ABSTRACT

THE WORLD SUGAR ECONOMY

AN ECONOMETRIC ANALYSIS OF PRODUCTION AND POLICIES

By

Gordon Gemmill

The purpose of this thesis was to estimate supply and demand functions for sugar for each of the major producing and consuming nations of the world and to use these functions to develop a model which would show the impact of alternative trade-policies. The model and its components were designed to give solutions both in long-run equilibrium and in an annual, recursive mode. Special attention was given to developing supply functions for both beet and cane in the U.S.A., taking into account the restrictions on acreage frequently imposed under the Sugar Program. Because the free market for sugar is typified by cycles in supply and price, a function capable of generating these cycles was used in estimating supply from each of the major cane-producing nations.

The supply of sugar in the U.S.A. was found to be generally price elastic, long-run elasticities being 0.00 for Puerto Rico, 0.75 for Louisiana, 0.90 for beet in the North and North-East, 0.99 for Hawaii, 2.71 for beet in the West and North-West and 4.23 for Florida. The supply of beet-sugar in Europe ranged in price elasticity from approximately 0.30 for the Communist countries to 1.63 for France. The major cane-producing countries were found to have short-run price elasticity

of supply in the 0.10-0.74 range, while their long-run elasticities were constrained to a maximum of 1.00 during estimation.

The demand for sugar, examined for more than 70 countries using both time-series and cross-section data, was found to be generally both price and income inelastic. For the U.S.A. price elasticity was estimated to be approximately -0.03 and income elasticity 0.03. The range in price elasticities across countries was from -1.49 to 0.00 and in income elasticities was from 0.00 to 2.44.

In the complete model there were 75 consuming and 68 producing regions, together comprising the whole world. Regions were separated by trade-barriers and transportation costs. Quota agreements were treated as exogenous flows. The model was solved for long-run equilibrium under trade-policies ranging from a most likely set to a set with universal free trade.

Using the concepts of producer and consumer surplus, there was found to be a world gain of $330 million from free trade in sugar, the U.S.A. gaining $66 million, the EEC $70 million and the cane-exporting nations $639 million. The losers would be the traditional importers from the free market such as Japan, Canada and many African and Asian countries.

Should the U.S.A. continue its current policy of free trade, there was estimated to be a 24 percent reduction in domestic production and a 13 percent drop in domestic price. Consumers would gain $330 million and producers and government would lose $307 million. Should the EEC begin free trade it would suffer a 23 percent reduction in domestic production due to a 23 percent reduction in price. Consumers would gain

$709 million and producers would lose $525 million. Other policies which were considered included the formation of a cartel to raise prices by the cane-sugar exporting nations. Such a cartel was found to be very ineffective due to the elastic supply of (beet) sugar in the major importing nations.

The policy implications of the solutions depend on whether producers and consumers in the developed countries are prepared to face a fluctuating free-market price. Freer trade would reduce the incidence of very low prices on the free market but not affect high prices. Since the international gains from freer trade are large, the multilateral reduction of barriers to trade in sugar would be feasible in a new kind of International Sugar Agreement.

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CHAPTER I

INTRODUCTION

Context and Objectives

The gyrations of the international market for sugar are now common knowledge to American consumers. During 1974 the retail price of sugar rose from 16.96 cents per pound in January to 62.76 cents per pound in December. Thereafter there was a continuous decline to 32.08 cents per pound at the time of writing, September 1975. Investigations into the causes of this price variation, such as that of the President's Council on Wages and Prices,[1] failed to find a culprit more specific than a fluctuating international and domestic supply of sugar. This thesis is an attempt to understand the workings of the international sugar market and to expose through a formal, quantitative approach, the effects of alternative policies on the international distribution of production.

The report falls naturally into two parts. The first, comprising Chapters I to VII inclusive, is concerned with the theoretical and empirical underpinning of the whole work and gives econometric estimates of supply and demand relationships. Chapter II discusses trade theory, spatial equilibrium and the model being developed in this research. In that chapter some previous research is also discussed in order to emphasize the need for the current work. Chapters III to VI present self-contained studies of U.S. Beet-Sugar Supply, U.S. Cane-Sugar Supply,

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[1]Council on Wage and Price Stability (1975). Staff Report on Sugar Prices. Office of Wage Price Monitoring, May, Washington D.C.: Government Printing Office.

European Sugar Supply and International Cane-Sugar Supply. Chapter VII reports on the demand for sugar in more than seventy countries and develops both general and country-specific equations. The second part of the report, comprising Chapters VIII and IX, is concerned with the solution, validation and policy-implications of the complete model of the world sugar economy.

From a methodological viewpoint, the first part of this research may be considered a "positive" analysis, (in-so-far-as any part of neo-classical economics may be considered positive in nature), while the second part is of a considerably more normative character since certain stronger assumptions are utilized in solving the model and comparing the welfare of different countries under alternative policies. It is not usual to address the "casual" reader of a report, but those wishing to acquaint themselves with the sugar market might usefully omit Chapters III to VII inclusive which have a technical rather than policy-oriented flavor.

The objectives of this research may be listed as follows:

1. To estimate supply and demand functions for sugar for the main producing and consuming nations of the world.

2. To construct a model, using the above functions, capable of simulating the behavior of the market over the last decade.

3. By counter-factual experiment, to examine the effects of the sugar-policies of the U.S.A. and European Economic Community on the price of sugar and the international distribution of income.

4. To project the behavior of the market for sugar under a variety of alternative policies including an examination of the feasibility and effectiveness of a producers' cartel.

Summarizing these objectives, the research may be characterized as an attempt, through econometric model-building procedures, to analyze the workings of the market under alternative policies, using somewhat weaker assumptions than have been used in previous research in this area.[2] The Introduction continues with a brief review of the international sugar market and a discussion of the policies of both exporting and importing nations.

The World Sugar Market Since 1950

Sugar, or more accurately that substance whice we call sugar and which is actually sucrose, is derived from sugar cane in the tropical and semi-tropical regions of the world and from sugar beet in temperate regions. Because of this duality of sources, sugar is produced in almost every country in the world, as may be seen in Figure 1.1 In 1973 41 percent of all centrifugal sugar was derived from beet, this proportion varying but little in recent years with a high of 45 percent in 1964 and a low of 39 percent in 1971.[3] Since the so-called "less developed countries" are concentrated in the warmer climates, almost all of their production is from cane. The only "developed" cane producers of any importance are Australia and the U.S.A. In consequence approximately 53 percent of the world's sugar was produced by less developed countries in 1973. These proportions may be slightly deceptive, as a crude product, called noncentrifugal sugar, is also produced in less developed countries for local consumption, but reliable data on its level of production do not exist. What data there are suggest that it

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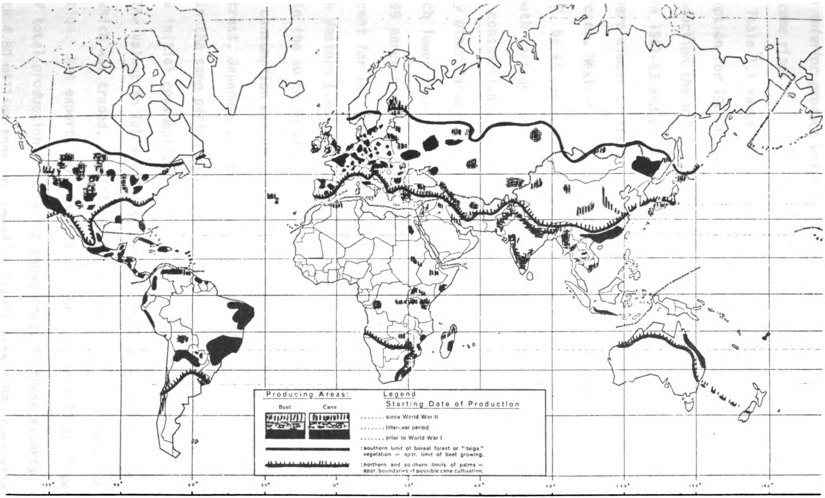
[2] Previous research is discussed in Chapter II.

[3] Except where otherwise stated, data are from: "International Sugar Organization (Annual). Sugar Yearbook. London: International Sugar Organization, 28 Haymarket, W.C.I." At the time of writing, data for 1974 are not completely available on a world basis. Alternative series are produced by F. O. Licht of Ratzeburg, Germany, the United Nations Food and Agriculture Organization and the U.S. Department of Agriculture.

Figure 1.1
Boundaries and Areas of Centrifugal Beet and Cane Sugar Production--1961



Source: International Sugar Organization (1963).

is an inferior product which is rapidly replaced by centrifugal sugar as income rises.

Table 1.1 ranks the most important countries by production and consumption for 1961-63 and 1971-73, as well as giving world totals. In production the U.S.S.R. ranked first in both periods followed by Cuba in 1961-63 and by Brazil in 1971-73. While Cuban and U.S. production were almost constant over the decade, Brazilian production rose 91 percent, Mexican 66 percent, Australian 58 percent and that of the U.S.S.R. by 45 percent. In consumption the U.S.S.R. and U.S.A. dominated both periods but U.S. consumption advanced only 17 percent whereas Soviet consumption gained 38 percent. However, the advances in consumption by other large countries, whose per capita consumption in 1961-63 was much lower than that in the U.S.A., were correspondingly greater, being 99 percent for Japan, 90 percent for China, 69 percent for Mexico, 54 percent for India and 49 percent for Brazil. Annual consumption per head in Western Europe, Canada and the U.S.A. has stabilized in recent years in the 40 to 50 kilogram range. For example, in 1963 U.S. per capita consumption was 48.2 kilograms and in 1973 it was 49.8 kilograms. By contrast, Japanese per capita consumption rose from 17.6 to 30.1 kilograms in the same period under the influences of a rising real income and low initial consumption.

The values in Table 1.1 disguise the relatively small volume of sugar which was traded, 22 million tons in 1973 or 28 percent of total production. Net exports were only 19 million tons in 1973 or 25 percent of total production. Table 1.2 shows that, of these exports, Cuba led with 4.80 million tons, followed by Brazil with 2.98, Australia with 2.10 and the Philippines with 1.39. Ten countries accounted for 81

Table 1.1. World's Ten Largest Producers and Consumers, 1971-1963 and 1971-1973 ('000 Metric Tons Raw Value)

Production (3-Year Average)				Consumption (3-Year Average)			
1961-1963		1971-1973		1961-1963		1971-1973	
Country	Tons	Country	Tons	Country	Tons	Country	Tons
U.S.S.R.	6,377	U.S.S.R.	9,225	U.S.A.	9,081	U.S.S.R.	10,767
Cuba	5,134	Brazil	6,128	U.S.S.R.	7,827	U.S.A.	10,595
U.S.A.	5,048	U.S.A.	5,687	U.K.	2,941	Brazil	4,063
Brazil	3,210	Cuba	5,340	Brazil	2,732	India	4,058
India	2,875	India	3,885	India	2,626	China	3,563
France	2,426	China	3,167	China	1,920	Japan	3,215
Australia	1,724	France	3,118	W. Germany	1,855	U.K.	2,923
W. Germany	1,685	Australia	2,728	Japan	1,614	W. Germany*	2,227
Mexico	1,583	Mexico	2,629	France	1,584	Mexico	2,097
Philippines	1,514	W. Germany	2,336	Mexico	1,239	France*	2,088
Sub-Total	31,576		44,244		33,419		45,596
World Total	52,989		57,953		53,358		76,355

*1970-1972.

