets processed in the face of stable sugar prices and rising costs of materials and labor.

Expansion of existing factory capacity appears to have fair potential in most locations. Construction of new plants would appear to be a questionable investment in the Eastern Region, even in the unlikely prospect of developing the necessary large supplies of beets at one location.

Marketing and demand.--The Eastern beet sugar industry supplies but a very small portion of the large East North Central sugar market. Producers in a deficit area would be expected to enjoy a considerable advantage, particularly for a product for which transportation costs are a significant factor. However, the freight advantage is at times offset in parts of the Eastern Region's market area by basis prices lower than that prevailing elsewhere in the nation. This price structure is a consequence of strong competition for the sweetener market among sugar suppliers from areas to the East, South and West, as well as from Midwestern corn sweetener producers.

The cost of transporting refined sugar is sufficiently large that each region is partly isolated from the others. This permits a degree of price discrimination in the deficit Midwestern markets. As a consequence of the large number of suppliers in that market, the demand facing each individual seller is more elastic than that in his home area. Thus, the price in the Midwestern market is generally lower than elsewhere.

The nature of the market for sugar is changing. Over half of all sugar supplies are now consumed by industrial users. Per capita direct domestic consumption is decreasing. Commercial users demand more varieties and grades and maintain more exact specifications for their purchases. Consumer packages now represent less than one third of the consumption. Some Eastern Region producers take advantage of a favorable acceptance of beet sugar by local consumers and market over half their output in consumer sized packages. This policy reduces some of the impacts of price and quality competition prevalent in the industrial grades.

Because of increased freight costs or from price concessions associated with penetrations of new markets, large scale expansion of output in the region would be likely to result in some reduction in net return per unit of sugar to both farmers and processors. These factors are of less importance than the competitive behavior of the large suppliers in the Midwestern market (given the level of sugar prices).

Conclusions

At this writing, the prospects for the beet sugar industry in the Eastern Region are not for either an immediate demise or for a period of rapid growth.

Sugar beet growers.--The outlook for the next half decade for sugar beet growers appears to be a period of relatively favorable returns to beet production. A better than average price situation appears likely for at least the next few crops. Technological advances are reducing costs and inconveniences and are eliminating variability of returns in beet production. There appears to be a strong likelihood that hybrid varieties will be available in commercial scale toward the end of this period. No comparable advantages are foreseen for the principal competing crops in the region. Thus, it appears that the crop will become more appealing to farmers who have not previously grown beets. The resulting increases in output are not expected to be large relative to present and prospective processing capacity.

Sugar beet processors.--Recent years have brought higher costs for nearly all purchased inputs, labor, equipment and fuel. Competitive conditions and government policy have not permitted equivalent increases in sugar prices. These problems are compounded by the adverse trend in the quality of the beets received in recent years. Offsetting factors for processors are the expected period of relatively favorable prices and the likelihood of increasing supplies of beets to enable more effective utilization of capacity. Possibilities appear to exist for continued moderate expansion of plant capacity and modernization of factories in the more favored locations.

The feasibility of making a large increase in capacity by construction of new plant facilities turns on a number of points. Even at full capacity for a large scale factory, a significant improvement in the quality of the beets would be required to attain returns sufficient to justify the investment. Furthermore, it is doubtful that such large supplies of beets could be acquired at any location in the region without the elimination of operations at one or more of the present plant sites. Given the pattern of distribution of favorably adapted soils and the relatively lesser cost per unit of capacity of expanding existing plants, it appears that new plant construction would not be economically feasible.

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APPENDIX I

CHRONOLOGICAL HISTORY OF BEET SUGAR FACTORIES IN THE EASTERN REGION[1]

Early Trials: 1838-1872

White Pigeon, Mich.	1838-40	Black Hawk, Wisc.	1870-75
Fond du Lac, Wisc.	1866-70	Freeport, Ill.	1871-72
Chatsworth, Ill.	1866-71		

1897

MENOMONEE FALLS, WISC. Erected by Wisconsin Sugar Co. Capacity, 500 tons. Dismantled in 1932.

