A STUDY OF THE PRODUCTION OF SUGAR IN TUCUMAN, ARGENTINA

By

Manuel L. Cordomí

THE UNIVERSITY OF CHICAGO

A STUDY OF THE PRODUCTION OF SUGAR IN TUCUMAN, ARGENTINA

A DISSERTATION SUBMITTED TO

THE FACULTY OF THE DIVISION OF THE SOCIAL SCIENCES

IN CANDIDACY FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF ECONOMICS

BY

MANUEL L. CORDOMI

CHICAGO, ILLINOIS

MARCH, 1969

ACKNOWLEDGMENTS

Since the sketch of the first ideas until the moment in which this portion is being written I received the help of many persons who generously gave me part of their time to pave a way that proved to be not very easy. To attempt to make a list of them would be beyond my time and energies and very likely incomplete.

There is certainly a group of men with whom I worked in closer contact and to whom the sense of gratitude is of a higher order of magnitude. They are the members of my thesis committee, Professors Arnold C. Harberger (Chairman), Richard Parks, and Larry Sjaastad. I received a great number of useful and relevant insights out of a series of meetings with Professor Harberger. The contact with Professor Parks was very fruitful in the design and elaboration of many experiments and statistical tests. Professor Sjaastad offered to me very generously quite a great portion of his time so that it became very difficult to conceal his ideas in the pages that follows. The contact with them all proved to be inspiring, generous and intellectually suggestive. They held me tight, however, whenever I tried to depart from higher objectives.

Two members of an earlier committee should be mentioned: Professor Theodore W. Schultz out of whom I got the first clear notion of how a project looks and Professor H. Gregg Lewis that liked to remain as a sort of sleeping partner but that proved to be awake most of the time.

I wish to express appreciation to my colleagues Victor J. Elias and Potluri Rao with whom I spent many hours of useful discussions. Both gave me the impression that it is very difficult to obtain the recognition of our contemporaries.

An attempt of describing the occasions and ways by means of which the ford Foundation and the University of Tucumán (Argentina) supported this project would be the matter of another research project. There is no evidence that they would give me financial support for this purpose.

I wish to acknowledge the chief of Dirección Nacional de Azúcar (Argentina), Mr. Juan A. Ahado for allowing me to have access to their archives and for his professional interest in this project. There, as well as in the administrations of the companies Amalia and Concepción of Tucumán, I learned something about the sugar business and the fact that it is not always a sweet one.

In almost every stage the ideas presented here were fully discussed in two main testing grounds: the Institute of Economic Research of the University of Tucumán and the Latin American Workshop of the University of Chicago. There were no casualties.

The recognition for my wife can only be understood by those that, while being married undertook a project like this, as for the others, they should marry immediately.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

"Fortune disposes our affairs better than we ourselves could have desired: look yonder, friend Sancho Panza, where thou mayest discover somewhat more than thirty monstrous giants, whom I intend to encounter. . ."

"Look, sir," answered Sancho, "those which appear yonder are not giants, but windmills; and what seem to be arms are the sails, which, whirled about by the wind, make the mill-stone go."

--Miguel de Cervantes Saavedra

CHAPTER I

INTRODUCTION

The sugar industry in Argentina, for practical purposes, began as a large-scale operation in 1875 although small-scale production of sugar dates at least from the second decade of the nineteenth century when Bishop Doctor Eusebio Colombres founded the first processing plant in the province of Tucumán.

The main center of production is the province of Tucumán and although the industry has spread over the northern parts of the Republic, Tucumán remains the main producing center. Table 1 shown the development of sugar production and the number of plants since 1908.

For the purposes of this study the sugar industry can be divided into four main sectors: (a) field (agricultural) production, (b) transport from the farms to the factories, (c) processing activities in the mills and (d) transport and distribution to consumers. This study will concentrate on the processing activities, although it will be necessary to draw somewhat on issues relating to agricultural production in order to understand some problems concerning sugar processing.

Most of the sugar produced in Argentina comes from sugar cane;

TABLE 1.--Production of Sugar in Tons and Number of Processing Plants by Province in Argentina for the Period 1908-65

Year		Tucumán	Jujuy	Salta	Santa Fe	Chaco	Corrientes	Total
1908	Production	136, 450	17, 857	1, 083	669	4, 396[a]	142	160, 597
	Plants	28	3	1	2	3	1	38
1920	Production	165, 150	28, 981	2, 911	2, 033	1, 100	559	200, 734
	Plants	26	3	2	2	1	1	35
1930	Production	276, 188	62, 985	34, 043	3, 742	4, 174	990	382, 122
	Plants	28	3	2	2	1	1	37
1940	Production	355, 345	93, 264	57, 134	22, 705	8, 688	1, 270	538, 406
	Plants	28	3	2	3	1	1	38
1950	Production	402, 164	123, 498	54, 467	19, 946	12, 919	--	612, 994
	Plants	27	3	2	3	1		36
							Misiones	
1960	Production	485, 225	186, 550	74, 189	27, 682	8, 728	--	782, 374
	Plants	27	3	2	3	1		36
1965	Production	749, 575	302, 294	102, 683	33, 673	17, 644	5, 612	1, 211, 481
	Plants	27	3	2	3	1	1	37

[a]Includes the Province of Formosa.

Source: Emilio J. Schleh (ed.), Estadística Azucarera, No. 7 (Buenos Aires: Centro Azucarero Argentino, 1947). Centro Azucarero Argentino, La Industria Azucarera, 1947-65.

some sugar beets were grown for sugar-production as early as 1929 in the provinces of Rio Negro and San Juan, but the beets sugar plants closed down in 1942. All the plants treated in this study handle cane sugar exclusively.

This industry is highly protected against world competition. Sugar production in Argentina is primarily for domestic consumption because, except in special circumstances when world prices are at extremely high levels, such as the Cuban crisis of 1963, it can not be profitably exported.

In addition to tariff protection, there are at least three areas in which government regulation has been important: (a) the control of the domestic price of sugar, (b) the control of the price of sugar cane, and (c) the control of production and sales during temporary gluts and scarcities. The full details of these regulations have been explored in other studies.[1] For the purpose of this thesis we will sketch the most important features of the government intervention as it relates to the development of the industry and the allocation of its resources.

Although there have been policy changes since 1928, the basic structure of regulation of the industry was established in that year, when the Laudo Alvear was first introduced.[2] Prior to that time the industry's activities were largely governed by the Saavedra Lamas Law (1912), which

---

[1]Emilio J. Schleh, "Precios históricos del azúcar," La Industria Azucarera, August, 1956, pp. 423-437. Argentina, Ministerio de Comercio e Industria, Instituto de Investigaciones Económicas, Problema azucarero argentino (Buenos Aires; IAPI, August, 1956).

[2]Argentina, Presidency, Laudo del Exmo. Sr. Presidente de la

continued in effect after the adoption of the Laudo Alvear. The Saavedra Lamas Law and the Laudo Alvear are very important not only because they cover most of the aspects of government intervention and incorporate the flavor of the pre-existing legislation but also because they have exerted pervasive influence on the future development of government actions.

The main provisions of the Saavedra Lamas Law refer to the set of import duties for sugar. This law also fixed a wholesale ceiling price of 0.41 Argentine Pesos per kilogram of sugar. Should domestic price rise above this level, the importation of sugar would be allowed. Laudo Alvear is a document promulgated during the presidency of Dr. Marcelo T. de Alvear in 1928, which arbitrated a conflict between cane growers and processing plants concerning the price of sugar cane for the "zafra"[1] of 1927. In addition, Laudo Alvear established the basis for setting the price of sugar cane from 1928 forward by creating a share system which divided the proceeds of the sale of sugar between farmers and producers. Initially the farmers' share was fixed at one half of the proceeds from the sale of sugar.

The adjustments of production to consumption in the short run in 1928 were influenced by a glut in sugar stocks resulting from abnormally large harvests for two successive years. This task was

---

Nación Doctor Marcelo T. de Alvear, May 1928 (Buenos Aires: Dirección nacional de Azúcar y Envases, n.d.).

[1] The zafra is the period during which sugar cane is cut ant the processing plants are operating, usually starting in May and continuing for two to four months.

accomplished mainly by laws that established a maximum quota of production per plant (set at 70 per cent of the production of each plant in 1926) and a heavy tax for every kilogram produced above this limit. These measures were matched by analogous measures in the farm sector. Simultaneously there were arrangements among factories to export a portion of the redundant stocks so as to ease the pressures on the domestic market. Substantial exports of sugar can be traced in the statistics for these years. These arrangements convey a fair description of the framework within which the industry operated until roughly 1944.

The period starting in 1945 is of special interest because it was characterized by increased government intervention in the context of a substantial inflation. Of the four main areas of government intervention, regulations of prices and the criteria for determining the price of sugar cane departed substantially from their earlier pattern.

During the early part of the 1945-63 period, the maximum ceiling price of 0.41 pesos per kilogram was effectively enforced, but from 1946 to 1949, a period of inflation, subsidies to producers were needed to induce them to supply what consumers demanded at this price. The subsidies were paid out of funds earned by a government agency engaged in the marketing of the main export products of the Argentine economy.[1] With inflation increasing substantially and IAPI doing poorly in foreign markets, subsidies became an unbearable burden for the government,

[1] This agency, IAPI, was known as Instituto Argentino para la Promoción del Intercambio.

hence it decided, in October, 1949, to suspend the policy of subsidies.

The years 1950-58 can be called the period of the "Regulatory Fund," a new arrangement for controlling the price of sugar and the profits of the plants. The price of sugar was allowed to rise to a new maximum established by the government. This maximum was set equal to the average of the costs of production, somehow determined, of all the existing plants. Apart from the problem of determing such a price, this scheme allowed each plant the right to retain from its sales an amount just enough to cover its average cost; any excess of sales over and above this amount was to be remitted to the Regulatory Fund to cover the losses of plants incurring deficits at the prevailing price. Originally the designers of this scheme made a projection of the price of sugar that would permit the Fund to be self financing. Normally the prices were fixed every year on the basis of the average national productivity of the industry expressed as the amount of sugar produced per unit of sugar cane.[1]

We do not have much evidence concerning the implementation of the policy. It seems to have functioned with great difficulties almost every year not only because the plants refused to make the payments that the system demanded but also because it was not self-financing in practice, even though payments were made, so that the government, through the official banks, had to cover the deficits that emerged in almost every year. As a result of these difficulties it appears that the Regulatory Fund

---

[1]The price was fixed in such a way that if productivity so defined was for any plant 7.8 per cent, then it should balance with the Fund.

was ineffective for at least a part of the period 1950-58. The best available information indicates that it was partially enforced during 1950-55 (which we will label as the period of a strong Regulatory Fund) and that was virtually unenforced from 1956 to 1958(which we will label the period of the weak Regulatory Fund).