Source: International Sugar Organization except for EEC countries in 1971-1973 for which the source was: "Comité Européen des Fabricants de Sucre (Annual). Recueil Annuel de Statistiques. Paris: C.E.F.S., 45 Avenue Montaigne."

Table 1.2. World's Ten Largest Exporters and Importers in 1973 ('000 Metric Tons Raw Value)

Exporters		Importers	
Country	Net Exports	Country	Net Imports
Cuba	4,797	U.S.A.	4,830
Brazil	2,975	U.S.S.R.	2,584
Australia	2,103	Japan	2,395
Philippines	1,385	U.K.	1,811
Dominican Republic	1,070	Canada	952
South Africa	913	China	580
Mauritius	738	Iraq	457
Mexico	590	Yugoslavia	380
Taiwan	508	Malaysia	331
Argentina	470	Indonesia	307
Others	3,659	Others	4,754
Total	19,208		19,381

Source: Same as for Table 1.1 except for U.K. for which it was "European Economic Community (1975) Yearbook of Agricultural Statistics, 1974. Luxembourg: E.E.C. Statistical Office."

percent of all exports in 1973. Turning attention to imports in 1973, the U.S.A. led with 4.83 million tons, followed by the U.S.S.R. with 2.58, Japan with 2.40 and the U.K. with 1.81. Table 1.2 shows that the top ten countries accounted for 76 percent of sugar imports and the top five alone for 65 percent of imports. The picture of production, consumption and trade which emerges is one of widespread production and hence widespread self-sufficiency. However, a few countries, notably the U.S.A., U.S.S.R. and Japan, rely heavily on imports which are also provided by a relatively few countries, dominated by Cuba, Brazil and Australia.

Very little trade in refined sugar occurs since the refined product is hygroscopic and therefore more expensive to handle. The lack of trade in refined sugar is also the result of higher tariffs on refined than on raw sugar and the development, during colonial times, of the export of raws for refining in the "mother" country. Raw sugar is the product of the sugar cane mill and a normal rate of conversion is 100 parts of raw to 92 parts of refined sugar. Sugarbeet is usually processed directly to the refined form since there are technical economies in this procedure and since beet sugar is generally consumed in its country of origin. The major centers of sugar trade are New York and London for raw sugar and Paris for refined.

To talk of a "world sugar market" is somewhat misleading. There are really three kinds of markets. Firstly, there are the domestic markets within producing countries which accounted for 72 percent of all sugar in 1973. Secondly, there are international agreements between some of the largest importers and their suppliers. Such agreements may cover price, quantity, or both price and quantity. Examples are the current or recently expired agreements covering imports to the U.S.A., U.S.S.R. and U.K. Thirdly, there is a residual "free-market" in sugar which has from time to time been regulated by International Sugar Agreements. Table 1.3 gives the volumes of sugar traded in 1973 in each of the major markets.

The table shows that just over half of traded sugar entered the free-market, however that half represented a mere 14 percent of total production. The U.S. Sugar Act covered 22 percent of trade, Cuban Agreements covered 14 percent of trade and the Commonwealth Sugar Agreement covered 8 percent of trade. Each of these three institutions

Table 1.3. International Trade in Sugar by Type of Market in 1973

Type of Market	Exporter	Importer	'000 Metric Tons	Percent of World Exports	Price in Cents Per Pound
Under U.S. Sugar Act	Philippines	U.S.A.	1,319		
	Dominican Republic		676		
	Brazil		591		(Duty-paid in New York)
	Mexico		577		
	Others		1,672		
Total			4,835	21.8	10.29
Under Commonwealth Sugar Agreement (Negotiated Price Quota)	W. Indies & Guyana	U.K.	736		
	Mauritius		386		(f.o.b. in Caribbean)
	Australia		340		
	Others		308		
Total			1,770	8.0	5.36*
Under Bilateral Cuban Agreements	Cuba	U.S.S.R.	1,661		
		China	302		(f.o.b. in Cuba)
		E. Germany	259		
		Bulgaria	213		
		Others	561		
Total			2,996	13.5	6.0-11.0
Free Market Exports	Brazil		2,530		
	Cuba		1,774		
	Australia		1,497		(f.o.b. in Caribbean)
	EEC		1,468		
	South Africa		824		
	China-Taiwan		428		
	Poland		422		
	Dominican Republic		396		
	Argentina		396		
	Others		1,930		
Total			11,665	52.7	9.61
Free Market Imports		Japan	2,395		
		U.S.S.R.	1,016		
		Canada	952		
		Iraq	474		(f.o.b. in Caribbean)
		Yugoslavia	368		
		Malaysia	331		
		Indonesia	307		
		Iran	302		
		Others	5,658		
Total			11,803	53.2	9.61
Gross Exports in all markets			22,145	100.0	
Net Exports in all markets			19,208		
Domestically consumed			55,950		
World Production			78,095		

*Plus a bonus of 1.18 cents per lb. for West Indies and Guyana and 0.75 cents per lb. to other "less developed" suppliers.

will now be briefly considered.

The U.S. Sugar Act in essence dates from the Jones-Costigan Act of 1934 and lasted until January 1975. The Act was effectively killed by a vote of Congress in June 1974. Under this legislation quotas for the supply of sugar were allotted to particular foreign suppliers as well as to domestic producers. To encourage compliance with quotas, domestic producers were awarded a bonus conditional upon their remaining within the allotted acreages. The "conditional payments" were financed from a small duty paid on imported sugar, which was 0.625 cents per pound in 1973. The payments in most years were modest, amounting in 1973 to 1.20 cents per pound of raw sugar to beet growers and 0.56 cents per pound of raw sugar to cane growers. Prior to 1960, Cuba was the main foreign beneficiary of a quota, exporting 3 million tons annually to the U.S. out of total imports of 4.2 million tons. Following the Cuban embargo of 1960, U.S. domestic production was encouraged by an increase in quota and the remaining shortfall was allocated to other foreign suppliers (mainly the Philippines, Mexico, Dominican Republic, Brazil, Peru and Australia). The Act was designed primarily to protect domestic producers, but it also protected the favored foreign suppliers whenever the U.S. price exceeded the free-market price (the usual situation). In 1971 a specific price-objective was written into the Act so that quotas were to be adjusted in order that the domestic sugar price should rise at a rate indexed to the average of the wholesale-price and agricultural input-price indices.[4] While, as shall be seen, the Act protected the

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[4]Stated formally this is: $POB = \frac{PSUG}{(PARINDEX + WPI)/2}$

where: POB = the price objective for sugar,
PSUG = the price of sugar from Sept. 1st 1970 to August 31st 1971,

favored suppliers from low prices, (the world free-market price standing at least 2 cents per pound less in most years), it did little to prevent prices from rising should there be a relative decline in world supply. A secondary part of the Act legislated minimum wages to be paid laborers in the industry and the probable effect of this on employment in cane production will be discussed in Chapter IV.

The Commonwealth Sugar Agreement, first established in 1951 and still existing, has the objectives of ensuring the supply of sugar to the United Kingdom and maintaining stable prices. Under the agreement the Commonwealth exporter is allotted on "overall-agreement-quota" (OAQ) and a "negotiated-price-quota" (NPQ) (equal to approximately two-thirds of the OAQ). The negotiated price is determined under the terms of the agreement, but is subject to annual adjustments. The U.K. thus obtains, at least theoretically, two-thirds of its imports at a predetermined price. The remaining one-third is to be purchased by the U.K. at the ruling world price. In a year such as 1974 in which prices rose rapidly in the free market, the negotiated price becomes a fiction and either the Commonwealth price rises to meet the currently existing free-market price or supply in the U.K. is cut.

The Cuban Agreements with Communist countries became necessary after the suspension of Cuban exports to the U.S.A. in 1960. New quantities and prices are announced from time to time following negotiations on a bilateral basis. Should world sugar prices rise, the previously agreed price is abandoned and a new price contracted. For

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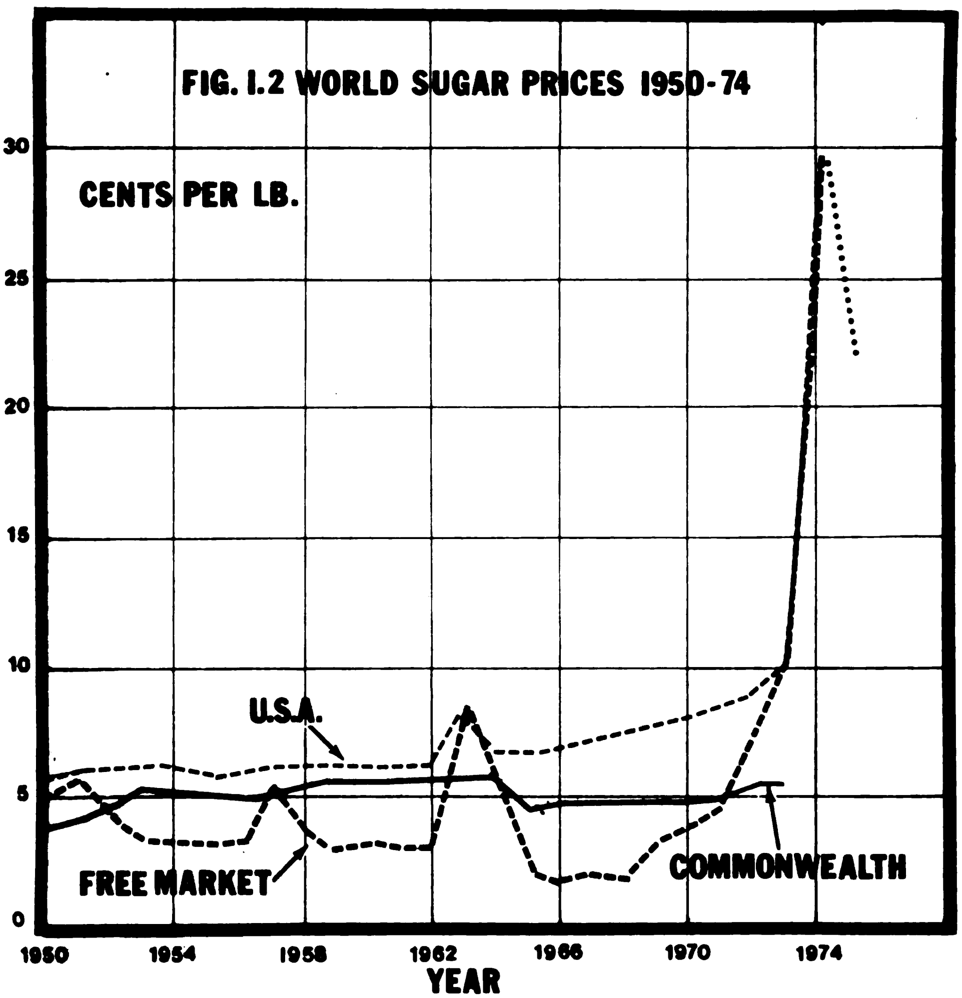
PARINDEX = the parity index of agricultural input prices (1967 = 100),
WPI = the wholesale price index (1967 = 100).

example, during 1974 the price to the U.S.S.R. was recontracted from 11.0 cents per lb. (approximately) to 20.0 cents per lb.[5] Cuba has not been obliged to fulfill its quota undertakings, at least in the case of the U.S.S.R. for which the quota stands at 3 million tons but which level has never been reached. During the 1960's the U.S.S.R. exported large quantities of refined sugar to the free market as well as importing Cuban raws, so that the Cuban Agreement did not diminish the volume on that market but simply changed the pattern of trade.

Figure 1.2 compares the annual average prices ruling in the three main "markets" over the last two decades.