1898

BAY CITY, MICH. Erected by Michigan Sugar Co. Capacity, 500 tons. Machinery moved to Waverly, Iowa, in 1907.

1899

ALMA, MICH. Erected by Alma Sugar Co. Original capacity, 600 tons. Dismantled by Michigan Sugar Co. in 1959.

BAY CITY, MICH. Erected by Bay City Sugar Co. Capacity, 600 tons. Dismantled by Michigan Sugar Co. in 1941.

BENTON HARBOR, MICH. Erected by Wolverine Sugar Co. Capacity 350 tons. Machinery moved to Kitchener, Ontario, in 1902.

CARO, MICH. Erected by Peninsular Sugar Refining Co. Original capacity, 600 tons and present capacity, 1,450 tons. Present owner, Michigan Sugar Co.[2]

HOLLAND, MICH. Erected by Holland Sugar Co. Original capacity, 350 tons. Dismantled by Lake Shore Sugar Co. in 1952.

KALAMAZOO, MICH. Erected by Kalamazoo Beet Sugar Co. Capacity, 500 tons. Machinery moved to Madison, Wisconsin, in 1905.

WEST BAY CITY, MICH. Erected by West Bay City Sugar Co. Original capacity, 500 tons. Dismantled by West Bay City Sugar Co. in 1943.

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[1]Source: U.S.D.A., Commodity Stabilization Service, Beet Sugar Factories in the U.S., Washington, D.C., 1961.

[2]Underlining indicates factory in operation for the 1963 season.

1900

MARINE CITY, MICH. Erected by Marine Sugar Co. Capacity, 350 tons. Dismantled in 1928.

FREMONT, OHIO. Erected by Continental Sugar Co. Original capacity, 350 tons and present capacity, 1,300 tons. Present owner, Northern Ohio Sugar Co.

1901

BAY CITY (SALZBURG), MICH. Erected by German-American Sugar Company. Original capacity, 400 tons and present capacity, 3,200 tons. Present owner, Monitor Sugar Division of Robert Gage Coal Company.

LANSING, MICH. Erected by Lansing Sugar Co. Original capacity, 800 tons. Dismantled by Michigan Sugar Co. in 1953.

SAGINAW, MICH. Erected by Saginaw Sugar Co. Capacity, 600 tons. Machinery moved to Sterling, Colorado, in 1905.

1902

CARROLLTON (SAGINAW), MICH. Erected by Saginaw Valley Sugar Company. Original capacity, 600 tons and present capacity, 1,500 tons. Present owner, Michigan Sugar Co.

CROSWELL, MICH. Erected by Sanilac Sugar Refining Co. Original capacity 600 tons and present capacity, 1,100 tons. Present owner Michigan Sugar Co.

MT. CLEMENS, MICH. Erected by Macomb Sugar Co. Original capacity, 600 tons. Dismantled by Franklin County Sugar Co. in 1951.

SEBEWAING, MICH. Erected by Sebewaing Sugar Refining Co. Original capacity, 600 tons and present capacity, 1,500 tons. Present owner, Michigan Sugar Co.

1903

EAST TAWAS, MICH. Erected by Tawas Sugar Co. Capacity, 600 tons. Machinery moved to Chaska, Minn., in 1906.

MENOMINEE, MICH. Erected by Menominee River Sugar Co. Original capacity, 1,000 tons. Dismantled by Menominee Sugar Co. in 1955.

OWOSSO, MICH. Erected by Owosso Sugar Co. Original capacity, 1,000 tons. Dismantled by Michigan Sugar Co. in 1948.

ST. LOUIS, MICH. Erected by St. Louis Sugar Co. Original capacity, 500 tons. Dismantled by Lake Shore Sugar Co. in 1955.

1904

CHIPPEWA FALLS, WISC. Erected by Chippewa Sugar Refining Co. Machinery moved from Kalamazoo, Mich. Dismantled in 1934.