The period 1959-63 involved no special government intervention apart from the enforcement of a price ceiling. Subsidies and the Regulatory Fund were abolished and the price of sugar cane was made to depend more fully on sugar yields.

Examination of the different policies pursued by government from 1943-63 conveys the impression that all of them were harmful from an economic welfare point of view. The quality of sugar cane was impaired as a result of the criteria selected for fixing the price of sugar cane, and the policies followed during the period of strong Regulatory Fund had misallocative effects within the operating plants.

CHAPTER II

ECONOMIC IMPLICATIONS OF GOVERNMENT POLICIES

Policy Variable

In this chapter special consideration will be given to those government actions that might have affected the quality of sugar cane delivered by cane growers to the processing plants and those that might have affected the use of the productive resources within the plants themselves.

An outstanding characteristic of the way in which the prices of sugar cane were determined during 1928-63, and probably long before, is the absence of organized markets in which the forces of supply and demand operated directly. The period under study can be conveniently divided into three parts: 1928-44, 1945-49, and 1950-63. During the first period a pure share system between cane growers and plants prevailed for the determination of the price of sugar cane; this method was already working somewhat spontaneously in operation in 1927 and earlier but from 1928 forwards it was established legally as a result of the arbitration of the then President of the Republic, Dr. Marcelo T. de Alvear. The arbitration decision can be found in a celebrated document "Laudo Alvear" and at the core of the principle established for the determination of the prices of sugar cane lies a share system between cane growers and factories. Laudo

Alvear established that the price for cane fulfilling minimal standards of quality and purity should be a fraction (50 per cent) of the commercial value of the sugar obtained (the sugars of different quality were reduced to a common base with the aid of a technical function; molasses was included separately). The yield of a grower's own cane could be automatically assessed at the average yield of the factory, but had to be independently measured upon the request of either the grower or the factory management. Considerations concerning the treatment of freight may complicate the picture but they will be ignored in the following discussion. If P_s is the price of sugar, f is the fraction of the proceeds that accrues to the cane grower and S/C is the yield of cane (tons of sugar obtained per ton of sugar cane), then Laudo Alvear prescribed that the price of cane should be:

$$p = f.p_s\,(S/C) = k.y \qquad (f.p_s = k;\ S/C = y).$$

There was no limit to the quantity of cane that could be delivered under this condition.

The period 1945-49 was of a substantially different nature. The price of sugar cane was established with no relation to its sugar content or yield and the price was a fixed amount per ton of sugar cane.

The period 1950-63 is characterized by a general effort relating cane prices more closely to sugar content, but in the process a considerable variety of different specific policies emerged.

The policies of this last period can very easily be described mathematically with a formula that depicts its nature clearly. The general idea was to fix a given price for cane of a certain yield plus a premium per point of additional yield over and above the base.

$$p = a' + b(y - y^o) \qquad (y^o = \text{base yield})$$

$$p = a' - b.y^o + b.y$$

$$p = a + by$$

This formula is very useful because depending on the values of a and b the whole set of the above mentioned policies can be replicated. If a equals zero we are in the case of Laudo Alvear, if b equals zero, the price is constant regardless of the yield, if both a and b are positive, then we have prices varying as a function of yields, so that different combinations of a and b can be used to describe the entire spectrum of policies followed during the period 1950-63.

It should be noticed that the prices emerging as a consequence of the yield formula are unlikely to coincide with those that would prevail under the free operation of the market forces; this may be an important source of misallocation of resources. It should be noticed also that the Laudo Alvear created in addition a share system which in itself (as we shall show below) may also be a potential source of misallocation of resources. Considerations concerning the way in which these different policies were implemented may also lead to further distortions of resource allocation. We will turn first, however, to the effects of the different schemes on the quality of cane which in turn would have its effects on the productivity of factories.

The ideal approach would be to compare the structure of prices resulting from a given policy with that (unobservable) structure that would prevail under competitive conditions. We propose instead to define each policy by a parameter Y:

$$Y = \frac{\text{average premium for yield}}{\text{average price}} = \frac{b\bar{y}}{a + b\bar{y}} .$$

So that

$$Y = \frac{1}{1 + \frac{a}{b.\bar{y}}}$$

where $\bar{y}$ is the average yield for the industry.

Y varies between zero and unity. When we have a policy like Laudo Alvear, then $a = 0$ and $Y = 1$, when we have fixed prices regardless of the yields then $b = 0$ and $Y = 0$ and when we have a policy that allows a and b to take on any positive values we have values of Y between zero and one.

Having information concerning the yields per plant and the prices per plant for most of the period under study it was possible to determine values of Y for each of the years under study we are interested in. This was done for each year by taking a cross-sectional regression of the form: $p = a + by$, and using the values of a and b thus estimated to generate the value of Y for the corresponding year.

The column of Table 2 (see page 22) labeled "Policy Variable" presents the values of Y. These values were estimated using information on 26 plants operating in the province of Tucumán during the period 1943-63.

The Share System

In addition to the economic implications of the Laudo Alvear pricing scheme insofar as the quality of cane is concerned we must also investigate further the functioning of the share system which Laudo Alvear in effect ratified.

Under fairly acceptable hypotheses, it can be shown that the share system can be a source of waste. A simple model to understand the elements at work can be obtained by assuming that sugar is produced with cane and other factors used in fixed proportions to cane. In the following graph the elements of the problem are shown:

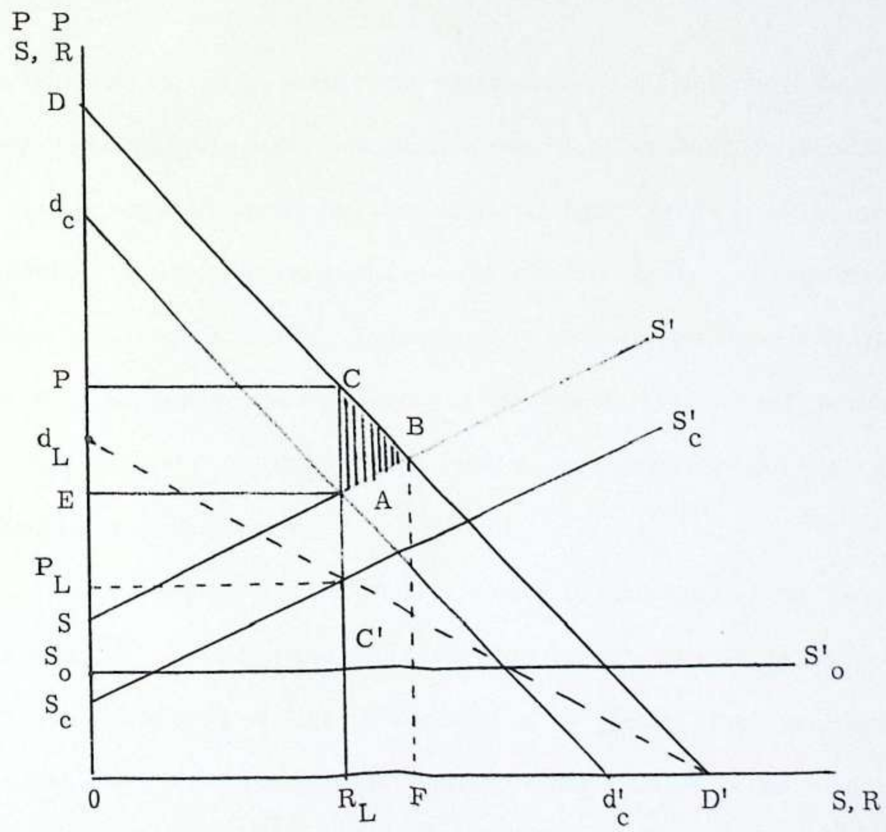

Fig. 1.--The Share System Under Fixed Proportions

where:

DD'	is the final demand for sugar;
SS'	is the supply of sugar in the absence of the share arrangement;
$S_oS'_o$	is the supply of other factors of production used in fixed proportions to cane;
$d_cd'_c$	is the derived demand for cane;
d_LD'	is the "demand" for cane that emerges from the Laudo Alvear rule (for the hypothetical case in which one half of the proceeds accrue to the cane grower);
$S_cS'_c$	is the supply of cane from cane growers;
R_L	is the quantity of cane actually purchased;
P_L	is the resulting price;
F	is the quantity of cane that would emerge under competitive conditions.

It can be shown that as a result of the share system, the society is consuming less sugar than under competitive conditions and that, in principle, a social cost equal to the shaded area of the triangle ABC is imposed on the community. A surplus equal to the area $AC'P_LE$ will accrue to the owners of the other productive services. In principle, this could not be an ultimate equilibrium as these returns in excess of the opportunity cost will attract additional resources into the industry, and/or pressure from the cane growers for a greater share.

If we assume that the share accruing to growers is fixed by institution or law and effectively enforced, then the only remaining degree of freedom is the number of days of operation of the plants. Pure profits in the industry will attract additional capital with the result that the annual rate of return on capital will fall as the number of days of operation is forced down. That is, for a given output of sugar, an increase in the amount of capital in the industry will require a reduction in the average number of days that the plants are operated, and vice versa for a reduction in the capital stock.

The hypothesis of fixed proportions simplifies the analysis of the relationship between the number of days of operation and the share system. This analysis is applicable in principle to any industry characterized by seasonality. It will also provide the basis for some a priori information concerning parameters to be estimated in later chapters.

The following notation will be employed:

K^*	stock of capital,
D	number of days of operation per year,
K	annual services of capital ($= K^*.D$),
r	annual rental of a unit of capital stock,
r'	daily rental of a unit of capital ($= r/D$),
L	annual services of labor (man-days),
L^*	labor force,
w	daily wage of labor,
R	raw material (sugar cane) consumed, and
S	sugar output.

We assume[1] $R = f(K, L), \; f_K > 0, \; f_L > 0,$

and $S = h(R, D), \; h_R > 0, \; h_D < 0.$

---

[1]The model presented here was developed by Professor L. Sjaastad in the occasion of a private conversation concerning the economic interpretation of the number of days operated by the industry.

Throughout we will hold R constant so as to focus on substitution effects rather than scale effects. We will assume that f is homogeneous of degree one with a constant elasticity of substitution.

The ratio of capital stock to labor force is the same as the ratio of K to L as both inputs operate the same number of days. Let

$$K/L = k = g(r'/w)$$

that is, the input ratio depends only upon the ratio of daily rentals. We explicitly assume that r and w are independent of D; that is, the supply of labor is independent of the number of days per year of employment offered, and interest cum depreciation on plant is taken as independent of the number of days operated. Both assumptions are intended as first approximations. Hence r' varies inversely with D.

By differentiation,

$$\frac{dk}{dD} = - \frac{r'}{w} \frac{g'}{D}$$

Hence $$\eta_{k, D} = - \frac{r'/w}{k} g' = -\sigma$$

where $$\sigma = \frac{d \log k}{d \log (f_K/f_L)} < 0$$

This tells us the rate at which the services of capital are substituted for those of labor as the daily rental of capital diminishes with an increase in the number of days of operation.