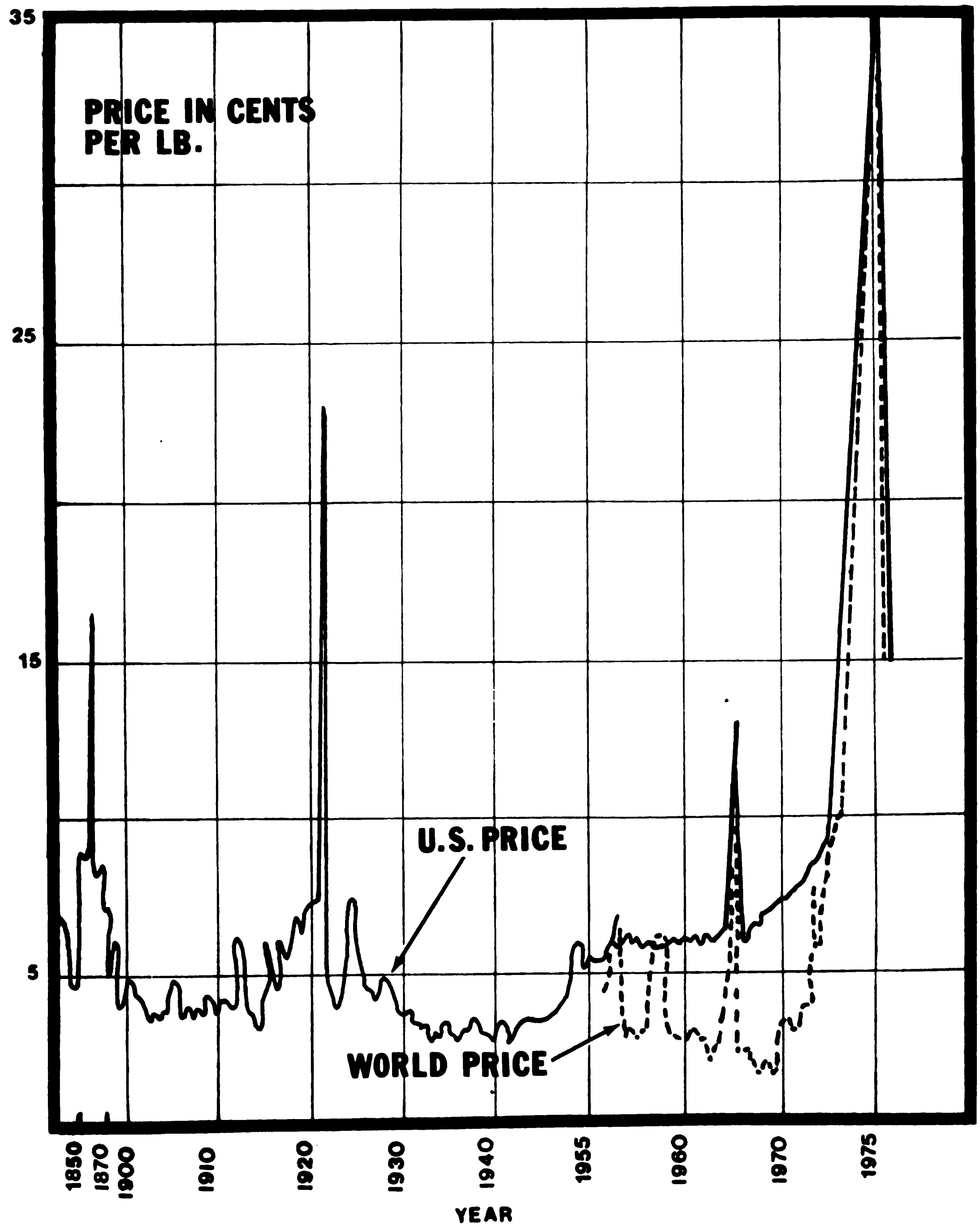
[5]New York Times, 26th January, 1975.

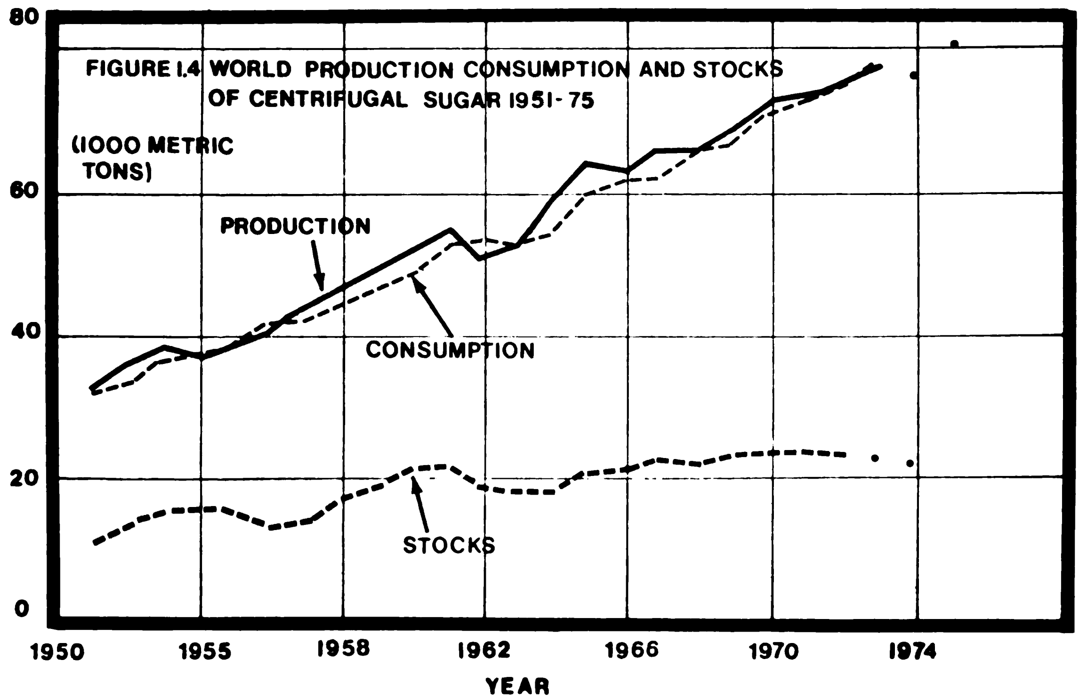
The U.S. and Commonwealth sugar prices were generally higher than that of the free market. Two exceptions exist, these being for 1963 and for 1974-75. In 1963 a diminished international supply pushed the free-market price temporarily above the U.S. price and also led to an increase in the U.S. price. By contrast, the Commonwealth price, which was predetermined, was not affected. In the 1974-75 period international supply was again diminished and this pushed up the free-market price which, in turn, took the U.S. price upward at the same rate. The Commonwealth price in 1974-75 also followed the upward movement but with a slight lag caused by the necessity of further price negotiatons, the lag being sufficient to cause actual shortages at retail in the U.K.

Until the recent, extended surge in the free-market price, the pattern in that market had been one of fleeting highs followed by extended lows. Such highs can be seen in Figure 1.2 for 1951, 1957, 1963 and 1974-75. A more general view of price fluctuations in the world and U.S. markets may be seen in Figure 1.3 which traces price back to 1845. The figure demonstrates that price fluctuations are not a recently developed phenomenon. For example, in 1864 the spot price for raw sugar reached an annual average of 16 cents per lb. and the monthly average 22 cents per lb. in 1921. These may be compared with the U.S. market's monthly peak of 57.30 cents per lb. in November 1974. In real terms, the peak of 1974 would not be higher than the previous highs.

The prices of the last two decades in Figure 1.2 may be compared with worldwide production, consumption and stocks for the same period as in Figure 1.4. It is hardly surprising to find that production and consumption have risen in parallel and that declines in stocks have

FIG. 1.3 RAW SUGAR PRICES 1845-1974
(ANNUAL PRICE TO 1900, MONTHLY THEREAFTER)
MAJOR SOURCE: COMMODITY YEARBOOK





occurred when consumption has exceeded production, resulting, in turn, in higher prices on all markets. It is a truism to state that free-market price is strongly (and inversely) related to stocks as a proportion of consumption.[6] Unlike some other agricultural commodities, sugar is expensive to store and stocks are not held for a number of years for speculative purposes. While "supply of storage" theory, such as that developed by Weymar for the Cocoa Market[7] may be useful in explaining very short-term price fluctuations, it has little relevance

[6] Work such as that of Ingersent along these lines is of limited value. See Ingersent, K. A. (1975). "Sugar Prices and Stocks,"(British) Journal of Agricultural Economics, 26, (2), (May), pp. 227-238.

[7] Weymar, F. H. (1968), The Dynamics of the World Cocoa Market. Cambridge, Massachusetts: M.I.T. Press.

to the annual fluctuations which are the concern of this report. Because the change in stocks is an "identity", being the difference between production and consumption, rather than causally related to market behavior, stocks are ignored in this thesis, especially as their magnitude is not very accurately recorded.[8]

There remains one further set of institutional arrangements to introduce, the periodic International Sugar Agreements. Such agreements existed for 1954-61 and 1968-73 and were made between both major exporting and importing nations. The objective of the agreements was to dampen the movement of price in the free market. At the beginning of the year the International Sugar Council would estimate market requirements and assign initial export quotas pro rata to agreed tonnages. Should price fall on the free market below an agreed minimum, quotas were reduced and the converse when prices rose above an agreed maximum. The agreements were conceived in years (1953 and 1967) in which free-market prices were very low, there being good reason for collaboration among producers at such times. The low prices were themselves the result of an expansion in output in response to the previous high prices of 1951 and 1963 respectively (see Figure 1.2). The agreement was not extended in 1961 because Cuba claimed an increase in its quota sufficient to offset fully its loss of U.S. sales while at the same time making alternative arrangements with the Communist countries outside the terms of the agreement. In 1973 the agreement was not renewed because the price of sugar was rising rapidly

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[8]During 1974 F. O. Licht, the respected source of sugar-market information, merely calculated stocks as a minimum proportion of consumption rather than actually measuring them.

on the free market and no quota limitations seemed appropriate. If the International Sugar Agreements had any effect it can only have been minor, since the agreements are seemingly not exogenous to the cycle of free-market prices, i.e., the cycle affected the agreements and not vice versa. Possibilities for stronger producer-dominated cartels will be considered later in this report.

A Conception of Market Behavior

The objective of this research, a formal analysis of alternative policies, has now been placed in the context of the world's sugar market. The remainder of this Introduction outlines the conception of market behavior on which the model was based.

The production of both cane and beet on a worldwide basis is subject to cycles, as has been well documented by Hagelberg.[9] The cause of the cycles is hypothesized in this research to be the investment decisions of the different producing countries. These decisions are, in turn, the result of imperfect knowledge concerning the actions of other countries and they are also influenced by domestic politics, since sugar production is usually regulated by government. The cycles in the supply of beet and cane, together with a relatively smooth expansion of demand through time, induce price cycles. An examination of the actions of beet and cane producers in the last full cycle, which had its peaks in 1963 and 1974 (see Figure 1.2), may be instructive in explaining the approach to modeling which was taken in this research.

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[9] Hagelberg, G. B. (1975). "Instability of World Centrifugal Sugar Production." Working Paper, Institut für Zuckerindustre, Amrumer Strasse, Berlin.