JANESVILLE, WISC. Erected by Rock County Sugar Co. Machinery originally erected at Dresden, Ontario, in 1902. Capacity, 600 tons. Moved to Quebec in 1941.

1905

RIVERDALE, ILL. Erected by Charles Pope. Operated in 1926, dismantled later, possibly 1927.

BLISSFIELD, MICH. Erected by Continental Sugar Co. Original capacity, 600 tons. Dismantled by Northern Ohio Sugar Co. in 1957.

MADISON, WISC. Erected by United States Sugar Co. Machinery moved from Rochester, Mich. Capacity, 600 tons. Dismantled in 1924.

1906

CHARLEVOIX, MICH. Erected by West Michigan Sugar Co. Capacity, 600 tons. Machinery moved to Ottawa, Ohio, in 1912.

1910

PAULDING, OHIO. Erected by German-American Sugar Co. Original capacity, 700 tons. Dismantled by Great Lakes Sugar Co. in 1952. (Present owner, Paulding Sugar Co., has announced intentions of reopening this plant in 1964 or 1965.)

1911

FINDLAY, OHIO. Erected by Continental Sugar Co. Original capacity, 600 tons and present capacity, 1,250 tons. Present owner, Northern Ohio Sugar Co.

1912

OTTAWA, OHIO. Erected by Ohio Sugar Co. Machinery originally erected at Charlevoix, Mich., in 1906. Original capacity, 600 tons and present capacity, 1,400 tons. Present owner, Buckeye Sugar, Inc.

TOLEDO, OHIO. Erected by Toledo Sugar Co. Capacity, 1,000 tons. Dismantled in 1941.

1920

MT. PLEASANT, MICH. Erected by Columbia Sugar Co. Original capacity, 1,200 tons. Dismantled by Michigan Sugar Co. in 1951.

GREEN BAY, WISC. Erected by Green Bay Sugar Co. Original capacity, 600 tons. Present owner, Menominee Sugar Co. (Ceased operations after 1961 season.)

APPENDIX II

APPENDIX TABLE 1. SELECTED SUGAR BEET AND BEET SUGAR PRODUCTION STATISTICS FOR MICHIGAN, 1937-61[a]

Crop Year	(1) Number of Farms	(2) Acreage Planted	(3) Acreage Harvested	(4) % of Planted Acres Har.	(5) Har. Acres Per Farm	(6) Sugar Beet Pro.	(7) Av. Yield Per Acre	(8)[b] Per Ton Payments	(9)[b] Gross Income Per Acre	(10)[b] Total Farm Value
		1,000 Acres				1000 T.	Tons	$	$	$1000
1937	10,383	85.9	76.5	89.1	7.4	549	7.2	-----	------	------
1938	13,758	127.0	122.4	95.7	8.9	1,005	8.2	-----	------	------
1939	13,495	125.3	120.1	95.8	8.9	1,033	8.6	7.41	63.73	7,655
1940	12,756	122.8	112.2	91.4	8.8	1,022	9.1	8.19	74.52	8,370
1941	10,533	100.0	93.8	93.8	8.9	1,016	10.8	9.17	99.04	9,317
1942	13,079	140.0	111.3	79.5	8.5	1,095	9.8	10.03	98.29	10,983
1943	6,006	59.5	47.4	79.7	7.9	297	6.3	13.54	85.30	4,021
1944	7,128	69.3	59.2	85.5	8.3	520	8.8	14.78	130.06	7,686
1945	8,498	92.4	77.6	84.0	9.1	627	8.1	13.94	112.91	8,740
1946	8,518	105.6	95.3	90.2	11.2	814	8.5	16.61	141.19	13,521
1947	6,620	83.5	66.4	79.5	10.0	446	6.7	16.03	107.40	7,149
1948	4,998	63.2	52.1	82.4	10.4	457	8.8	16.29	143.35	7,445
1949	6,795	96.3	76.6	79.5	11.3	743	9.7	14.26	138.32	10,595
1950	7,706	121.3	97.7	80.5	12.7	1,020	10.4	14.19	147.57	14,474
1951	4,626	65.5	53.4	81.5	11.5	605	11.3	14.93	168.71	9,033
1952	3,924	55.4	49.3	89.0	12.6	527	10.7	15.88	169.92	8,369
1953	3,564	55.7	40.3	72.4	11.3	570	11.8	15.29	180.42	8,715
1954	4,232	76.6	64.2	83.8	15.2	771	12.0	12.39	148.68	9,552
1955	3,379	63.6	60.1	94.5	17.8	885	14.7	13.53	198.89	11,974
1956	3,370	69.9	63.4	90.7	18.8	696	11.0	15.43	169.73	10,739
1957	3,449	74.5	70.0	94.0	20.3	907	13.0	13.38	173.94	12,136
1958	3,356	77.3	71.4	92.4	21.3	1,112	15.6	13.43	209.51	14,934
1959	3,342	78.1	74.0	94.8	22.1	1,299	17.5	11.01	192.68	14,302
1960	2,885	69.4	67.9	97.8	23.5	943	13.9	13.96	194.04	13,164