The effect on the capital stock of increasing D will be the combined effect of the substitution of capital for labor and the effect of substitution of time for capital stock. As $K^* = K/D$

$$\frac{dK^*}{dD} = \frac{1}{D} \cdot \frac{dK}{dD} - \frac{K}{D^2} .$$

From above, $\frac{dk}{dD} = - \sigma \; k/D$;

also $\frac{dk}{dD} = \frac{d\frac{K}{L}}{dD} = \frac{1}{L} \cdot \left[\frac{dK}{dD} - k \frac{dL}{dD} \right]$;

but for R constant, $dL = - \frac{f_K}{f_L} dK$,

hence,

$$\frac{dk}{dD} = \frac{1}{L} \cdot \frac{dK}{dD} \cdot \left[1 + \frac{\alpha_K}{\alpha_L} \right]$$

$$= \frac{1}{\alpha_L \cdot L} \cdot \frac{dK}{dD} ,$$

where α_L and α_K are the shares of labor and capital in value added ;i.e.,

$$\alpha_L = \frac{f_L \cdot L}{f} .$$

Hence

$$\frac{dK}{dD} = \alpha_L \cdot L \cdot \frac{dk}{dD}$$

$$= - \alpha_L \cdot \frac{L \sigma k}{D}$$

$$= - \frac{\alpha_L \cdot K\sigma}{D}$$

Thus $\frac{dK^*}{dD} = - \frac{\alpha_L \cdot K\sigma}{D^2} - \frac{K}{D^2} = - \frac{K}{D^2} (1 + \alpha_L \sigma)$,

and $\eta_{K^*, D} = - (1 + \alpha_L \sigma)$

$$= -\alpha_K, \quad \text{when } \sigma = -1.$$

As r is constant, $\frac{d(rK^*)}{dD} = \frac{dK^*}{dD}$; hence we have the effect on capital costs of a change in D. As R is constant, D has no effect on the cost of raw materials. Labor costs decline, however as D increases due to substitution of capital for labor:

$$\frac{d(wL)}{dD} = w \cdot \frac{dL}{dD}$$

$$= w \cdot \left[-\frac{f_K}{f_L} \quad \frac{dK}{dD} \right] ,$$

which reduces to $\frac{d(wL)}{dD} = + \frac{\alpha_K w L \sigma}{D}$.

As TC $= wL + rK^* + p_R \cdot R$ where TC is total cost, p_R is the (constant) price of raw material,[1] and R is held constant,

$$\frac{dTC}{dD} = + \alpha_K \cdot \frac{wL\sigma}{D} - \frac{rK^*}{D} (1 + \alpha_L \sigma).$$

Defining total revenue as TR $= p_s \cdot S$, where p_s is a (given) price of sugar,

$$\frac{dTR}{dD} = p_s \cdot \frac{dS}{dD}$$

$$= TR \cdot \frac{h_D}{S} .$$

We define h_D/S as ρ, hence $\frac{dTR}{dD} = TR\, \rho$.

[1] This analysis is for a constant price of R rather than a constant share.

Profits are maximized when MC ($= \frac{dTC}{dD}$) equals MR ($= \frac{dTR}{dD}$). Putting $\sigma = -1$, we have

$$\frac{dTC}{dD} = -\alpha_K \left[\frac{wL}{D} + \frac{rK^*}{D} \right]$$

$$= -\alpha_K \frac{VA}{D},$$

where VA is value added by labor and capital.

Putting MC = MR, we have:

$$-\alpha_K \frac{VA}{D} = TR\ \rho,$$

hence $$\rho = -\frac{\alpha_K}{D} \frac{VA}{TR}.$$

As will be shown in next chapter the share of capital can be taken as equal to 0.70, the relation VA/TR as roughly 0.5 and the average number of days operated by the plants as roughly 100. Hence we can estimate the percentage effect on total output of working an extra day as:

$$\hat{\rho} = -0.0035$$

CHAPTER III

PRODUCTION FUNCTION ESTIMATES AND HYPOTHESIS TESTING

The Model

In this chapter it will be assumed that sugar (S) is produced with the aid of sugar cane (R) used in fixed proportions with other inputs. The amount of sugar to be obtained from cane of a given quality index (Q_o) is:

$$S = R^{\lambda} Q_o \quad (1)$$

The way in which other inputs, namely labor (L) and capital (K), combine will be assumed to be described by a Cobb-Douglas production function which in turn is used in fixed proportions with physical units of cane:

$$\frac{S}{Q_o} = [\text{Min}\,(R^{\lambda},\ b\,L^{\alpha} K^{\beta})] \quad (2)$$

where α and β are the shares of labor and capital in value added. For any quality of cane, Q, in general:

$$S = \text{Min}\,(R^{\lambda} Q,\ b\,L^{\alpha} K^{\beta} Q) \quad (3)$$

Among the most obvious exogenous factor that may affect the quality of sugar cane are climatic conditions (W), and policy-induced changes in the quality of sugar cane (Y).

In the regressions it was found useful to use the following specification for Q:

$$Q = B.e^{(\gamma Y + \delta W)} \qquad (4)$$

It is well known that factors such as temperature, precipitation, humidity, luminosity, and frost affect the quality of sugar cane. They seem to act in a complex manner, such that a linear combination of them would be a highly idealized representation. The lack of a theory to explain weather lead us to rationalize it by means of a random law and in what follows it will be assumed that climatic conditions along with other random elements that affect the quality of cane are subsumed in a residual, u, assumed to be distributed log-normally.

Equation (3) will then appear as:

$$S = \text{Min}\,(B.R^{\lambda}.e^{\gamma Y}\,e^{u},\;\; A.L^{\alpha}K^{\beta}.e^{\gamma Y}\,e^{u});\;\; (A = b.B) \qquad (5)$$

This model was tested statistically for observations on plants operating in the province of Tucumán. Three different sets of estimates were made: (a) Estimates for an aggregate of 24 plants during the period 1943-63; (b) Estimates for two plants during the period 1927-63; and (c) Estimates at the plant level, pooling 20 plants for the period 1943-63.

<u>Estimates for 24 Plants of Tucumán 1943-63</u>

In this section we report on the study of 24 plants operating in the province of Tucumán during the period 1943-63. These plants represent more than 90 per cent of the production of Tucumán and well above 50 per cent of the national production. During this period the output of those plants was growing at an average annual rate of 2.8 per cent. Table 2 presents the main series associated with the model we purport to test.

As an exploratory step estimates of two alternative production functions were made:

(6) $$S = B.R^{\lambda}.e^{\gamma Y}$$

(7) $$S = A\,L^{\alpha}\,K^{\beta}\,e^{\gamma Y}\,e^{\delta F}$$

It should be noticed that the necessary services of labor and capital to obtain a given bundle can be affected by the dummy variable F reflecting for strong "Regulatory Fund," 1950-55. The coefficient of this variable, if negative, will tend to confirm that the strong Regulatory Fund policies generated misallocations of resources during the years when they were in effect. The services of labor were measured using the methodology described in Appendix B. The services of capital, taken as the stock of capital times the number of days effectively operated by the plants, are measured by a method which takes into account the changing specifications (i.e. quality) of the various types of machinery, etc., used by the plants (see Appendix A).

In order to test the plausibility of the results, the share of labor was estimated independently on the basis of the value of output in 1943. By estimating value-added and knowing the wage bill, it was found that

TABLE 2.--Estimates of the Index of Output, Raw Materials, Average Number of Days Effectively Operated, Stock of Capital, Policy Variable and Index of Man-Hours, 24 Plants, 1943-63

Zafra Year	Index of Output	Raw Materials	Average Number of Days	Stock of Capital		Policy Variable	Index of Man-Hours
				Plant	Equipment		
1943	100.0	27,491	74.7	22,226	62,678	1.000	100.0
1944	116.9	33,758	92.4	22,894	62,911	1.000	114.6
1945	111.8	42,794	106.1	23,546	62,557	0.000	135.9
1946	173.9	50,855	128.9	24,101	62,351	0.000	203.9
1947	160.6	44,390	113.0	25,708	65,791	0.000	258.5
1948	143.6	45,060	114.3	27,342	68,128	0.000	289.8
1949	138.5	43,790	103.7	28,963	70,941	0.000	210.8
1950	154.6	44,241	102.7	30,037	71,233	0.065	247.9
1951	162.2	52,740	111.2	30,890	73,266	0.117	237.8
1952	147.5	58,823	113.2	30,907	73,851	0.238	239.0
1953	198.6	64,837	121.7	31,455	74,183	0.480	247.7
1954	202.3	62,513	118.8	32,238	76,694	0.181	250.1
1955	143.9	62,206	114.3	33,352	79,724	0.070	258.5
1956	194.1	62,383	110.8	34,209	79,699	0.077	220.5
1957	166.1	59,239	104.8	34,719	81,651	0.245	249.8
1958	284.9	80,040	134.8	37,141	86,263	0.338	316.2
1959	224.9	61,227	103.0	37,614	88,311	0.406	243.8
1960	183.8	58,904	96.7	38,091	90,161	0.443	255.2
1961	147.7	51,970	81.7	40,200	96,747	0.684	210.1
1962	184.3	55,901	87.4	40,316	103,578	0.615	201.7
1963	246.9	69,271	101.2	40,623	112,983	0.939	228.9

References: Zafra Year - The Zafra Year is the period of time that starts on May 1 and end on April 30 of the following year.

Index of Output - The index of output is a Laspeyres quantity index (1943 = 100). Sugars of different qualities were weighted with the following prices of 1963: pilé,

33.00 pesos per kilogram; granulated, 32.00 pesos per kilogram; crude 27.00 pesos per kilogram and low product, 20.00 pesos per kilogram.

Raw Materials - Sugar cane ground in hundred tons. Source: Schleh, Estadística Azucarera, No. 7, pp. 45-49. Centro Azucarero Argentino, La Industria Azucarera, 1947-60. Dirección Provincial de Estadística de Tucumán, Archives. Dirección Nacional de Azúcar y Envases (Buenos Aires), Archives.

Average Number of Days - Is the weighted average of the number of days effectively operated by the plants. The weights used were the output of each plant expressed in tons. Source: The same as Raw Materials.

Stock of Capital - The stock of capital used in production was estimated in thousands of 1938 pesos for both plant and equipment. For source and methods see Appendix A.

Policy Variable - See Chapter II. The estimates of Y were obtained with information on prices and yields obtained from the following sources: (a) Dirección Provincial de Estadística de Tucumán, Anuario Estadístico 1943; (b) Tucumán, Cámara Gremial de Productores de Azúcar, Archives; (c) Buenos Aires, Ministerio de Comercio, Dirección Nacional de Azúcar y Envases, Archives. For the years 1943-49 the policy variable was not estimated statistically.