In 1963 the free-market price averaged 8.50 cents per pound in New York, as compared with 2.98 cents per pound in 1962. In 1964 a 22 percent expansion of world beet production occurred and an 8 percent expansion of cane production. Price fell moderately, to an average for the year of 5.87 cents per pound. In 1965 beet production expanded less than 1 percent more, but cane production expanded an additional 14 percent and price was driven down to 2.12 cents per pound. For the period 1966-68 there was little change in either beet or cane production, but the price was less than 2 cents per pound in all three years. Thereafter price began climbing slowly, due (it is hypothesized) to the smoothly expanding nature of demand, and price was 3.37 cents per pound in 1969, 3.75 cents in 1970, 4.52 cents in 1971, 7.43 cents in 1972 and 9.61 cents in 1973. Note that in terms of 1963 dollars, the 1973 price was only 6.62 cents per pound, less than the peak of 1963. During the 1969-73 period of slowly rising prices, production of beet expanded a mere 3.6 percent but production of cane, being more dependent on the free market, expanded 19.1 percent. Suddenly, in 1974, the free-market price rose dramatically to an average of 29.99 cents per pound for the year (equivalent to 18.63 cents per pound in 1963 dollars). The price rose rapidly, it is hypothesized, not only because of the inelastic nature of demand with respect to price in the high-income importing countries, but also because many of the exporting countries did not allow the price to rise in their domestic markets, preferring, instead, to ration exports.[10] By 1975 the price was again falling, under the influence of an expected increase of 13 percent in beet

[10] Note that of the top-ten exporters, Brazil, Philippines, South Africa, Mexico and Argentina all have large domestic markets.

production but a mere 2 percent in cane production.[11]

This interpretative description of one price-cycle implies that the following features be included in a model of the world sugar market. Firstly, beet and cane supplies should be separately included since they are subject to different lags in response to price. A one-year lag for beet and a two-year lag for cane may be expected to be the minima. In addition, cane supplies should be modeled in such a way that high prices induce new investment but low prices do not lead to disinvestment, due to the fixity of assets. It is important to remember that cane is a perennial crop while beet is an annual crop. Secondly, demand should be shifting steadily to the right and of a low price elasticity. Thirdly, the behavior of exporters should be to ration exports in the interest of low domestic prices.

The above statements about modeling are normative, but each will be examined in a more formal and objective manner in the relevant chapter. The nature of responses by beet producers is the subject of Chapter III for the U.S.A. and Chapter V for European countries. Responses by cane producers are examined in Chapter IV for the U.S.A. and Chapter VI for the major exporters. The demand for sugar in more than seventy countries is examined in Chapter VII. The rationing of exports by some countries when prices are high is examined in Chapter VIII, where the results of the whole modeling exercise are presented. In Chapter II, which now follows, the structural equations of the model will be expounded in their simplest form and trade barriers will be discussed as they relate to the model and its solution. The chapter gives an overview of the model in skeletal form which is then "clothed" in Chapters III to VII and solved in Chapter VIII under alternative policies.

[11]Data from F. O. Licht, Ratzeburg, West Germany.

CHAPTER II

THE MODEL AND ITS SOLUTION UNDER ALTERNATIVE TRADE POLICIES

The Model

The model was conceived in both static and dynamic (recursive) forms. For simplicity, the static form is expounded first. The structural relations may be stated in seven equations.[1]

Let there be m producing and n consuming regions, subscript i always denoting a producing region and subscript j a consuming region.

Let Q_j^D = the quantity of raw sugar demanded in the j^{th} region;

Q_i^S = the quantity of raw sugar supplied by the i^{th} region;

P_j = the wholesale price of raw sugar in the j^{th} region;

q_{ij} = shipment of raw sugar from region i to region j;

G_{ij} = cost of shipment, including trade barriers, from region i to region j.

Then the seven equations are as follows:

Demand relations for each consuming region:[2]

(2.1) $Q_j^D = Q_j^D(P_j), \quad j = 1,2,\ldots,n$

Supply relations for each producing region:[2]

(2.2) $Q_i^S = Q_i^S(P_i), \quad i = 1,2,\ldots,m$

Total quantity demanded in equilibrium equals the sum of all shipments:

---

[1]The whole of this exposition owes a large debt to the very clear presentation of "Zusman, P. et al. (1969). Possible Trade and Welfare Effects of EEC Tariff and Reference Price Policy on the European-Mediterranean Market for Winter Oranges, Giannini Monograph No. 24, University of California."

[2]These relations will be complicated by the inclusion of the other exogenous variables in addition to price later in this chapter.

$$(2.3) \quad Q_j^D = \sum_i q_{ij}, \quad j = 1,2,\ldots,n$$

Total quantity supplied in equilibrium equals the sum of all shipments:

$$(2.4) \quad Q_i^S = \sum_j q_{ij}, \quad i = 1,2,\ldots,m$$

Shipments cannot be negative:

$$(2.5) \quad q_{ij} \geq 0, \quad i = 1,2,\ldots,m \quad j = 1,2,\ldots,n$$

At equilibrium the prices in any two regions cannot differ by more than transfer cost per unit:

$$(2.6) \quad P_j - G_{ij} - P_i \leq 0, \quad i = 1,2,\ldots,m \quad j = 1,2,\ldots,n$$

At equilibrium the sum of transfer expenditures is exactly balanced by the sum of price differences times quantities shipped for all regions:

$$(2.7) \quad \sum_i \sum_j [(P_j - G_{ij} - P_i)\, q_{ij}] = 0$$

Because of Equation (2.7), should the strict equality hold in Equation (2.5) then the strict inequality holds in Equation (2.6) and the exact converse if the strict inequality in Equation (2.5) holds.

Equations (2.3) to (2.7) are nothing more than the well-known transportation model, given the particular unit costs of transportation, G_{ij}. The addition of the demand and supply equations, (2.1) and (2.2), adds to the difficulty of solution but not greatly to the conception.

To change the model for recursive solution requires merely that the supply in year t become a function of previous and not current prices; i.e., it is predetermined for the current year. Equation (2.2) becomes:

$$(2.2)' \quad Q_i^{SR} = Q_i^{SR} (P_{it-1}, \ldots, P_{it-k}), \quad i = 1,2,\ldots,m$$

where Q_i^{SR} denotes recursively-determined supply in region i.

Although it may be shown, under certain conditions, that any quota may be represented by an equivalent tariff, it is simpler in this context to treat quotas separately, since they are used in such a widespread manner by importing countries. Hence there is an additional identity:

$$(2.8) \quad 0 \leq QUOT_{ij} \leq q_{ij}, \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n$$

where $QUOT_{ij}$ is the quota given by importing-region j to exporting-region i.[3]

Should solutions in different time-periods be desired, the supply and demand functions are affected. With respect to demand, population and income change over time so that the fully-specified demand relationship becomes:

$$(2.1)' \quad Q_{jt}^D = Q_j^D (P_{it}, POP_{jt}, INC_{jt}) \quad j = 1,2,\ldots,n$$

where:

POP = population,

INC = income,

t = year.

With respect to supply, technology, the prices of competing crops and input prices change so that the fully-specified supply relationship becomes (in static form):

$$(2.2)'' \quad Q_{it}^S = Q_{it}^S (P_i, T, PA_i, PIN_i)$$

---

[3]Equation (2.8) implies that actual shipment may exceed the quota. However, if so desired, the shipment may be limited to the quota by imposing a heavy tariff on additional imports; such a procedure was used for the U.S.A.

where:

T = technology,

PA = the price of a competing crop,

PIN = the price of inputs.

Some elaboration of the regions and trade relationships used in the model may help to add substance to the bare outline which has now been presented. The world was divided into 66 supplying regions and 75 demanding regions. For simplicity, the 66 were an exact subset of the 75. The regions are listed in Table 2.1. The choice of regions was on the basis of the magnitude of production/consumption in the region, the region's importance in sugar-trade, geographical distribution on a worldwide basis and policy considerations. Thus, the U.S.A. was divided into three regions, Canada into two regions, the U.S.S.R. into two regions and the European Common Market into its constituent countries. Whereas, by contrast, many African and Asian countries were grouped together into single regions.

The table also delineates the kind of supply function which was used for each region. In general, beet-producing regions had double-logarithmic functions, cane-producing regions asymmetric functions (i.e., functions for which the response to rising and falling prices may be dissimilar), and a few regions either simple time-dependent supplies or even totally price-inelastic "point" estimates. The functions, their forms and estimates are the subject matter of Chapters III to VI and will not be elaborated here. Similarly, semi-logarithmic functions were used for demand and these are the subject matter of Chapter VII.

Table 2.1. Regions in the Model

Continent	Region	Log-Linear	Asymmetric	Time Only	Point	None
Europe	Austria			✓		
	Belgium	✓				
	Czechoslovakia				✓	
	Denmark	✓				
	Finland			✓		
	France	✓				
	Germany (West)	✓				
	Germany (East)	✓				
	Greece	✓				
	Iceland					✓
	Ireland			✓		
	Italy	✓				
	Netherlands	✓				
	Norway					✓
	Poland	✓				
	Portugal					✓
	Spain			✓		
	Sweden			✓		
	Switzerland				✓	
	Turkey	✓				
	U.S.S.R. (West)	✓				
	U.S.S.R. (East)					✓
	U.K.	✓				
Eastern Europe:	Albania, Bulgaria, Hungary, Roumania, Yugoslavia			✓		
North America	Canada (West)					✓
	Canada (East)				✓	
	U.S.A. (West)	✓				
	U.S.A. (South)		✓[2]			
	U.S.A. (East and North)	✓				
Central America	Barbados		✓			
	Cuba		✓			
	Dominican Republic		✓			
	Guatemala		✓			
	Jamaica		✓			
	Mexico		✓			
	Nicaragua		✓			
	Puerto Rico		✓[2]			
	Trinidad and Tobago		✓			
Central America:[1]	Bahamas, Belize, Bermuda, Costa Rica, Ecuador, El Salvador, Haita, Honduras, L Netherland Antilles, Panama, Surinam, Virgin Isles		✓			
South America	Argentina		✓			
	Bolivia and Chile		✓			
	Brazil		✓			
	Columbia		✓			
	Guyana		✓			
	Paraguay and Uruguay		✓			
	Peru		✓			
	Venezuela		✓			
Asia	China			✓		
	China - Taiwan		✓			
	Hong Kong					✓
	India		✓			
	Indonesia		✓			
	Iran		✓			
	Japan		✓			
	Korea (North and South)			✓		
	Pakistan and Bangladesh			✓		
	Philippines		✓			
	Saudi-Arabia			✓		
	Singapore					✓
	Sri Lanka				✓	
	Thailand		✓			
Near East:	Iraq, Israel, Jordan, Lebannon, Syria			✓		
Far East:	Afghanistan, Burma, Malaysia, Nepal, Vietnam			✓		
Africa	Mauritius		✓			
	South Africa		✓			
North Africa:	Algeria, Etypt, Libya, Morocco, Tunisia			✓		
West Africa:	Cameroun, C.A.R., Chad, Dahomey, Equatorial Guinea, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Spanish Sahara, Togo, Upper Volta			✓		
North-East Africa:	Ethiopia, Sudan, Somalia			✓		
East Africa:	Burundi, Kenya, Rwanda, Tanzania, Uganda, Botswana, Malawi			✓		
South-Central Africa:	Mozambique, Rhodesia, Swaziland, Zambia			✓		
South-West-Central Africa:	Angola, Congo, Namibia, Zaire			✓		
Oceania	Australia		✓			
	Fiji		✓[2]			
	Hawaii		✓			
	New Zealand					✓
TOTALS	75	14	31	18	4	8

[1]Ecuador and Surinam strictly part of South America; also including French possessions.

[2]Of a special nature to be described later.