[a] Source: U.S.D.A., C.S.S., Sugar Statistics and Related Data, Vol. II, Stat. Bull No. 244, February, 1959, and Sugar Reports, various issues.

[b] Includes government payments.

APPENDIX TABLE 2. SELECTED SUGAR BEET PRODUCTION STATISTICS, OHIO, 1937-61[a]

Crop Year	(1) Number of Farms	(2) Acreage Planted	(3) Acreage Harvested	(4) % of Planted Acres Har.	(5) Har. Acres Per Farm	(6) Sugar Beet Pro.	(7) Av. Yield Per Acre	(8)[b] Per Ton Payments	(9)[b] Gross Income Per Acre	(10)[b] Total Farm Value
		1,000 Acres				1,000 Tons	Tons	$	$	$1,000
1937	3,145	28.8	24.7	85.8	7.9	144	5.8	-----	-------	-------
1938	5,094	52.8	50.9	96.4	10.0	366	7.2	-----	-------	-------
1939	5,015	51.0	46.7	91.6	9.3	363	7.8	7.76	60.53	2,817
1940	4,471	44.8	40.8	91.1	9.1	374	9.2	8.88	81.70	3,311
1941	4,108	40.5	37.6	92.8	9.2	419	11.1	9.23	102.45	3,867
1942	4,900	51.1	47.8	93.5	9.8	593	12.4	8.97	111.23	5,339
1943	2,126	21.0	11.4	54.3	5.4	70	6.1	14.36	87.60	1,005
1944	1,981	17.4	12.6	72.4	6.4	113	8.9	14.61	130.03	1,651
1945	2,416	23.8	20.9	87.8	8.7	208	9.9	14.45	143.06	3,006
1946	2,639	28.8	25.6	88.9	9.7	229	9.0	16.45	148.05	3,367
1947	2,214	26.2	21.1	80.5	9.5	151	7.2	16.03	115.41	2,421
1948	1,327	14.4	13.0	90.3	9.8	161	12.3	14.93	183.63	2,404
1949	2,283	30.7	23.9	77.9	10.5	252	10.5	13.98	146.79	3,523
1950	2,195	30.3	22.4	73.9	10.2	277	12.4	13.98	173.35	3,872
1951	1,069	14.4	12.7	88.2	11.9	127	10.0	15.19	151.90	1,929
1952	1,014	13.6	11.8	86.8	11.6	131	11.1	15.29	169.72	2,003
1953	1,132	15.8	13.7	86.7	12.1	178	13.0	14.66	190.58	2,609
1954	1,100	18.0	15.2	84.4	13.8	247	16.2	11.40	184.68	2,816
1955	1,164	19.4	18.0	92.8	15.5	279	15.5	11.99	185.84	3,345
1956	1,019	18.8	16.3	86.7	16.0	199	12.2	15.07	183.85	2,999
1957	1,164	22.8	21.9	96.0	18.8	289	13.2	12.56	165.79	3,630
1958	1,101	23.1	21.9	94.8	19.9	309	14.1	13.14	185.27	4,060
1959	1,020	22.9	21.7	94.8	21.3	354	16.4	10.39	170.40	3,678
1960	921	23.2	22.4	96.6	24.3	328	14.6	13.74	200.60	4,507

[a] Source: U.S.D.A., C.S.S., Sugar Statistics and Related Data, Vol. II, Stat. Bull. No. 244, February, 1959, and Sugar Reports, various issues.