Index of Labor - Represents an index of man-hours. For source and methods see Appendix B.

that under varying, but extreme, assumptions, the share of labor would fall between .15 and .52 of value added, depending on the relationship of labor to other materials, administration costs, freights, etc. Using census data it was estimated that the share of labor was 0.30 in 1935 and 0.32 in 1946. In Table 3 estimates of equations 6 and 7 obtained by regression analysis on the equations 6 and 7 of our model in logarithmic form are shown.

TABLE 3.--Regression Estimates for the Aggregate of 24 Plants Operating in Tucumán During 1943-63

Dependent Variable	Independent Variable					R^2
	Labor L	Capital K	Policy Y	Dummy F	Raw Material	
S	0.10 (0.20)[o]	1.04 (0.23)	0.14 (0.09)	-0.06 (0.06)		0.85
S			0.11 (0.08)		0.93 (0.12)	0.78

[o] Parentheses indicate standard errors.

These regressions, run over 21 observations and at a high degree of aggregation, do not deny our a priori presumptions concerning labor's share, constant returns to scale and the direction of the effects of the policy and Regulatory Fund variables upon production. Statistical significance is not achieved for the majority of the coefficients, so the results should be taken as highly tentative suggesting that improvement might be obtained if it were possible to disaggregate.

<u>Study of Two Plants during the Period 1927-63</u>

A good set of observations was gathered for two plants in which an appreciable portion of time was spent in making estimates for a longer period of time. They were studied closely since 1903 and special care was taken in estimating annual series of gross investment in equipment, plant and repairs. Except for the deflator of equipment and plant, estimates of the services of capital were made using data from sources other than those used so far (number of days effectively operated by the plants were estimated using plant records). To estimate labor input, the wage bill reported by the plants was used as the main source. The period of study is of a quite different nature, and the number of days effectively operated by the plants varied over a wider range than during the period 1943-63. As a result of this characteristic, a new shifter could be introduced: D^{o}, which stands for number of days effectively operated beyond 80 (a sort of ideal length of the zafra). In Table 4 the results of regression analysis is shown.

TABLE 4.--Regression Estimates for Two Selected Plants Operating in Tucumán for the Period 1927-63

Dependent Variable	Independent Variable						
	Labor L	Capital K	Policy Y	Dummy F	D^o	Raw Mat. R	R^2
S	0.22	0.69	0.21		-0.0036		0.79
	(0.16)*	(0.19)	(0.08)		(0.0018)		
S	0.19	0.76	0.18	-0.16	-0.0031		0.83
	(0.15)	(0.18)	(0.08)	(0.06)	(0.0017)		
S			0.11			0.78	0.84
			(0.05)			(0.07)	

°Parentheses indicate standard errors.

The regressions, using 37 observations, do not permit rejection of the hypothesis of constant returns to scale. Moreover they allowed us to have a statistical estimate of the parameter ρ which is the outcome of the model developed at the end of Chapter II. The result coincides with the a priori value estimated there. It is clear that as the zafra is extended beyond 80 days, it is anticipated that the quality of the cane will diminish. A rough idea of the extent of which the deterioration occurs is indicated by β, the coefficient of D^o, and can be obtained as follows. If the daily input of capital, labor, and cane were to remain constant as the zafra were extended from 80 to, say, 100 days, output should increase by 25 per cent. However, the above equation indicates that output would increase by 25 minus approximately six to eight per cent, for a net increase of about 18 per cent. This calculation implies that the quality of the cane ground during the additional 20 days was only about 70 per cent of the quality of the cane ground during the first 80 days. This is, of course, only a rough approximation of the marginal efficiency. It can be noticed also that the direction of influence of the policy and strong Regulatory Fund variables is as expected.

Estimates Using Pooled Data at the Plant Level 1943-63

The purpose of this part is to present the results of pooling observations of output and labor and capital inputs for 20 plants during the period 1943-63. These observations relate to sugar plants of Tucumán, the production of which represented 80 per cent of the total production of this province at both the beginning and the end of the period under study. The actual number of observations is 320 and the breakdown of these observations by plant and year is shown in Table 5.

In pooling data of different plant we encountered the problem of errors in the measures of both labor and capital, but in the presentation of the model developed to handle this problem, special reference will be made to errors in capital only. This will simplify the exposition without loss of generality.

As in the previous study, the services of capital per plant were taken as equal to the stock (estimates of equipment only were used in the study of plants) times the number of days actually operated by the plant. For the estimates of the stock per plant the methodology and deflating

TABLE 5.--Tucumán 1943-63. Distribution of the Observations of the Pool of 20 Plants Classified by Year and Plant

Plant \ Year	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	
1																						21
2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						5
3																						21
4																						21
5	x	x	x	x	x	x	x															14
6																						21
7	x	x	x	x	x	x	x	x	x	x	x					x						9
8																		x				20
9														x								20
10																						21
11																						21
12																		x				20
13														x								20
14	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					4
15	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						5
16														x			x					19
17	x	x	x	x	x	x	x	x	x	x	x											10
18																						21
19	x	x	x	x	x	x	x	x	x	x	x	x										9
20	x													x				x				18
	12	13	13	13	13	13	13	14	14	14	14	16	17	13	17	16	18	17	20	20	20	320

The symbol x means that there was no information to make estimates of either labor or capital.

procedures described in Appendix A were used. Thus, save for the series of gross investment, which varied among plants, Appendix A should be regarded as the prototype. For the services of labor, the expression $WDE_i^t / \bar{w}_t$ was used as the estimate of labor input of plant i in year t. See Appendix B.

Estimates of equation (7) made without further adjustment led invariably to failure, most of the time the share of labor being the one expected for capital and vice-versa. This being the case, it was found necessary to normalize the measures of the services of capital with respect to some arbitrary plant. It was assumed that the true services of capital K_{it}^o, of any plant i in year t were equal to $K_{it} \cdot \theta_i$, so that the production function for the plant can be represented as:

$$S_{it} = A\, L_{it}^{\alpha} (K_{it}^{o})^{\beta} = A\, L_{it}^{\alpha}\, K_{it}^{\beta}\, \theta_i^{\beta}$$

where K_{it} is the observed service of capital.

Taking logs:

$$\log S_{it} = \log A + \alpha \log L_{it} + \beta \log K_{it} + \beta \log \theta_i ,$$

so that in addition to the usual constant there is an additional shifter to estimate the value $\beta \log \theta_i$ for each plant. This is the rationale that justifies the inclusion of a dummy variable per plant when the task assigned to the regression is to pool the information of different plants.[1]

---

[1]An alternative model, which emerges when we assume $K_{it}^o = K_{it} + \theta_i$ was tried. This alternative, which was estimated using an approximation, lead to similar results. See Appendix C.

We must recall the nature of the task assigned to the dummies while interpreting the results of the regression, because the meaning that we shall attach to the constant of each plant will in this case include something more than some intrinsic, non-reproducible, superiority or weakness of entrepreneurial capacity. More generally, if errors in measuring output and labor are also present: $S^o_{it} = \sigma_i S_{it}$; $L^o_{it} = \mu_i L_{it}$, then the coefficient P_i of a plant dummy i, will be the result of a combination of the form:

$$P_i = \alpha \log \mu_i + \beta \log \theta_i - \log \sigma_i + p_i$$

where p_i stands for some intrinsic, non reproducible characteristic of the plant.

This approach proved to be useful in solving the puzzles mentioned above. When the pooled data were regressed with output as the dependent variable and with labor and capital as explanatory variables, the results did not fit our a priori expectations as has been pointed out, but when plant dummies were included in the regression, the shares of labor and capital behaved satisfactorily (see regressions 1 and 2 of Table 6). The warnings concerning the dummies proved to be correct, 11 out of 19 (one plant is taken as a point of reference) are significant at the 5 per cent level. Another convincing piece of evidence in this respect is that when sugar was regressed against raw materials, the plant dummies became insignificant for the most part. The results can be seen in regressions 4 and 5 of Table 6; it will be noticed that the dummies have coefficients completely different from the ones in the regression on labor and capital and that only two of them are significantly different from zero at the 5 per cent level.

Regression 3 which is the regression of raw materials on labor, capital and policy supports the hypothesis of fixed proportions that underlies our model. While the regression of sugar on raw materials substantially clarifies the role of the dummies in the production function, it raises additional puzzles. The effect of the policy variable is not the same; 0.20 in the regression on labor and capital and 0.14 in the regression on raw materials. Under the hypothesis of fixed proportions this finding suggests that either capital and labor were inflated and deflated, pari passu, with movements in the policy variable, or that some other force was affecting the productivity of labor and capital at the plant level. In searching for an explanation it was recalled that as a result of the policies analyzed for the period 1943-63, there was a strong presumption that during the period labeled strong Regulatory Fund a substantial misallocation of resources was expected to occur. To test for this possibility another experiment was done in which the production function was allowed to shift for the years 1950-55. This was achieved by introducing a dummy variable F (=1 for year 1950-55; 0 otherwise). The coefficient of the shifter that reflects the influences on production of the functioning of Regulatory Fund can be seen in regression 6 of Table 6.

These efforts to reconciliate the conflicting finding seem to have been largely successful and provide us with a means to examine another

TABLE 6. -Tucumán, 1943-1963. Data Pooled for 20 Plants. N = 320

Reg. No.	Dependent Variable	Raw R	Labor L	Capital K	Policy Y	Dummy F	P_1 (1)	P_2 (2)	P_3 (3)	P_4 (4)	P_5 (5)	P_6 (6)	P_7 (7)	P_8 (8)	P_9 (9)	P_{10} (10)	P_{11} (11)	P_{12} (12)	P_{13} (13)	P_{14} (14)	P_{15} (15)	P_{16} (16)	P_{17} (17)	P_{18} (18)	P_{19} (19)	P_{20} (20)	R^2
							Plant Dummies																				
1	S		0.57 (0.04)	0.31 (0.04)	0.30 (0.05)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.67
2	S		0.29 (0.04)	0.52 (0.04)	0.20 (0.04)		0	0.13 (0.11)	0.22* (0.08)	0.50* (0.08)	0.32* (0.08)	0.16* (0.07)	0.59* (0.09)	0.08 (0.07)	-0.42* (0.08)	-0.08 (0.07)	0.04 (0.07)	0.16* (0.07)	0.39* (0.07)	0.22 (0.12)	0.08 (0.11)	-0.07 (0.07)	0.27* (0.08)	0.45* (0.07)	0.22* (0.08)	0.10 (0.07)	0.84
3	R		0.24 (0.04)	0.52 (0.03)	0.03 (0.03)		0	0.19 (0.09)	0.26* (0.06)	0.64* (0.07)	0.28* (0.06)	0.20* (0.05)	0.54* (0.07)	0.06 (0.05)	-0.24* (0.06)	-0.02 (0.05)	0.13* (0.06)	0.21* (0.06)	0.45* (0.06)	0.22* (0.10)	0.10 (0.09)	0.02 (0.06)	0.26* (0.07)	0.49* (0.06)	0.18 (0.07)	0.16* (0.06)	0.88
4	S	0.99 (0.02)			0.15 (0.03)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.91
5	S	0.99 (0.03)			0.14 (0.03)		0	-0.07 (0.07)	0.02 (0.05)	-0.06 (0.06)	0.05 (0.05)	-0.03 (0.05)	0.05 (0.06)	0.02 (0.05)	-0.14* (0.05)	-0.05 (0.05)	-0.05 (0.05)	-0.06 (0.05)	-0.06 (0.05)	0.04 (0.08)	-0.01 (0.07)	-0.10* (0.05)	0.02 (0.06)	0.02 (0.05)	0.03 (0.06)	-0.04 (0.05)	0.92
6	S		0.30 (0.04)	0.52 (0.04)	0.17 (0.04)	-0.076 (0.028)	0	0.12 (0.10)	0.21* (0.08)	0.48* (0.08)	0.33* (0.08)	0.16* (0.06)	0.59* (0.09)	0.08 (0.07)	-0.43* (0.08)	-0.09 (0.06)	0.04 (0.07)	0.16* (0.07)	0.39* (0.07)	0.20 (0.12)	0.06 (0.11)	-0.07 (0.07)	0.26* (0.08)	0.43* (0.07)	0.22 (0.08)	0.09 (0.07)	0.84

The symbol * means t > 2.
Parentheses omdocate standard errors.

source of resource misallocation in the sugar industry.