Solving the Model

The solution of spatial-equilibrium models is well documented. Samuelson[4] showed in 1952 that the spatial problem could be converted into a maximizing problem, the "net-social-pay-off" (NSP) to be maximized being defined as:

$$(2.9) \qquad NSP = \sum_{j=1}^{n} \int_{0}^{Q_j^D} P_j\,(Q_j)dQ_j - \sum_{i=1}^{m} \int_{0}^{Q_i^S} P_i\,(Q_i)\,dQ_i - \sum_{i}\sum_{j} q_{ij}G_{ij}$$

Smith[5] showed in 1963 that spatial-price equilibrium was equivalent to the dual of Samuelson's formulation and that minimizing transfer costs was a necessary condition for equilibrium. Takayama and Judge[6] demonstrated that, given linear demand and supply functions, spatial equilibrium could be solved by quadratic programming. Given nonlinear supply and demand functions, as in the present research, the functions can either be approximated to become linear so that quadratic programming may be utilized, or a different kind of algorithm is required. One such algorithm was developed by Tramel and Seale[7] and called "reactive programming." This procedure combines a systematic adjustment of supply and demand together with linear programming for solving the transportation component. While "reactive programming" cannot guarantee convergence,[8]

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[4]Samuelson, P. A. (1952). "Spatial Equilibrium and Linear Programming," American Economic Review, 42, (3), (June), pp. 283-303.

[5]Smith, V. L. (1963). "Minimization of Economic Rent in Spatial Price Equilibrium," Review of Economic Studies, 30 (1), (Feb.), pp. 24-31.

[6]Takayama, T. and G. G. Judge (1964). "Spatial Equilibrium and Quadratic Programming," Journal of Farm Economics, 46, (1), (Feb.), pp. 67-93.

[7]Tramel, T. E. and A. D. Seale (1963). "Reactive Programming Techniques" in Interregional Competition Research Method Workshop. North Carolina State University, January 10-11.

[8]See Zusman, et al., pp. 26-27, for a discussion.

a solution within tolerable limits of precision is usually forthcoming. Apart from the advantage of using this procedure with nonlinear supply and demand functions, it appeared easier to adapt to a variety of trade policies than quadratic programming and hence was utilized in this study.[9]

The Model, Trade Policies and Welfare

Transfer Costs

Thus far the conposition of G_{ij}, the transfer cost, has not been addressed. This will now be elaborated. The transfer cost between regions i and j comprises: 1) the cost of transportation per unit T_{ij}; 2) tariff costs, the latter including specific or fixed tariffs, $FTAR_j$, variable or ad valorem tariffs, $VTAR_j$, and variable levies, $VLEV_j$; and 3) export taxes, $ETAX_i$. The identity for G_{ij}, the transfer cost per unit, is then:

$$(2.10) \quad G_{ij} - T_{ij} + FTAR_j + VTAR_j + VLEV_j + ETAX_i \qquad \begin{array}{l} i = 1,2,\ldots,m \\ i \neq j \\ j = 1,2,\ldots,n \\ j \neq i \end{array}$$

The ad valorem tariff is itself a function of price:

$$(2.11) \quad VTAR_j = P_j/(1 + V_j), \quad j = 1,2,\ldots,n, \quad j \neq i$$

where:

V_j = the ad valorem tariff rate in percentage terms.

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[9]The actual algorithm used as a starting point came from King, R. A. and F. S. Ho (1972). "Reactive Programming: A Market Simulating Spatial Equilibrium Algorithm." Economics Research Report No. 21, Department of Economics, North Carolina State University.

Similarly, the variable levy, such as that of the EEC, depends on the threshold (minimum import) price at destination and supply price at origin, namely:

$$(2.12) \quad VLEV_j = PTH_j - T_{ij} - P_i, \qquad i = 1,2,. . .,m \quad i \neq j$$
$$j = 1,2,. . .,n \quad j \neq i$$
$$VLEV_j \geq 0,$$

where:

PTH_j = the predetermined threshold price in region j, below which imports may not occur.

Information concerning tariffs was obtained from the International Customs Journal.[10] Information on the cost of transportation was provided by Professor Thomas Bates of San Francisco State University. Professor Bates developed a variety of linear cost functions which proved rather complex because of the large number of dependent variables. Given unit cost per mile as a function of distance alone, a nonlinear relationship emerged, implying short-hauls to be more costly per nautical mile than long-hauls. Professor Bates' function was approximated by:[11]

$$(2.13) \quad t_{ij} = 0.03\, D_{ij}^{0.5}$$

where:

t_{ij} = the cost in 1974 cents per lb. per nautical mile,

D_{ij} = the distance between i and j in nautical miles.

---

[10] International Customs Tariff Bureau (various). International Customs Journal. Brussels: I.C.T.B.

[11] The approximation was made informally, but an allowance for inflation to 1974 from data on actual costs for 1971-73 was included.

Then simply,

(2.14) $T_{ij} = t_{ij} \cdot D_{ij}$

A matrix of distances was drawn up using the U.S. Naval publication entitled "Distances Between Ports."[12] Distances within Europe, the U.S.S.R., the U.S.A. and Canada were included on an overland basis where appropriate. Overland costs were assumed the same as those by sea. As an example of the shipping costs implied by Equation (2.13), the Cuba-New York route (1,199 nautical miles) is estimated to cost 1.04 cents per lb., while Australia-New York (9,692 nautical miles) costs 2.95 cents per lb. The distances in the matrix assumed the Suez Canal to be closed. This was a reasonable assumption in simulating 1974 equilibria but would slightly distort prices (particularly in the Near East) in projections.

Trade Policies and Welfare

A graphical presentation of the trade policies considered in this research will now be given, together with a discussion of welfare measurement. The objective of this section is to show how trade policies affect international equilibrium. In Chapter VIII, experiments on the model will be conducted which empirically show how such policies affect equilibrium and welfare for the 75 regions of the world.

The presentation assumes two countries, an exporter and an importer, both of which produce sugar under free trade and there are initially no costs of transportation. The first trade barrier to

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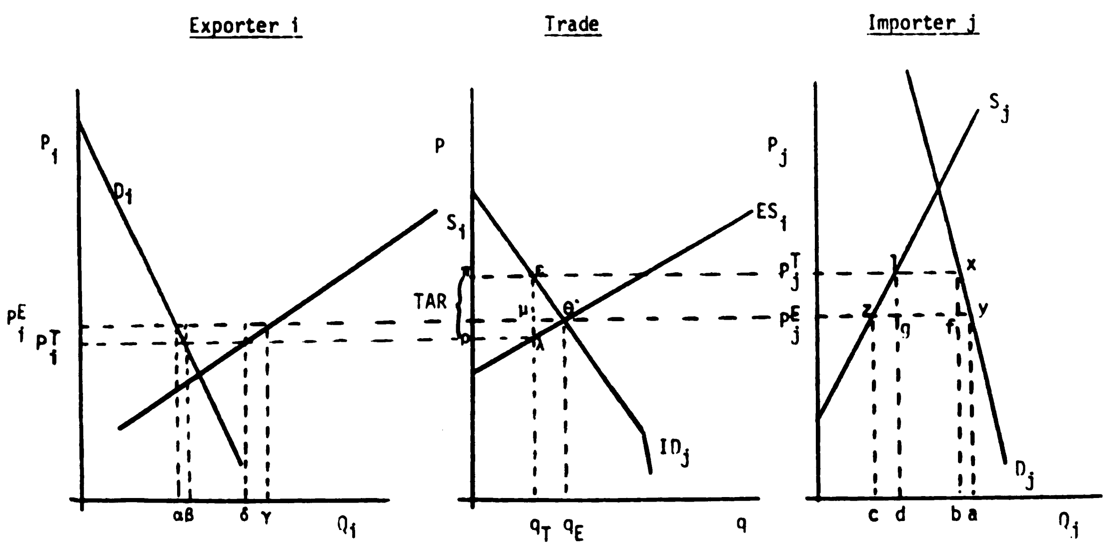
[12] United States Naval Oceanographic Office. (1964). "Distances Between Points." Washington, D.C.: U.S. Government Printing Office.

consider is the tariff. In Figure 2.1 the free-trade equilibrium at price P_i^E $(=P_j^E)$ implies trade at the level q_E. The imposition of the tariff, TAR, reduces quantity traded to q_T, reduces quantity supplied but increases quantity demanded in the exporting country i, and increases domestic quantity supplied but reduces quantity demanded in the importing country j. Assuming that the marginal utility of money is constant across the two nations, and that the income-effects of change in the price of sugar are negligible, the gains and losses from the tariff may be summed as follows: Consumers in i gain P_i^E r u P_i^T. Producers in i lose P_i^E v w P_i^T. The government in i gains lxfg and hkwu in tariff revenues. It may be shown that the summation yields a "dead-weight" loss equal to $\varepsilon\Theta\lambda$ in the central, trade graph, this loss being apportioned $\varepsilon\Theta\mu$ to the importer and $\mu\Theta\lambda$ to the exporter. Note also that transfer payments to the government of the importing country j equal $\pi\varepsilon\lambda\rho$.

Figure 2.1 Representation of a Tariff



The tariff thus analyzed could be either an ad valorem or a specific tariff. Similarly, transportation costs are analogous to a tariff in terms of dead-weight loss, although they yield no government revenues.

Figure 2.1 could equally well demonstrate the effect of a quota imposed by the importer j. Let the quota equal q_T and the effects, in terms of price changes from equilibrium, are exactly as for the tariff TAR. The dead-weight loss is also exactly as before, but the distribution of government revenues is different--there are no such revenues. The suppliers in i receive the full sum which previously accrued to the government in j. Should the government in i be the export agent, it receives these revenues. Should the government in j auction the quota q_T competitively, then it receives the revenues and the tariff and quota become exactly equivalent. Under the U.S. Sugar Act, quotas were allocated to "friendly" foreign suppliers. Since the exporting governments were usually also the export agents, the revenues from possession of a quota passed to them. It is hardly surprising, therefore, to discover that such governments expended large sums of money in lobbying in Washington for the maintenance or expansion of quotas.[13]

The European Economic Community protects its domestic sugar industry with a variable levy on imports. This is depicted in Figure 2.2. The notation is exactly as in Figure 2.1, except that PTH is threshold price and q_{L2} is quantity traded under the levy with threshold price PTH_2. To explain, the EEC decides upon a minimum import or "threshold" price, PTH. Should this price be less than the free-trade

[13]For example, Brazil paid $180,000 in 1973 to its agent in Washington.