[b] Includes government payments.

APPENDIX TABLE 3. **OPERATIONS AND INPUTS PER ACRE** FOR SUGAR BEETS, LAKE BED SOILS OF EASTERN LOWER MICHIGAN AND NORTHWEST OHIO, 1966

Dates	Equipment or Operation	Size or Capacity	Power	Men	Man Hours Per Acre	Materials and Remarks
Sept.-Oct.	Plow	3-16"	3-plow tractor	1	.95	
April-May	Pre-planting tillage-spring tooth with spike harrow behind	8'	"	1	.35	Minimum tillage
April-May	Plant, fertilize and band spray (pre-emergent)	4R drill with spray attach.	2-plow tractor	1	.40	1.5# Monogerm seed @ $1.00 /# - 600# 5-20-10 fert. - spray; TCA and Endothal mix - 2 gals. @ $3.50/gal. Spray concentrate contains 3/4# Endothal and 1 1/4# TCA per gallon
May-June	Nitrogen side-dress	"	"	1	.40	50# actual nitrogen
"	Cultivate - 1X	4R	"	1	.40	
"	Hand thin (hoe-trim)			labor crew	.55	$9.00 per acre
June	Cultivate - 1X	4R	"		.40	
June-July	Hand hoe			"	.30	$4.50 per acre
Sept. 25-Nov. 7	Beat off leaves	Beater-topper	"		.50	No man hours charged. Assumed to be done by harvester operator or truck driver while waiting.
"	Harvest	1 row harvester	3-plow tractor	1[a]	2.0	Yield: 18 tons Custom rate: $20.00 per acre
"	Haul - 10 mile haul, 7 tons/load	2 or 3 trucks		2 or 3	6.5	Custom rate: $1.50 per ton

[a] Additional man (or men) may be required in cloddy or rocky fields to sort out foreign matter.

APPENDIX TABLE 4. OPERATIONS AND INPUTS PER ACRE FOR DRY EDIBLE BEANS, LAKE BED SOILS OF MICHIGAN AND NORTHWEST OHIO, 1966

Dates	Equipment or Operation	Size or Capacity	Power	Men	Man Hours Per Acre	Materials and Remarks
April May	Plow	3-14"	3-plow tractor	1	.90	
April May	Soil prep., disk & harrow	8'	"	1	.35	
May	Pre-emergent spray	4R	2-plow tractor	1	.30	Spray materials (e.g., DNPB: 4.5#)
May 28 June 10	Plant	4R	"	1	.40	35 lbs. seed, 200# 5-20-10
June 5 June 17	Cultivation-weeder	4R	"	1	.20	
June 1 July 10	Cultivation-2X	4R	"	1	.80	
June 1 July 10	Hand hoeing				2.0	Family labor
Aug. 10 Sept. 1	Chopping				1.0	Family labor
Aug. 25 Sept. 15	Pulling	2R	2-plow tractor	1	.70	
Aug. 25 Sept. 15	Windrow-Side del. rake	8'	"	1	.40	
Aug. 25 Sept. 15	Combine	10'	SP	1.5	.6	Yield: 18 cwt.
Aug. 25	Hauling			1	.35	8 miles with 90 bu./load

APPENDIX TABLE 5. OPERATIONS AND INPUTS PER ACRE FOR CORN (FOR SILAGE OR GRAIN), LAKE BED SOILS OF EASTERN MICHIGAN AND NORTHWEST OHIO, 1966