The Problem of Economies of Scale

So far we have neglected a problem that our production function estimates present; this is the finding of diseconomies of scale. The shares of labor and capital sum to 0.82, a magnitude that is statistically different from 1 at the 5 per cent level.

In the search for an explanation of this result we explored many hypotheses of which include: (a) bias attributable to an elasticity of substitution different from unity and, (b) effects of length of the zafra beyond a critical maximum number of days. Neither of these hypotheses, received support when tested.

Finally, it was noticed that the larger coefficients of the plant dummies were usually associated with the larger plants. This suggest that perhaps the dummies are capturing a part of the explanatory power of capital and labor; in addition it was also observed that, on the average, those plants which were also engaged in producing alcohol had smaller dummies, which could mean that the incentives were stronger for diverting--for distilling purposes--a portion of the sugar that otherwise they would have produced. To test for this possibility the following equation was estimated:

$$P_i = a + b \bar{S}_i + c A$$

where:

P_i is the size of the plant dummy coefficient (pool 1943-63),

$\bar{S}_i$ is the average output of sugar, in tons, for the years effectively included in the regression (see Table 3), and

A is a dummy variable which is taken as equal to 1 if the plant was engaged in distilling activities during the period 1943-46, and zero otherwise.

The estimates of the parameters turned out to be consistent with this interpretation, as can be seen in Table 7.

TABLE 7.--Regression Estimates of the Relation between Coefficients of Plant Dummy on Average Output and Characteristic of Plant

a	b	c	R^2
-0.006 (0.125)*	0.000015 (0.000006)	-0.1458 (0.0918)	0.34

*Parentheses indicate standard errors.

However, when the sample is broken down into relevant subperiods, it appears that the effect measured in the coefficient b of Table 7 is largely due to the events of 1950-55. In these years, there is a high correlation between plant dummies and size, $r^2_{P,\bar{S}} = +0.81$, whereas for the remaining years there is virtually no such correlation. When attention is centered on years other than 1950-55 for which the correlation between plant dummies and size is negligible (thus suggesting that some of the effects of capital and labor are not being captured by the dummies), the sum of the estimates of the shares of capital and labor is not significantly different from unity.

The statistical analysis of the estimates of Table 8 is consistent with our hypothesis. When the correlation between dummy and average output was small the shares of labor and capital was consistent with constant returns to scale (notably, the period 1956-63). When the correlation was high, as it is for the period 1950-55, the dummies are capturing a greater share in the explanation and decreasing returns to scale are present. This seems to be a good explanation for the pool of 1943-63 where $r^2_{P,\bar{S}} \cong +0.25$.

The Plant Dummies

So far we have focussed on the relation between the plant dummies and the estimated returns to scale of our production function. But beyond that nothing can be said concerning their size, except perhaps that no economic meaning should be attached to the correlation between the size of the dummy coefficients and output. In effect, the dummy variables appear to be capturing a bundle of different effects such as errors in the measures of labor, capital, and output, plus some intrinsic differences among the plants.

TABLE 8.--Tucumán, Data Pooled for 20 Plants. Estimates for Three Main Subperiods

Sub-Period	1943-49	1950-55	1956-63
No. Observations	90	89	141
R^2	0.93	0.88	0.88
Share Labor	0.09	-0.13	0.27*
Share Capital	0.84*	0.48*	0.72*
Constant	-1.51	-0.13	0.27
Dummy Plant 2	--	--	0.06
Dummy Plant 3	0.15	0.64*	0.05
Dummy Plant 4	0.39*	0.99*	0.41*
Dummy Plant 5	--	0.12	0.42*
Dummy Plant 6	0.39*	0.24*	-0.03
Dummy Plant 7	--	0.05	0.78*
Dummy Plant 8	0.25*	-0.04	0.04
Dummy Plant 9	-0.67*	-0.24	-0.47*
Dummy Plant 10	-0.60	-0.04	-0.04
Dummy Plant 11	0.05	0.33*	-0.14
Dummy Plant 12	0.38*	0.21	0.13
Dummy Plant 13	0.57*	0.40*	0.47*
Dummy Plant 14	--	--	0.16
Dummy Plant 15	--	--	-0.08
Dummy Plant 16	0.62*	-0.24*	-0.43*
Dummy Plant 17	--	0.20	0.11
Dummy Plant 18	0.60*	0.84*	0.18
Dummy Plant 19	--	-0.29	0.16
Dummy Plant 20	0.15	0.31*	-0.04

The symbol * means $t > 2$.

CHAPTER IV

CONCLUSIONS

In the study of sugar production of Tucumán, Argentina, and in the search for the forces that influenced its productivity, the production function approach was found useful. Concerning the manner in which the different productive services combine the various experiments lead us to conclude that it is appropriate to aggregate the services of labor and capital via a Cobb-Douglas production function and to assume in turn that capital and labor, so aggregated, combine with sugar cane in fixed proportions in the production of sugar.

Since the operation of this industry is highly seasonal, the services of capital were expressed as the stock of capital multiplied by the number of days operated by the plants each year.

In order to test for errors in the measures of output, labor, and capital, two different models were explored: a multiplicative error model and an additive error model. Both lead to similar results when tested empirically, suggesting that the magnitude of the correction is large enough so that failure to take it into account would very likely lead to meaningless results in statistical estimates of production function parameters using data at the plant level.[1] Even when from the theoretical point of view, these models were designed to account for a bundle of different effects such as errors in the measures of labor, capital, and output, plus intrinsic differences among the plants, alternative experiments using sugar cane as the regressand suggest that a major portion of these total effects must be assigned to errors in the measures of the services of capital and labor. The rationale behind this conclusion is that even when the stock of capital was measured with a methodology that takes into account changes in the quality of the various types of machinery, there still remains a further adjustment in order to achieve homogeneity among plants. This type of error in the measure of the services of capital would remain undetected when experiments are made at a higher level of aggregation.

Estimates, using a Cobb-Douglas production function form suggest that there is no convincing evidence that this industry faces either economies or diseconomies of scale. In addition, no evidence was found indicating the presence of technical change in the industry, once the capital stock estimates were adjusted for quality. Moreover, there appears to be no relation between the magnitude of the plant dummies and the age of the plant.

Concerning the forces that affect the productivity of this industry,

---

[1] The magnitude of the correction is certainly important. In regression number 2 of Table 6 the coefficients of the plant dummies ($=\beta \log \theta_i$) oscillate between -0.42 and +0.59 which implies that θ_i, the factor of correction, varies between 0.50 and 2.30 of the observed services of capital.

estimates of the parameters of production functions based on aggregate data for 24 plants for the period 1943-53, and data for two plants over the period 1927-63, and data for 20 plants using pooled observations on 1943-63 show a substantial agreement in that productivity was impaired as a consequence of:

1. changes in the quality of sugar cane induced by the different pricing schemes implemented by the Argentine Government;
2. resource misallocation within the plants as a consequence of the scheme known as strong Regulatory Fund (1950-55);
3. extension of the zafra beyond 80 days.

The following table gives estimates per year of the percentage effects on output resulting of these three main sources. Year 1943 is taken as a base year, although it should be mentioned that this does not mean that optimal conditions were met in that year.

It will be noted that the Productivity Index of Table 9 abstracts from effects of weather variability that can either ameliorate or impair the effects of the real, more permanent, forces that underlie it. That is, the Productivity Index measures the systematic contribution of the three variables considered but does not include the residual. The computed residual is, of course, independent of each of the variables.

In the task of evaluating the economic aspects of these three main sources of productivity change in sugar production, we should recognize that each variable attempts to summarize the ultimate outcome of a host of circumstances that worked its way through the economic incentives and signals as seen by the plants and the cane growers (cañeros). There is no doubt that the optimal length of the zafra is an economic decision resulting from profit maximization objectives in the face of given prices for inputs or outputs but that can be influenced by government actions when, as the case of Laudo Alvear, a relationship between value added and total receipts is imposed exogenously. Hence it is very likely that distortions in the markets for either products or factors (leaving aside accidents and strikes) lead the industry to choose this behavior. The aspect of the effects of government policy on the quality of sugar cane are much more clear and straightforward; it is clearly evident that cane growers responded quickly to economic incentives and that whenever the pricing schemes provided economic rewards for higher quality sugar cane, they responded accordingly. The lesson reflected by the strong Regulatory Fund variable confirms what is a tenet in the everyday discussion of efficiency and economic incentives and that deleterious effects in the allocation of resources should be expected as a consequence of interference with the free functioning of entrepreneurial decisions.