Figure 2.2 Representation of a Variable Levy

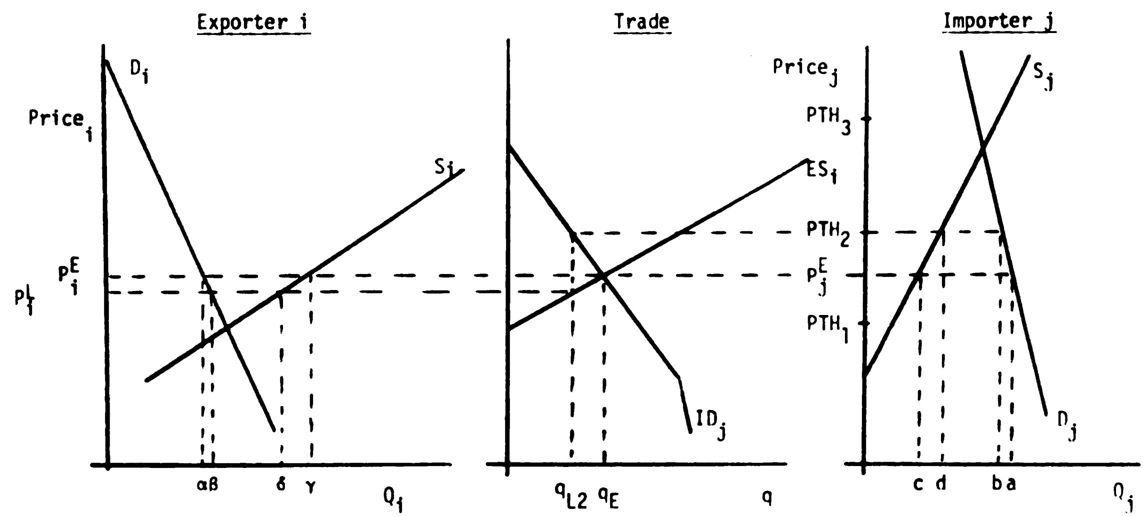
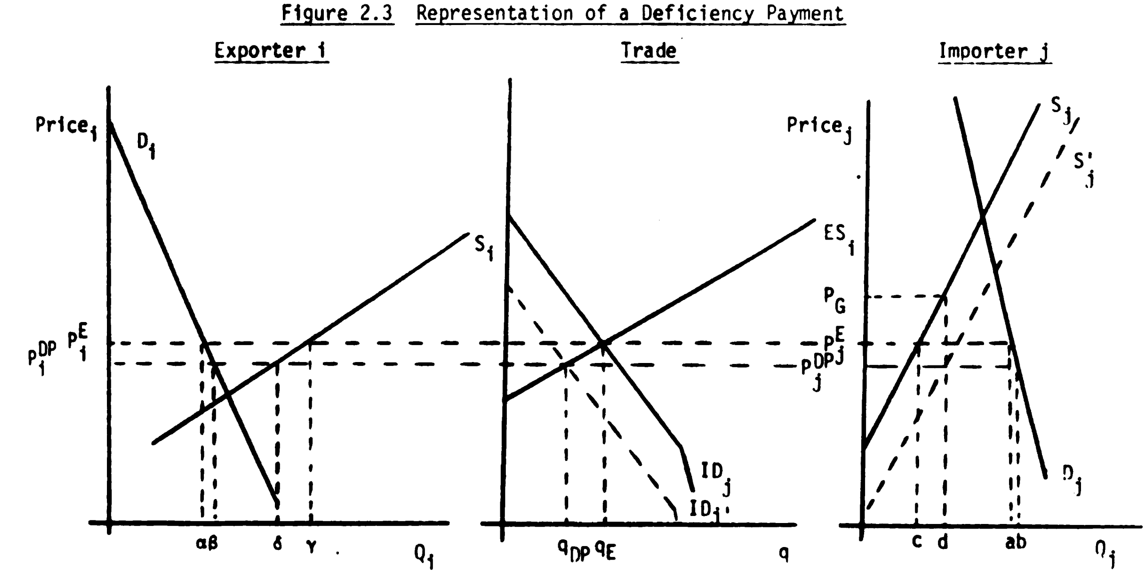


Figure 2.3 Representation of a Deficiency Payment



equilibrium price, it has no impact, e.g. PTH_1 in the figure. Should this price exceed the equilibrium price P_j^E, such as PTH_2 in the figure, imports are restricted to that quantity entering at this price. The effect may again be interpreted as being exactly equivalent to a tariff of magnitude $(PTH_2 - P_i^L)$. Because the EEC demands competitive bidding on the quantity to be imported at price PTH_2, all of the government revenues accrue to the EEC and none to the exporting country's government. In the recent past, the threshold price for sugar was fixed by the EEC-SIX at a level such as PTH_3 at which no imports occurred. With Britain's entry to the Community, the situation is somewhat changed, as will later be examined.

The next trade barrier to be considered is the direct subsidization of the industry in the importing country. Such subsidization is often called a "deficiency payment." While such payments are not important at present in the sugar-importing countries, they will be considered in Chapter IX as a feasible alternative to tariffs and quotas. In Figure 2.3, begin again with equilibrium price P_i^E in the exporting country i, which is the same as P_j^E in the importing country. The government in j then guarantees producers in j the price P_G which leads to an expansion in output from c to d. The consumer in j is not charged P_E for sugar, but the new international "equilibrium" price P_j^{DP} and the government pays producers in j the "deficiency" between the guaranteed price and the actual price, i.e. $(P_G - P_j^{DP})$, on the d units of output. In the figure the subsidization of producers in j is equivalent to a shift in the supply curve from S_j to S_j' and, in turn, this shifts the import demand curve from ID_j to ID_j'. The distributional consequences of a deficiency payment are different from those of a tariff. From the viewpoint of the exporter, the deficiency payment is preferable to an equivalent[14] tariff since both exports and prices are higher. From the viewpoint of the importer, both producers and consumers gain directly from a deficiency payment relative to free trade but the government (and hence indirectly taxpayers in general) loses.

It may be demonstrated that the dead-weight loss under a deficiency payment is likely to be less than that under a tariff which affords equivalent protection to producers in the importing country. In Figure 2.4 the right-hand graph of Figure 2.3 is redrawn to compare a tariff and a deficiency payment, both of which result in a price to domestic producers of P_G $(=P_j^T)$. The free-trade price would be P_j^E and the price which consumers pay under the deficiency payment is P_j^{DP}. Under a tariff which resulted in price P_G, the price in the exporting nation necessarily would be lower than P_j^{DP} $(=P_i^{DP})$, the exporter's price under the deficiency payment. This is a necessary condition since consumption in j is higher under the deficiency payment than under the tariff, yet, by assumption of equivalent protection, production in j is the same under both policies. Hence P_i^T, the exporter's price under the tariff, is marked below P_j^{DP} $(=P_i^{DP})$ in Figure 2.4. Further, since the price to the exporter is higher under the deficiency payment and exports larger, it is necessary that the net effect on the exporter of a deficiency payment is a smaller loss relative to free trade than under an equivalent tariff.

Returning to Figure 2.4 and considering now the importer only, the losses and gains relative to free trade may be listed as in Table 2.2. Gains from the deficiency payment in the importing country

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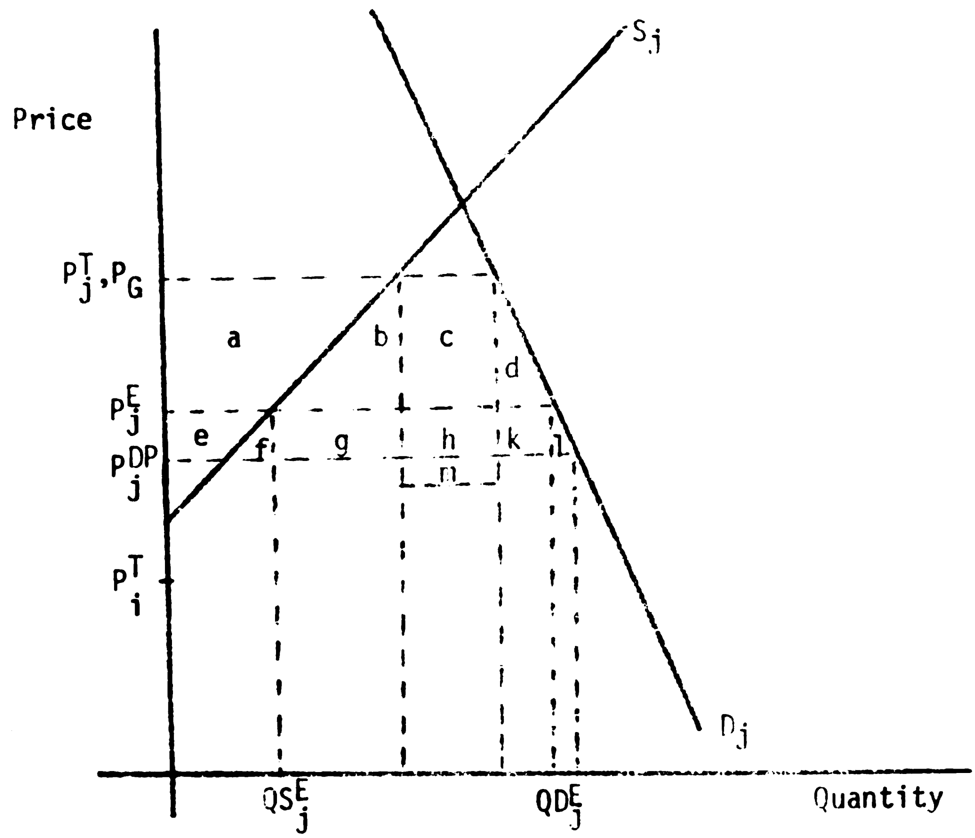
[14]Equivalent in terms of protecting domestic producers in j.

Figure 2.4 Tariff v. Deficiency Payment

Importer j



exceed those from the tariff if (k + l + d) exceeds m. Since m is a transfer payment from the exporter, the dead-weight loss under a deficiency payment is shown to be less than under a tariff, but the net effect for the importer depends on the size of m, hence on the elasticity of export supply from i.

This digression on deficiency payments versus tariffs helps to explain why some importers use a combination of quotas, tariffs and deficiency payments. An example is the U.S. Sugar Act under which deficiency (conditional) payments were made to producers, imports were subject to quotas and there was a specific tariff. Similarly the EEC

Table 2.2. Gains Under Tariffs and Deficiency Payments Relative to Free Trade for an Importer

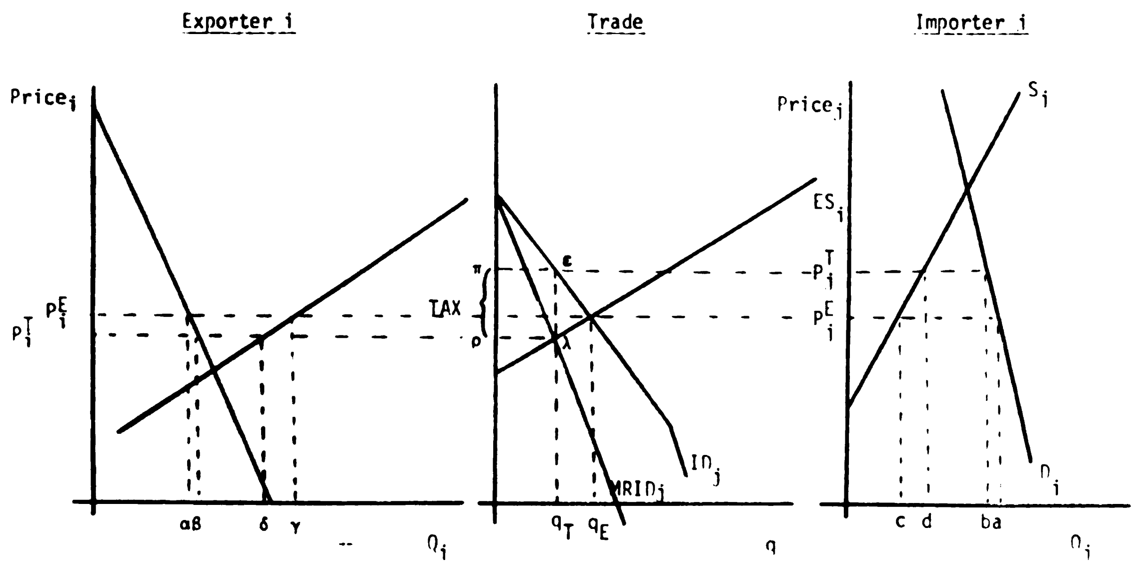
Item \ Policy	Deficiency Payment	Tariff
Government Revenue	-(a+b+e+f+g)	+c+h+m
Consumer Surplus	e+f+g+h+k+l	-(a+b+c+d)
Producer Surplus	a	a
Total	-b+h+k+l	-b-d+h+m

combines its variable levy on imports with a quota on domestic production and guarantees certain prices through subsidization of exports. Some combination of policies may achieve a given target with a smaller "net loss" relative to free trade than a single such policy.[15]

The final set of policies to be considered in the context of modeling are forms of export restriction or producer cartels whose objective is to raise the international price of a commodity in order to increase returns to the exporting countries. The International Sugar Agreements were weak forms of cartel. Assuming that exporters have a sufficient community of interest to agree upon, and maintain, restrictions on exports, the gains and losses will be very similar to those from an import tariff or quota, but the distribution of gains or losses is different. Figure 2.5 is completely analogous to the import-tariff diagram, Figure 2.1. The exporter imposes a tax, equal to $(\pi - \rho)$ in the central graph, the revenue from which, equal to $\pi\varepsilon\lambda\rho$, passes to the exporting country's government. When there is more than

[15]See Josling, T. E. (1969). "A Formal Approach to Agricultural Policy," Journal of Agricultural Economics, 20, (2), (May), pp. 175-192.