Dates	Equipment or Operation	Size or Capacity	Power	Men	Man Hours Per Acre	Materials and Remarks
April May	Plow	3-14"	3-plow tractor	1	.90	
April May	Soil prep. disk & harrow 2X	8'	"	1	.70	
May 1 May 25	Planting	4R	2-plow tractor	1	.40	.2 bu. seed (300# 5-20-10)
June 1-15	Side dress (N)	4R	"	1	.40	100# ammonium nitrate
June 1-30	Spray	16'	"	1	.40	.5# 2,4-D amine
May 10 June 25	Cultivate - 2X	4R	"	1	.80	
Sept.	Harvest (silage) - forage chopper	12 T/hr.	3-plow tractor	1	1.50	1 row small forage harvest w/row crop head. 12T/hour capacity
"	Haul and store silage 2 wagons, blower		2-plow tractor	1	5.50	Yield: 18 tons, Michigan 19.5 tons, Ohio
<u>or</u>						
Oct. 10 Dec. 1	Harvest (ear corn)[1/]	1R	3-plow tractor	1	1.35	Yield: 100 bu., Michigan 110 bu., Ohio
"	Haul and store		2-plow tractor		.70	

1/ Ear corn is assumed to be shelled only if sold. Cost deducted from net price in this case.

APPENDIX TABLE 6. OPERATIONS AND INPUTS PER ACRE FOR WINTER WHEAT, LAKE BED SOILS OF EASTERN MICHIGAN AND NORTHWEST OHIO, 1966

Dates	Equipment or Operation	Size or Capacity	Power	Men	Hours Per Acre	Materials and Remarks
Aug. 15-Sept. 20	Disk & harrow - 2X	8'	3-plow tractor	1	.70	Assumed to be after beans; no plowing required.
Sept. 15-25	Plant & fertilize	8' drill	2-plow tractor	1	.40	105# seed 300# 10-20-10
Mar. 1-April 20	Top-dress nitrogen Plant alfalfa	8' drill	2-plow tractor	1	.40	30# act. N 8# seed @ 49¢ (Seed charged to alfalfa account.)
July 8-18	Harvest	10' SP combine	-	1	.45	Yield: 55 bu. in Michigan 45 bu. in Ohio
"	Haul	wagon	2-plow tractor	1	.45	

APPENDIX TABLE 7. OPERATIONS AND INPUTS PER ACRE FOR OATS, LAKE BED SOILS OF EASTERN MICHIGAN AND NORTHWEST OHIO, 1966.

Dates	Equipment or Operation	Size or Capacity	Power	Men	Man Hours Per Acre	Materials and Remarks
April	Plow	3 x 14"	3-plow tractor	1	.90	
April	Tillage - 2X	8' disk harrow	3-plow tractor	1	.70	
April	Plant and fertilize	8'	2-plow tractor	1	.40	200# 10-20-10 72# seed
June	Spray	12'	2-plow tractor	1	.30	2-4,D amine, 1/4#
July 20 Aug. 10	Harvest	10' SP	--	1	.45	Yield: 80 bu., Michigan 70 bu., Ohio
July 20 Aug. 10	Haul	wagons	2-plow tractor	1	.45	

APPENDIX TABLE 8. OPERATIONS AND INPUTS PER ACRE FOR BALED ALFALFA HAY, LAKE BED SOILS OF EASTERN MICHIGAN AND NORTHWESTERN OHIO, 1966

Dates	Equipment or Operation	Size or Capacity	Power	Men	Man Hours Per Acre	Materials and Remarks
April	Plant	Charged to small grain enterprise.				Plant in small grains 8# seed @ $1.49
April	Fertilize	8'	2-plow tractor	1	.40	60# actual P_2O_5 20# actual K_2O
June	Mow	7'	"	1	.55	
"	Rake	8'	"	1	.40	
"	Bale		"	1	.35	twine: 55¢ per ton
"	Haul and store		"	2	1.50	Yield: 1.25 tons
July	Repeat above - mow, rake and bale				1.20	twine
	Haul and store				1.30	Yield: 1.00 tons
Sept.	Repeat mow, rake and bale				1.15	twine
	Haul and store				1.00	Yield: .75 tons