A brief inspection of Table 9 suggests that substantial gains in productivity in the short run could have been obtained if the industry were faced by conditions similar to the ones prevailing in the years 1943-44. This might strike immediately as a strong argument on behalf of the reinforcement of Laudo Alvear. There is no doubt that a decision of this type represents a step in the right direction, especially with respect to its effects on the quality of sugar cane. It should be recognized, as has been

TABLE 9.--Tucumán, 1943-63. Average Percentage Effects on Output Resulting from: Extension of the Grinding Season Beyond 80 Days; Changes in the Quality of Sugar Cane Induced by Pricing Schemes, and Strong Regulatory Fund

Zafra Year	Source of Loss in Output			Productivity Index 1943=100
	Zafra beyond 80 Days[a]	Quality of Sugar Cane[b]	Regulatory Fund[c]	
1943	0.0	0.0	0.0	100.0
1944	-3.7	0.0	0.0	96.3
1945	-7.8	-14.5	0.0	78.8
1946	-14.7	-14.5	0.0	72.9
1947	- 9.9	-14.5	0.0	77.0
1948	-10.3	-14.5	0.0	76.7
1949	- 7.1	14.5	0.0	79.4
1950	- 6.8	-13.6	-7.6	74.4
1951	- 9.4	-12.8	-7.6	73.0
1952	-10.0	-11.1	-7.6	73.9
1953	-12.5	- 7.6	-7.6	74.7
1954	-11.6	-12.0	-7.6	71.9
1955	-10.3	-13.5	-7.6	71.7
1956	- 9.2	-13.4	0.0	78.6
1957	- 7.4	-11.0	0.0	82.4
1958	-16.4	- 9.6	0.0	75.6
1959	- 6.9	- 8.6	0.0	85.1
1960	- 5.0	- 8.1	0.0	87.3
1961	- 0.5	- 4.6	0.0	94.9
1962	- 2.2	- 5.6	0.0	92.3
1963	- 6.4	- 0.9	0.0	92.8

[a] The estimates of the effects on output of zafras longer than 80 days were obtained using the estimated average effect on output per additional extra day given by Table 4.

[b] This percentage is taken with respect to the base year 1943 and the estimate for each year is equal to: $0.17\ (Y_t - 1)/1.17$, where 0.17 is the estimate of γ, the coefficient of the policy variable, shown in regression 6 of Table 6 and Y_i is the value of the policy variable corresponding to year t.

[c] The effects of strong Regulatory Fund are expressed by the regression coefficient of the dummy variable F in regression 6 of Table 6, which is the percentage effect on production due to the functioning of this scheme.

pointed out, that a policy such as the Laudo Alvear has shortcomings of its own, the most important being that misallocative effects must be expected due to the share character of the relation between plants and cane growers. Waste results from the fact that even though Laudo Alvear creates appropriate incentives in the form of rewards for quality in the production of sugar cane, the prices emerging as a consequence of the share formula are unlikely to coincide with those that would emerge from the free operation of market forces.

All these findings indicate very clearly that the creation of conditions to allow the forces of supply and demand for either productive services or final products to operate directly in highly competitive markets, with a minimum of government intervention, will do the greatest justice to both the owners of productive resources and consumers of the final product.

APPENDIX A

ESTIMATES OF THE SERVICES OF CAPITAL: SOURCES AND METHODS

The services of capital were defined as equal to the stock of capital (K^*) times the number of days of operation of the plants (D).

$$K_t = K_t^* . D_t .$$

Estimates of the stock of capital were obtained using the formula:

$$K_t^* = \Sigma_j \left(\frac{I_j}{\overline{P}_j} \right) v_{jt}$$

where:

- I_j represents the flow of gross investment at current prices during the zafra year j;
- $\overline{P}_j$ represents a deflator designed to express the flows of current gross investment in constant prices;
- v_{jt} represents a survival coefficient, where t is the zafra year in which the service of capital stock is rendered and j is the zafra year in which the investment creating that stock was made.

Gross Investment

Data on gross annual investment was obtained from the office that collects reports on sugar plants at the Dirección Nacional de Azúcar y

Envases, Secretaría de Estado de Comercio, Buenos Aires, Argentina. This information does not correspond to the calendar year but rather to the zafra year, which is the period that starts on May 1 and ends on April 30 of the following year.

The Deflator

The construction of an index designed to deflate the flows of gross yearly investment on durable equipment (or by the same token, plant) was not an easy task. There were many problems; which prices to follow through time, what to do as the consequence of changes in size and quality of capital goods arising generally as the result of different models or designs, and what system of weights to use in collapsing the relevant prices into a single number.

As a starting point it was found useful to know something about the actual technical process by means of which sugar cane is transformed into sugar. In a nutshell, the process consists in extracting the sweet juice from the sugar cane then extracting water and impurities from the sweet juice leaving just the sugar. That is all that a factory does. For the purpose at hand, the actual process of production was divided into the following stages: (a) reception and grinding of sugar cane; (b) purification of the raw juice and filtration; (c) evaporation of the purified juice into syrup; (d) concentration and crystallization of the syrup into massecuite; (e) centrifuging of the massecuite, whereby the sugar crystals are separated from the molasses; (f) steam generation; (g) electricity generation.

The above mentioned classifications gave us a good idea of what are the main sections in which a processing factory is divided and a great effort was devoted to identifying the durable goods associated with each of them. Availability of data imposed further restrictions upon what was already a formidable task. Even when a durable item or a piece of equipment was found useful for our purposes, there was often not an adequate stock of price quotations and even less of actual purchases of them. It was decided finally to trace the price quotations of some traditional dealers[1] and suppliers of equipment even though these did not always refer to equipment actually purchased by the sugar plants.[2] This information was supplemented with data gathered from books of the sugar companies, and from engineering firms which had worked in installing equipment in the factories.

Having selected the durable goods whose prices we purported to follow, it soon became evident that important changes in size and quality over time had occur. Although it is true that more than one dimension could be attached to a durable good (and presumably a price to each one) so as to identify it in a unique form, most of the quotations consist in rather elaborate statements often accompanied by blueprints and a host of other specifications. Even though some efforts has been made to tackle this

---

[1]Thanks are given to the following firms engaged in selling durable goods to sugar factories: Carlino Hnos., Corporación Técnica, Enrico Hnos., Gambandé y Filippone, Hans Bertschi Ing, Armando Villasuso, Mellor Goodwin SAC, Perez Prado S.R.L., for allowing me to have access to their records.

[2]In the task of collecting the price quotations I received the enthusiastic collaboration of the then research assistant Mr. Roberto A. Recalde.

problem[1] we favored a rather simple methodology, which was that of expressing the price in per capacity units. When, for instance, we were studying boilers, it was found very often that a snapshot of its price quotation could be expressed in pesos per square meter of heating surface. So we proceeded on the basis of collecting prices per unit of capacity, somewhat arbitrarily defined and in many cases with units defined ad hoc, while simultaneously devoting some effort in keeping other specifications constant.

The changes in size and quality over time was solved in a way similar to the one used by Burstein in his study of refrigerators.[2] The following passage summarizes his procedure: "Burstein's index compares, in chainlink fashion, the prices of models with similar specifications in adjacent years. In each adjacent-year comparison quality is thus held constant."[3] Using this principle, the price index of a capacity unit of say, centrifuges, in year j, will be:

$$\bar{p}_j = \frac{p_j}{p_{j-1}} \bar{p}^c_{j-1}$$

---

[1]Z. Griliches, "Notes on the Measurement of Price and Quality Changes" in Models of Income Determination (National Bureau of Economic Research Studies in Income and Wealth, Vol. XXVIII; Princeton: Princeton University Press, 1964).

[2]M. L. Burstein, "The Demand for Household Refrigeration in the United States," in A. C. Harberger (ed.), The Demand for Durable Goods (Chicago: University of Chicago Press, 1960).

[3]Ibid., p. 11.

where p_j and p_{j-1} are the prices per capacity unit of centrifuges with the same specifications.

In order to have an idea, however rough, of the system of weights, w_i, by means of which set of separate prices should be collapsed into a single number (i.e., our deflator $\overline{P}_j$), we inquired into the number of units of specific equipment in a number of plants. It was possible to study three plants, one in 1946, one in 1957 and another in 1965.[1] It was possible to estimate the number of capacity units existing in each of these years for each of these plants. Knowing the stock of capacity units for each of these years, we estimated the flow of gross additions that would take place in every year assuming a certain net rate of growth (2.5 per cent per year, similar to the average rate of growth of output of the period 1943-63) and adding to it a rate of replacement that varied between 2 per cent to 5 per cent depending on the assumed durability of the item in question. Using the current prices in 1957 we computed what would have been the cost of the flow of gross capacity incorporated, and what would have been the share in this bundle of gross investment of each of the items under study. The resulting weights are very similar for the three plants. The weights, however, are slightly modified, reducing the importance given to crushing rollers and increasing that assigned to evaporators, vacuum pans, and copper tubes. The reason for this adjustment was that, while the crushing

---

[1]This material was obtained from the personal archives of Ing. Isidoro Spellzini during a series of personal interviews held in Tucumán, Argentina, in September and October, 1967.

operation as such has a relatively large weight, rollers represent only a samll fraction of total crushing equipment. On the other hand, evaporators, vacuum pans, and copper tubes represent a larger fraction of total capital used in their particular operations. Table 10 describes the items whose prices were studied, the operations in which they are used, the stage of production to which they belong, their assumed durability, the capacity units in which their prices were expressed and the weight assigned in computing the deflator.

The methodology described above allowed us to build the deflator by using the following expression:

$$\bar{P}_j = \Sigma_i w_i \bar{p}_j^i .$$

The available information allowed us to go back as far as 1932 but lack of information precluded the effort of keeping quality constant prior to that year. Since for most of our purposes, it was necessary to have estimates going back as far as 1913, we searched for some existing index that could be used as a good proxy of our deflator and that by splicing to it we could have estimates of our deflator for the period 1913-31. It was found useful, in this score, the wholesale price index constructed by A.C. Diz in his doctoral dissertation.[1] Estimates of our deflator were obtained using the linear regressions: $\bar{P}_j = \alpha_1 + \beta_1 w_j$. Estimates for the over-

[1] A. C. Diz, "Money and Prices in Argentina, 1935-62 (unpublished Ph.D. dissertation, Department of Economics, University of Chicago, 1966), p. 94.

lapping period 1932-49 are very satisfactory, yielding the following estimates of the parameters:

$$\alpha_1 = \underset{(3.86)}{16.89} \qquad R^2 = 0.99$$

$$\beta_1 = \underset{(0.02)}{0.82} \qquad N = 18$$

which were used to obtain the splicing estimates. To inquire into the usual standards of goodness of fit we also estimated a regression on the first difference which yielded a constant not different from zero and a regression coefficient that was not statistically different from the other estimate of β_1 at the usual levels of significance. It should be mentioned, finally, that our deflator refers to quotations collected on a calendar year basis.

<u>The Survival Coefficient</u>

The problem of durability is one which we found very difficult to investigate. Inspection of amortization rates used by the companies and government agencies convey the general impression that on the average the items last something like 30 years.[1] In obtaining our estimates for the stock of capital we assume a one-horse-shay concept. To smooth the effects of sudden death, v_{jt} was taken equal to 1 for $t \leq j + 27$, and .90 for $t = j + 28$; .70 for $t = j + 29$; .30 for $t = j + 30$; .10 for $t = j + 31$ and 0 afterwards.

---

[1] It should be noticed that 30 years is the weighted average of the durability assigned to different capital goods of Table 10 when the system of weights is the same as the one used to obtain the deflator.