Figure 2.5 An Export Restriction Scheme



one exporter, agreement upon a uniform export tax is not as likely as upon a minimum export price or a given export supply (quota). Suppose the cartel agrees the minimum export price π or the quota q_T on exports, the effect will be exactly as in the case of the tax already discussed. In Figure 2.5 the trade graph also shows the marginal return from import demand, which is labeled MRID$_j$. The exporter maximizes profit by equating export supply, assumed to be the marginal cost of production, with the marginal return from exports. In the diagram the tax (or other policy) resulting in exports q_T maximizes the exporter's profits. The approach to modeling such a cartel in this research has not been to impose quotas on exports but to place a uniform tax on exports which leads to the same restriction on output as a quota.

A word of caution is in order. The gains and losses here described are in a static context. Although time enters the supply and demand functions, through its influence on technology and growth in population/income respectively, gains and losses have been measured at a single point in time. The dynamic gains or losses from trade in sugar lie outside the context of this research but may also be important.

The Context of Previous Research

The research, which has now been broadly outlined, is an extension and synthesis of several previous works. The spatial-equilibrium approach to modeling the sugar market is based upon the work of Thomas Bates[16] in this area. The controversy in Britain on the desirable size of the domestic sugar industry[17] was an impetus to making some more formal calculations on this subject for the EEC as a whole. The conclusion of Sanchez,[18] that the U.S. Sugar Act raised rather than lowered the free-market price of sugar, provoked the testing of this hypothesis. Most importantly, the works of Harry Johnson[19] and R. H. Snape[20] on gains to developed countries from freer trade in sugar and the similar work of D. Gale Johnson[21] for the U.S.A. provoked attention in the present

[16]Bates, T. H. (1965). "The World Sugar Economy and U.S. Supply Policy." Unpublished Ph.D. dissertation, University of California, Berkeley.

[17]Sturrock, F. G. (1969). "Sugar Beet or Sugar Cane," Journal of Agricultural Economics," 20, (1), (January), pp. 125-132.

[18]Sanchez, N. (1972). "The Economics of Sugar Quotas." Unpublished Ph.D. dissertation, University of Southern California.

[19]Johnson, H. G. (1966). Economic Policies Towards Less Developed Countries. (New York: Brookings Institution).

[20]Snape, R. H. (1969). "Sugar: Costs of Protection and Taxation," Economica, 36 (141), (February), pp. 29-41.

[21]Johnson, D. Gale (1974). The Sugar Program: Large Costs and Small Benefits. (Washington, D.C.: American Enterprise Institute).

research to gains and losses accruing both to exporters and to importers from alternative policies. Finally, the uncertainty concerning new U.S. Sugar Acts, changes in EEC sugar-policy following enlargement of the Community and the current interest in cartels to protect exporters of raw products were all motivating influences.

The report now turns to the estimated supply and demand relationships, the discussion of which occupies Chapters III to VII inclusive. Attention will be refocused on the whole model again in Chapter VIII.

CHAPTER III

U.S. DOMESTIC BEET-SUGAR SUPPLY

Introduction

In this chapter the objective is to derive supply functions for U.S. beet production and hence determine the kind of price responsiveness to be expected. In the introduction the structure and recent history of the sector are discussed as a foreword to the development of the econometric procedures of the second section. There follows a third section which gives the results by region and finally there is a brief summary.

The production of sugar-beet in the U.S.A. dates from the late 19th century. The first successful factory was constructed in Alvarado, California, in 1870, although four unsuccessful factories had been constructed between 1838 and 1856.[1] About the turn of the century there was a considerable expansion, so that by 1899 production was 82,000 short tons of sugar per annum as compared with less than 2,000 before 1888. By 1906 domestic beet sugar production was 517,000 tons raw value and exceeded domestic cane sugar production for the first time. By 1920, beet sugar represented 48 percent of total domestic sugar production (including Hawaii, Puerto Rico and the Virgin Islands). However, beet only maintained an approximately 40 percent share of domestic production until the recent expansion of the 1960's and since 1968 has

[1]Ballinger, R. A. (1971). "A History of Sugar Marketing," Agricultural Economics Report No. 197, U.S. Department of Agriculture, Washington, D.C.

regularly been more than half of the total U.S. production of sugar.[2] Figure 3.1 demonstrates the relatively steady growth in beet production since 1900. Actual production in 1973 was 3,209,000 raw tons or approximately 53 percent of all domestic sugar production and 28 percent of U.S. consumption.

The production of beet is widely scattered throughout the country, as may be seen in Figure 3.2. Over time the industry has become more and more concentrated in certain regions, reflecting the climatic and soil differences which exist rather than the possible distributional advantages which are small.[3] Production in Maine and New York states existed in the 1960's as shown in the figure, but no longer exists.

There were 36 beet sugar factories operating in 1901 and this number had climbed to 97 by 1920. Because of the economies of scale in processing, the number of factories had declined to 54 by 1974. Table 3.1 presents the distribution of factories by individual state together with the daily slicing capacity of the factories in tons. Daily slicing capacity is only an approximate measure of "capacity" since it is not independent of the number of hours per day that the factory is operated and length of the operating season. As may be seen in Table 3.1, California has the greatest daily slicing capacity with ten factories, followed by Colorado with its ten factories, Minnesota with its five factories and North Dakota with its three factories. Because the beet cannot be stored for long periods due to respiratory losses of sucrose, the manufacturing season closely follows the harvesting period. In all

[2]These and other data from U.S.D.A. "Sugar Statistics and Related Data," Volumes I and II, Washington, D.C.

[3]Walter, B. J. (1972). "The Wholesale Pricing System for Sugar," unpublished Research Report, University of California, Berkeley.

FIG. 3.1 U.S. BEET SUGAR PRODUCTION

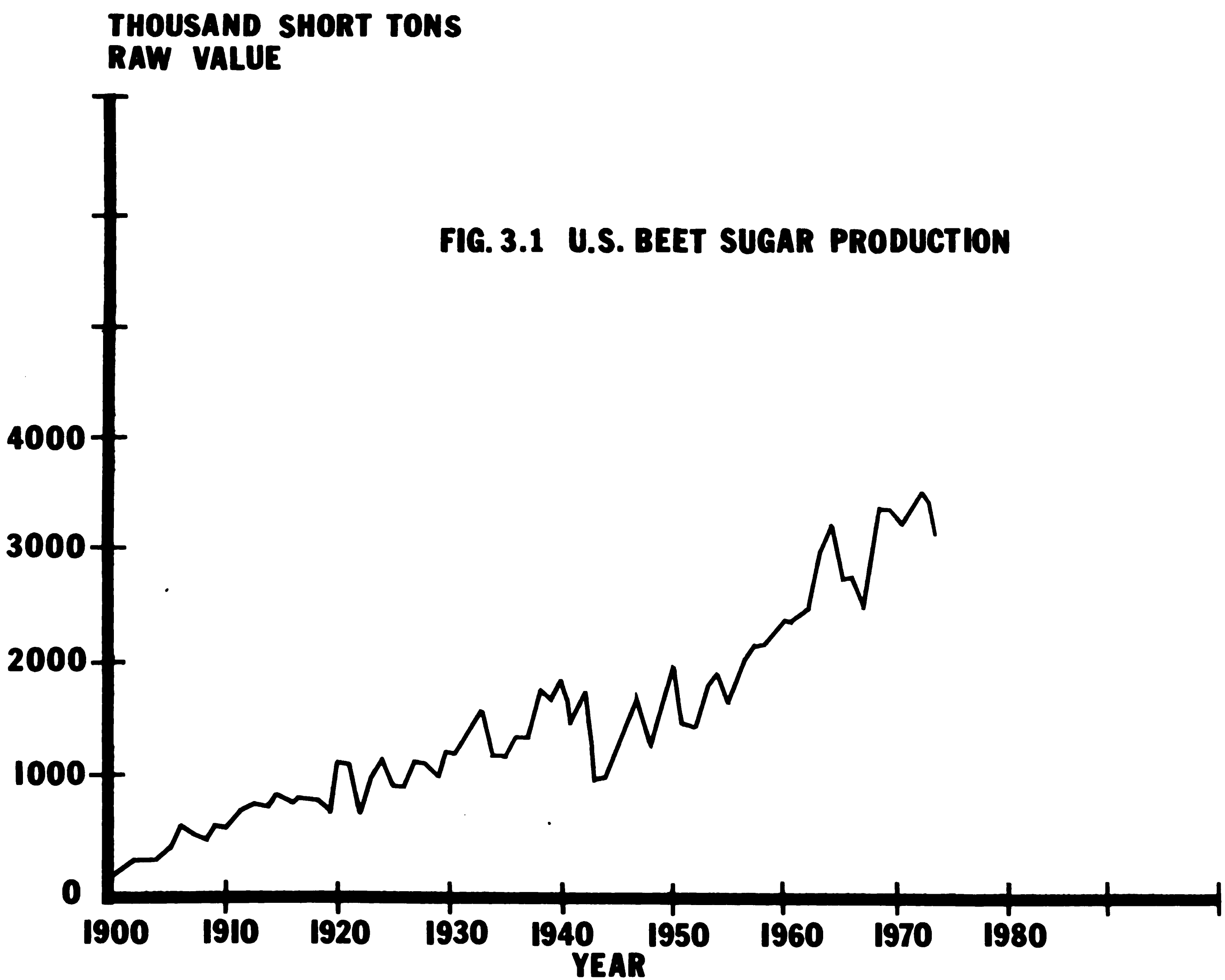
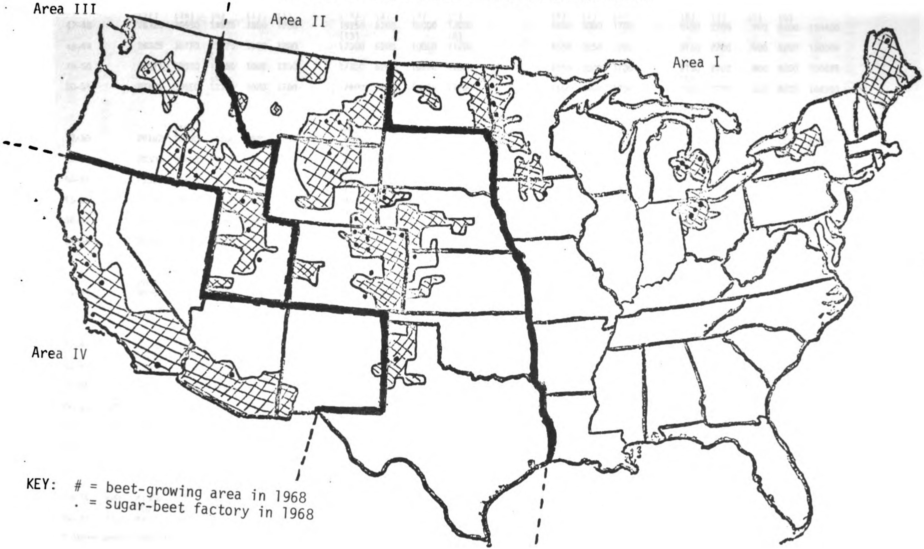


Figure 3.2
Location of Sugar-Beet Production in the U.S.A.