TABLE 10.--Durable Goods whose Price per Capacity Unit were Used in Estimating the Deflator

Item	Operation	Stage	Durability	Capacity Units	W_i
Crushing Rollers	Grinding	(a)	30 years	Cubic meters	0.30
Evaporator	Evaporation	(c)	30 years	Square meters of heating surface	0.05
Vacuum pans	Concentration	(d)	30 years	Hectoliters	0.05
Copper tubes[a]	Evaporation and Concentration	(c, d)	20 years	Kilograms of 30-50 milimeter diameter tubes	0.05
Boilers	Steam Generation	(f)	30 years	Square meters of heating surface	0.25
Centrifuges	Centrifuging	(e)	20 years	Cubic foot of massecuite per day	0.10
Filters	Purification	(b)	30 years	Square meters of surface of filtration	0.05
Turbine-Generator[b]	Electricity Generation	(g)	50 years		0.10
Heaters	Evaporation	(c)	30 years	Square meters of heating surface	0.05

[a]The inclusion of copper tubes is due to the fact that the price quotations of evaporation and concentration items were usually done excluding copper so that estimates of the quantity of copper to make these items complete were made separately.

[b]For turbine-generators we could not get enough observations so as to warrant the effort of keeping quality constant. For that purpose we resorted to the use of the appropriate index published by Whitman, Requart and Associates, Handy-Whitman Index of Public Utility Construction Costs (Baltimore, 1964). There a substantial effort in the direction of keeping quality constant can be noticed. The Handy-Whitman index was multiplied by an index of the relevant exchange rate for the dollar. The exchange rate for the dollar was obtained from: A. C. Diz, "Money and Prices in Argentina, 1935-1962" (unpublished Ph.D. dissertation, Department of Economics, University of Chicago, 1966), pp. 124-125.

TABLE 11.--Estimates of Stock of Capital (Equipment only) for 24 Plants of Tucumán During 1943-1963 at 1938 Prices

Zafra Year	Gross Investment in Pesos at Current Prices	Deflator	Estimate of Stock of Capital in 1,000 Pesos of 1938
1913	330,154	74.7	--
1914	133,249	75.4	--
1915	275,253	79.8	--
1916	432,564	87.9	--
1917	165,935	104.7	--
1918	237,084	113.6	--
1919	542,579	116.1	--
1920	1,245,174	120.9	--
1921	849,971	99.8	--
1922	838,749	92.4	--
1923	846,117	94.9	--
1924	683,206	100.8	--
1925	457,074	101.9	--
1926	992,321	93.9	--
1927	471,278	92.1	--
1928	353,059	92.6	--
1929	631,554	90.6	--
1930	495,552	87.0	--
1931	352,691	84.2	--
1932	236,293	88.0	--
1933	837,733	87.8	--
1934	448,001	91.1	--
1935	505,610	93.6	--
1936	670,994	96.5	--
1937	560,996	98.5	--
1938	413,714	100.0	--

TABLE 11. --Continued

Zafra Year	Gross Investment in Pesos at Current Prices	Deflator	Estimate of Stock of Capital in 1,000 Pesos of 1938
1939	755,482	113.2	--
1940	984,445	124.5	--
1941	676,791	134.8	--
1942	537,234	150.1	--
1943	633,603	162.9	62,678
1944	862,135	173.9	62,911
1945	942,231	186.4	62,557
1946	1,025,208	211.2	62,351
1947	3,823,628	236.6	65,791
1948	5,651,199	272.1	68,128
1949	7,324,444	336.6	70,941
1950	7,326,262	451.6	71,233
1951	8,996,118	560.1	73,266
1952	9,405,987	638.5	73,851
1953	10,616,969	721.8	74,183
1954	12,793,508	798.0	76,694
1955	14,514,331	1,120.4	79,724
1956	12,349,664	2,279.9	79,699
1957	11,510,580	2,581.4	81,651
1958	58,275,041	3,410.9	86,263
1959	30,478,904	5,799.8	88,311
1960	36,357,659	7,201.0	90,161
1961	130,427,873	7,668.3	96,747
1962	33,714,103	9,926.0	103,578
1963	55,546,535	12,484.4	112,983

APPENDIX B

ESTIMATES OF SERVICES OF LABOR, SOURCES AND METHODS

In estimating the services of labor we used the following relationship:

$$H_t = \frac{WB_t}{\overline{w}_t} f_t$$

where: H_t is the (implicit) number of hours worked during the zafra year t,

WB_t is the wage bill expressed in current pesos during the zafra year t,

$\overline{w}_t$ is an average of the nominal wages per day paid to different categories of workers during zafra year t[1],

f_t is average hours per day in year t.

Since we were interested in the production of sugar, the main effort was directed towards getting information of the wage bill at the plant level. Payments to labor engaged in agricultural activities and remuneration of white collar employees in the administration were not included.

Two different approaches were explored concerning the concept of the wage bill: (a) a wage bill gross of yearly bonuses, holidays,

---

[1] Virtually identical results were obtained when $\overline{w}$ was defined as the daily wage of unskilled labor.

accidents, separation payments, family allowances, housing, social security, etc.; or (b) a wage bill net of these items. Even when we had access to bodies of data of roughly the same quality on this score, considerations concerning $\bar{w}$ lead us to prefer the second approach. It was found far easier to make estimates of basic salary than to make a series that would include all the supplements. So we proceeded to estimate the basic wage bill including extra hours.

Information on wages paid were obtained from two government agencies: Dirección Provincial de Estadística (Province of Tucumán)[1] and Dirección Nacional de Azúcar (Federal Government).[2] The information of Dirección de Estadística was for the wage bill on calendar year basis--WDE--whereas that of Dirección de Azúcar was on zafra year basis--WDA. So even though from a purely definitional point of view there were a substantial homogeneity, WDE figures were available for only 1943-55 and 1963 on a comprehensive basis, with partial samples for some years in between, and WDA data were available for only 1953-63. Since we were working with zafra year it was necessary to transform WDE so as to bring in a greater homogeneity among them. Fortunately for most of the years and plants there were data on the monthly wage bill, so we undertook the task of recomputing the wage bill from WDE data so as to obtain it, for

---

[1]Tucumán, Dirección Provincial de Estadística, collection of "Estadística Industrial," Archives.

[2]Argentina, Secretaría de Comercio, Dirección Nacional de Azúcar y Envases, collection of "Planillas de Costo," Archives.

each plant, on a zafra year basis.

For the years for which complete WDE data were not available, the figures used were based on WDA data. To achieve comparability the figures actually used for these non-WDE years were generated from WDA data by regressions of the form:

$$WDE_i^t = A_i + B_i \, WDA_i^t .$$

Such regressions were run for each individual plant in an effort to correct for any systematic effects that might result from the differences that existed between the two reporting systems. They were based on the years for which overlapping WDE and WDA data were available for each plant.

The period for which we made estimates of the labor input is for Tucumán 1943-63. Estimates of WDE_i^t were done mainly for $t = 1957$ to 1962 and overlapping observations were available for the years ranging from 1953 to 1963. Estimates of A_i and B_i were usually obtained by regressions on an average of four observations per plant. Estimates of $\overline{w}$ were obtained using a weighted average of different categories of workers employed by the sugar industry. The system of weights was obtained out of a study of 17 plants in the province of Tucumán in 1956.[1] In this study a classification was made of 9, 708 workers according to their basic salary per day in 1948. Table 12 gives the numbers and the weights.

After having made the distribution of the 9, 708 workers of the 17

---

[1]F. Avila et al., "Nivel de Salarios en la Industria" (trabajo de Seminario, Universidad de Tucumán, 1958).

plants by basic salary per day (which was centered on the basic salary for unskilled labor), specific categories earning these basic salaries were found in the lists included in the documents of collective agreements between unions and firms (see Table 12 under heading "skill") and these

TABLE 12.--Distribution of the Number of Workers of 17 Plants in Tucumán, 1956, by Basic Salary Per Day in 1948

Basic Salary	Number	Weight	Skill
7.20	5.831	0.6006	Peones en General
7.80	1.836	0.1891	Ayudante Práctico
8.40	652	0.0672	Medio Oficial Plomero
9.00	202	0.0208	Capataz Centrífugas
9.60	316	0.0326	Centrífugas pilé
10.20	230	0.0237	Pintores
10.80	299	0.0308	Sopletero autógeno
11.40	150	0.0155	Cobrero o Mecánico
12.00	110	0.0113	Mecánico Diesel
12.60	0	0.0000	---
13.20	3	0.0003	Encargado de Usina
13.80	65	0.0067	Maestro de Azúcar la.
14.40	14	0.0014	Asistente de Fábrica

skills were traced in the period 1948-63 so that their basic salary was assessed monthly. For the period 1943-48 we used a narrower piece of information; this was a study of basic salary for unskilled labor for the sugar industry by Emilio Schleh.[1] We then assumed proportionality between Schleh's basic salary series and the desired average wage series. Having estimated the average basic salary per month since 1943, we had still the problem of computing the monthly average over the zafra year. This was especially important because of the seasonality of the employment and because of the adjustments resulting from collective bargaining. The weights attached to each month were obtained from a study of the number of workers effectively employed at the end of each month during the period 1943-55,[2] the resulting system of weights is shown in Table 13.

TABLE 13.--Fraction that the Number of Workers at the End of Each Month Represents of the Sum over the Twelve Months

Month	Weight
May	0.075
June	0.122
July	0.129
August	0.130
September	0.121
October	0.091
November	0.062
December	0.054
January	0.050
February	0.053
March	0.055
April	0.058
	1.000

[1] Emilio Schleh, "Salario en fábrica de peones en general y otras categorías," La Industria Azucarera, April, 1956.

[2] Dirección Provincial de Estadística, Boletín Estadístico Nos. 7, 8, and 12, and Publication No. 7 (September, 1957).

All the information described above was used in obtaining the estimates of $\bar{w}_t$ for the zafras 1943-63. In Table 14 the series of average basic salary is shown. A brief exploration concerning the variability of f through time conveys the impression that it can be assumed, without great error, that it remained constant so that the index of the services of labor for year t with respect to some basic year 0 can be expressed as:

$$L_t = \frac{H_t}{H_0} = \frac{(WB_t/\bar{w}_t)}{(WB_0/\bar{w}_0)} \qquad (WB = \sum_i WDE_i)$$

This index was computed for the 24 plants under study for the period 1943-63. For the subperiod 1943-55 the information on the wage bill was complete and available for the 24 plants, but for the subperiod 1956-62 estimates of the wage bill were made for a smaller number of plants so that the index of labor input was obtained by chainlinking:

$$L_t = \frac{\sum_j (WDE_j^t/\bar{w}_t)}{\sum_j (WDE_j^{t-1}/\bar{w}_{t-1})} L_{t-1}$$

where j refers to the plants for which information on the wage bill is available in the adjacent years. It should be noticed that the number of plants satisfying this condition was never less than 18.

Table 14 also describes the main ingredients used in estimating the index of man hours for the plants under study. Alternative estimates of labor were done using information on the average number of workers at the end of each month. If N_t is the monthly average for zafra of year t, and

TABLE 14. --Index of Man-Hours for 24 Plants of Tucumán During the Period 1943-63

Zafra Year	Number of Plants	$\overline{w}_t$ Average basic salary	Index of Man Hours
1943	24	4.59	100.0
1944	24	4.78	114.6
1945	24	5.53	135.9
1946	24	6.56	203.9
1947	24	7.87	258.5
1948	24	8.13	289.8
1949	24	13.95	210.8
1950	24	15.05	247.9
1951	24	21.57	237.8
1952	24	29.10	239.0
1953	24	29.74	247.7
1954	24	34.70	250.1
1955	24	36.73	258.5
1956	19	46.94	220.5
1957	18	52.82	249.8
1958	20	88.33	316.2
1959	19	145.52	243.8
1960	18	150.16	255.2
1961	19	192.37	210.1
1962	22	251.55	201.7
1963	23	348.86	228.9

N_0 is the average of some base year, then the index of labor input is:

$$I_N^t = \frac{N_t}{N_0}$$

estimates of this index were computed for the period 1943-63 for data on calendar year basis and for 1943-56, 1963 for data on zafra year basis.

TABLE 15.--Indexes of Labor Input Based on Average number of Workers at the End of Each Month for 24 Plants of Tucumán During the Period 1943-63

Year	Average Number of workers for calendar year	Average Number of workers for zafra year	Index of Labor Input: Calendar Year	Index of Labor Input: Zafra Year	Ratio of L_t/I^t_N Calendar
1943	5,618	5,596	100.0	100.0	1.00
1944	6,313	6,241	112.4	111.5	1.02
1945	7,249	7,711	129.0	137.8	1.05
1946	9,612	9,930	171.1	177.5	1.19
1947	11,729	11,443	208.8	204.5	1.24
1948	12,230	12,472	219.3	222.9	1.32
1949	12,325	11,751	219.4	210.0	0.96
1950	11,497	11,339	204.6	202.6	1.21
1951	11,480	11,609	204.3	207.5	1.16
1952	11,744	11,621	209.0	207.7	1.14
1953	12,114	11,816	215.6	211.2	1.15
1954	12,058	12,163	214.6	217.4	1.17
1955	12,436	12,347	221.3	220.6	1.17
1956	12,702	11,821	226.1	211.3	0.98
1957	12,546*	--	223.3	--	1.12
1958	13,530*	--	240.8	--	1.31
1959	13,625*	--	242.5	--	1.01
1960	10,771*	--	191.7	--	1.33
1961	9,479*	--	168.7	--	1.25
1962	9,760*	--	173.7	--	1.16
1963	10,451	10,467	186.0	187.1	1.23

The symbol (*) means that the average number of workers was actually estimated out of the corresponding index of labor which in turn was obtained by chainlinking information on plants for which there was information for two successive years (no less than 15 plants).

Table 15 shows the main results of this part. There is no substantial difference among the indexes on either calendar or zafra year basis. To have some idea on the number of hours worked by each worker, the ratio between L_t and I_N^t is given. The ratio of L_t on I_N^t, although showing no trend at all, seems to depart substantially as between years in general with occasional, erratic, shocks. Ideally the ratio should be equal to one. There are at least three reasons why coincidence does not occur. First, since the I_N data report the labor force on only the last day of the month, they may be unrepresentative of the average labor force over the entire month. Second, even if the I_N data were representative of the average number of workers employed, they would not accurately reflect labor inputs if there were variations in average hours of work per day. Finally it appears that at least on some occasions, the I_N data include workers on strike.

These considerations lead us to the conclusion that the index of man-days based on the wage bill is a better estimate of the labor input used by the sugar plants and in making our estimates this was the measure of labor actually used.

APPENDIX C

AN ALTERNATIVE MODEL: ERROR ADDITIVE

While searching for an explanation for the economies of scale posed by our estimates of the pooled data, it was thought that this finding could be due to the multiplicative form in which the correction of the services of capital was made: $K_{it} \cdot \theta_i$. This specification of the errors in the services of capital implied a correction by a factor of proportionality which in itself could introduce a downward bias in our estimates of the share of labor and capital.

To explore a little further the possibility of a statistical bias of this type, a different model was tried. Under the new model, it was assumed that the services of capital included a backlog of past investments that did not disappear after its useful life but that is constant over time so that whenever the services of capital increased the implied factor of correction should be proportionately less. This assumption lead us to the following specification:

$$K^o_{it} = K_{it} + \theta_i ,$$

so that the production function of any plant i, for year t, is:

$$S_{it} = A\, L^{\alpha}_{it} (K^o_{it})^{\beta} = A\, L^{\alpha}_{it} (K_{it} + \theta_i)^{\beta}$$

taking logs:

$$\log S_{it} = \log A + \alpha \log L_{it} + \beta \log (K_{it} + \theta_i)$$

$$\log S_{it} = \log A + \alpha \log L_{it} + \beta [\log K_{it} (1 + \theta_i K_{it}^{-1})],$$

and taking as an approximation the first term of the log expansion of the factor $(1 + \theta_i K_{it}^{-1})$ we obtain:

$$\log S_{it} = \log A + \alpha \log L_{it} + \beta \log K_{it} + \beta . \theta_i K_{it}^{-1}$$

Instead of a dummy variable for each plant, we now include as a regressand the inverse of the services of capital for each plant, the coefficient of which will give us $\beta \theta_i$. The term θ_i for each plant can be identified by dividing the coefficient of K_{it}^{-1} by the estimate of β. This model was applied to the same observations of the pool of 20 plants of Tucuman 1943-63. Estimates of some regressions are shown in Table 16 (numbers are given so as to facilitate comparison with the corresponding regressions of Table 6). It can be seen that the coefficient of labor, the policy variable, and strong Regulatory Fund turned out to be the same as in the multiplicative model. The coefficient of capital seems to improve in what could be regarded the right direction. The sum of the share of labor and capital is now 0.90, which is still statistically different from unity.

Further elaboration has shown that the additive model does not represent an improvement over the multiplicative type, even though it is useful as a check on the coefficients of the main shifters studied, and a clarification of the role played by the dummy variables. In connection with the relation between the dummy in the first model and the correction for "backlog" in the services of capital that the second model implies, it should be noticed that the dimensionality of θ_i in the second model is that of a stock of capital times the number of days effectively operated by the plants. Here the coincidence of both models is also great: in nearly all the cases in which the multiplicative model lead to coefficients of plant dummies statistically different from zero, the corresponding ones of the additive model turned out to be statistically significant also.

The additive correction for the services of capital can be expressed:

$$K_{it} + \theta_i = K_{it} \left(1 + \frac{\theta_i}{K_{it}}\right)$$

Using the average of K_{it}^{-1} for each plant, estimates of the implicit factor of correction that the additive model yields were made which were compared with the corresponding ones obtained in the multiplicative model. This was done for the plants for which θ_i was statistically significant. The values so compared have a strong correspondence in both ranking and order of magnitude.

TABLE 16.--Estimates of the Production Function Parameters for Tucumán 1943-63: Data Pooled for 20 Plants; N = 320; Model: $K_i^o = K_i + \theta_i$

Independent Variable		Regression (2)	Regression (5)	Regression (6)
Policy Variable		0.19 (0.04)	0.15 (0.03)	0.17 (0.04)
Labor		0.26 (0.04)		0.28 (0.04)
Capital		0.64 (0.05)		0.63 (0.05)
Raw			1.00 (0.03)	
K^{-1}	plant 2	0.675 10^{7} (0.193 10^{8})[a]	-0.200 10^{8} (0.127 10^{8})	0.528 10^{7} (0.192 10^{8})
	plant 3	0.836 10^{8} (0.401 10^{8})	0.152 10^{7} (0.275 10^{8})	0.786 10^{8} (0.399 10^{8})
	plant 4	0.264 10^{9} (0.436 10^{8})	-0.467 10^{8} (0.306 10^{8})	0.257 10^{9} (0.434 10^{8})
	plant 5	0.635 10^{8} (0.147 10^{8})	0.946 10^{7} (0.807 10^{7})	0.638 10^{8} (0.146 10^{8})
	plant 6	0.368 10^{8} (0.180 10^{8})	-0.647 10^{7} (0.115 10^{8})	0.359 10^{8} (0.178 10^{8})
	plant 7	0.843 10^{8} (0.121 10^{8})	0.142 10^{7} (0.654 10^{7})	0.826 10^{8} (0.121 10^{8})
	plant 8	0.489 10^{7} (0.137 10^{8})	0.211 10^{7} (0.869 10^{7})	0.403 10^{7} (0.136 10^{8})
	plant 9	-0.357 10^{9} (0.415 10^{8})	-0.948 10^{8} (0.274 10^{8})	-0.357 10^{9} (0.412 10^{8})
	plant 10	-0.277 10^{8} (0.171 10^{8})	-0.143 10^{8} (0.111 10^{8})	-0.285 10^{8} (0.170 10^{8})

TABLE 16.--Continued

	Regression (2)	Regression (5)	Regression (6)
plant 11	-0.161 10^8 (0.259 10^8)	-0.254 10^8 (0.175 10^8)	-0.182 10^8 (0.257 10^8)
plant 12	0.319 10^8 (0.138 10^8)	-0.107 10^8 (0.777 10^7)	0.311 10^8 (0.137 10^8)
plant 13	0.786 10^8 (0.143 10^8)	-0.133 10^8 (0.769 10^7)	0.778 10^8 (0.142 10^8)
plant 14	0.687 10^8 (0.289 10^8)	0.950 10^7 (0.186 10^8)	0.640 10^8 (0.288 10^8)
plant 15	0.945 10^7 (0.407 10^8)	-0.297 10^7 (0.278 10^8)	0.339 10^7 (0.405 10^8)
plant 16	0.159 10^8 (0.112 10^8)	-0.653 10^7 (0.646 10^7)	0.150 10^8 (0.111 10^8)
plant 17	0.856 10^8 (0.281 10^8)	0.851 10^7 (0.189 10^8)	0.830 10^8 (0.280 10^8)
plant 18	0.184 10^8 (0.289 10^8)	0.608 10^7 (0.194 10^8)	0.180 10^9 (0.287 10^8)
plant 19	0.500 10^8 (0.231 10^8)	0.501 10^7 (0.152 10^8)	0.473 10^8 (0.230 10^8)
plant 20	0.141 10^8 (0.245 10^8)	0.141 10^8 (0.245 10^8)	0.130 10^8 (0.243 10^8)
Dummy	-------- --------	-------- --------	-0.064 (0.028)
R^2	0.83	0.92	0.83

[a]Parentheses indicate standard errors.