KEY: # = beet-growing area in 1968
. = sugar-beet factory in 1968

Table 3.1 Beet Sugar Factories and Capacities

	Az.	Ca.	Co.	Id.	Ia.	Ka.	Me.	Mi.	Mn.	Mt.	Ne.	NY	ND	Oh.	Or.	SD	Tx.	Ut.	Wa.	Wi.	Wy.	Total
47-48		(11) 26325	(16) 30550	(8) 14875	(1) 1800	(1) 1200		(14) 19250	(3) 6200	(5) 10000	(7) 13000			(4) 4550	(1) 3000	(1) 1700		(6) 9150	(1) 2700	(1) 900	(5) 8200	153400
48-49		26325	30750	15075	1800	1200		(13) 17300	6200	10000	(6) 11200			4550	3250	1700		9150	2700	900	8200	150300
49-50		27075	30550	(7) 14250	1800	1200		17300	6200	10000	11200			4550	3300	1700		9150	2700	900	8200	150075
50-51		27800	30550	(6) 13300	1800	1200		17400	6200	10000	11200			4550	3400	1700		(5) 7450	2700	900	8200	148350
52-53		28102	(15) 29400	14200	1800	1200		(10) 14000	6500	(4) 8600	11200			(3) 3350	3750	1700		7650	(2) 4900	900	8450	145902
53-54		28300	29400	14700	1800	1200		(9) 13000	(4) 9302	8600	11200			3550	3750	1700		7750	5500	900	(3) 5700	146352
54-55		29300	29400	(5) 13750	1800	1200		(8) 11900	9300	8600	11200			3550	3950	1800		7950	6200	900	5700	146500
55-56		29700	29400	13950	1800	-		(7) 10600	10300	8600	11200			3550	3950	1800		7950	6200	1100	5700	145800
56-57		29700	29400	13950	1800	-		(6) 10600	10300	8600	11200			3550	3950	1800		7950	6200	1100	5700	145800
57-58		30500	29400	14850	1800	-		9400	10900	8900	(5) 9400			3550	4050	1800		8100	6900	1100	5700	146350
59-60		(10) 30350	(13) 26750	15900	1900	-		(5) 8100	12150	9350	9500			3950	4500	1800		8750	7450	1100	5900	148050
62-63		34400	(12) 25300	16040	2200	-		9500	12300	9450	10200			4600	6000	1800		(3) 5915	8150	-	6250	152105
63-64		(11) 39600	25400	(4) 16155	2400	-		9700	12450	9500	10200			4600	6275	1800		6015	10000	-	6450	160545
65-66		40050	25400	14845	2400	-		10600	12800	9500	(4) 9000	(1) 4000	(1) 5000	4600	6575	-	(1) 6000	6035	10000	-	6450	173255
66-67	(1) 4200	40100	27700	19650	2400	-	(1) 4000	10600	12800	(3) 8000	9300	4000	5000	4700	6575	-	6000	6300	10250	-	6600	188175
68-69	4200	(10) 39800	(10) 25400	20950	2400	(1) 3200	4000	10900	12800	8720	9510	4000	5000	5000	6650	-	6500	6350	10525	-	7200	193105
70	4200	40100	25725	25600	2400	3400	-	10900	13500	9320	9510	4000	5000	6175	6650	-	6500	6350	10525	-	7100	196955
73-74	4200	41800	(10) 27200	(4) 24600	-	3200	-	(5) 12200	(3) 11500	(2) 8200	9900	-	5200	6650	6500	-	6500	(1) 2750	12325	-	(2) 5400	188125
74-75	(1) 4200	(10) 41100	(10) 26500	(4) 24350	-	(1) 3200	-	(5) 12300	(5)* 22000	(2) 8000	(4) 9900	-	(3) 15200	(3) 6400	(1) 6375	-	(1) 6500	(1) 2500	(2) 14900	-	(3) 7600	211025

* Three under construction in May 1975.

Source: Beet Sugar Growers Association, Washington, D.C.

states except California and Arizona, planting occurs from February to June, harvesting from September to November and manufacture from October to February. In California there is a spread of seasons, but, in general, planting occurs in the Autumn and harvest in the Spring or early Summer. In Arizona, planting and harvest may be in the Spring or Autumn depending on altitude.

The economic structure of the industry is one of 12,000 farmers providing the 54 factories with the beet from which the manufactured sugar is distributed through a smaller number of wholesalers. The factories are either owned by relatively large sugar companies, e.g. Spreckels in California or the Great Western Sugar Company in the West and Mid-West, or, less commonly, they are owned cooperatively by the farmers themselves. In the latter case the supply of beet may be more price inelastic since the growers are obliged to provide certain quantities of beet for a duration of years rather than having annual contracts. In the more usual case of factories owned by sugar companies, the annual contracts, which are made before planting, cover both quantity to be supplied and the proportion of total returns from the sugar to be provided to the farmer. Thus in 1973, for example, the grower received an average 65 percent of the returns (excluding government payments) and the processor 35 percent. These proportions have been relatively constant since 1950.

The size of farm, like that of the factory, has been rising quite rapidly. In 1950, 37,328 farms planted an average of 27.1 acres of beet. In 1960, 24,219 farms planted an average of 40.4 acres of beet. By 1973 only 12,486 farms were supplying beet, but each had an average of 102.3

planted acres. The advent of mechanical harvesting prior to 1950 and the development of mechanical (circa 1950) and chemical (circa 1960) weeding and monogerm beet (circa 1960) were the technical advances necessary to this increase in farm size. The inducement for such innovation as the increased price of labor which rose from $0.888 per hour in 1950 to $2.455 per hour in 1973.[4]

Since 1934, beginning with the Jones-Costigan Act of that year, quotas for domestic beet production have been fixed annually in relation to total U.S. sugar consumption requirements, and similarly such quotas have been allocated for domestic cane production and for imports. The basic quota for domestic beet production was 1,800,000 tons in 1948, following the Sugar Act of 1947. The quota was slightly increased in a 1956 amendment of the Act and was substantially increased in the 1962 amendment. Further small changes occurred in the amendments of 1965 and 1971. In 1973 the basic quota was 3,692,000 short tons raw value. Whenever beet production was deemed likely to exceed the quota, acreage allocations were established by the Secretary of Agriculture on a state-by-state basis, these allocations being some proportion of the average acreage of the last five years. Such acreage limitations were in force in 1955-1960, 1965-1966 and 1970. While such "proportionate shares" did not have the force of law, the inducement for individual farmers to comply was the so-called "conditional payment" or government subsidy which was the surplus obtained from the small import duty on sugar once the costs of the Sugar Program had been deducted. Such a conditional

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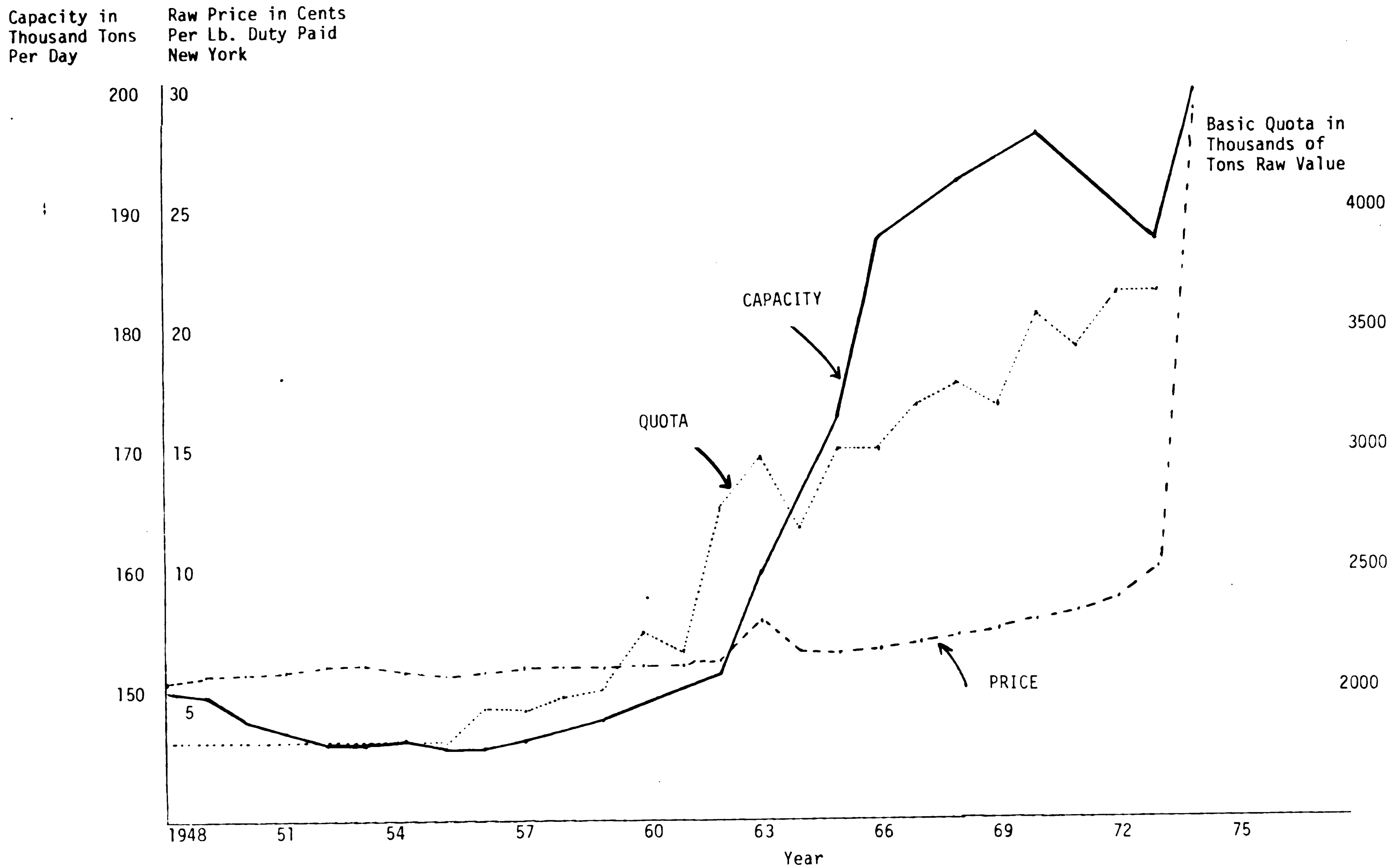
[4]See, Hayami, Y. and Ruttan V. W. (1971). Agricultural Development: An International Perspective. (Baltimore: Johns Hopkins Press) for a discussion of "induced innovation" in beet production.

payment was $2.00 per ton of beet in 1973 when the direct payments from processors averaged $31.66 per ton. Such a small subsidy is no great inducement and one must conclude that producers and processors saw the price advantage of the Act's protection against imports as an additional incentive for compliance with periodic restrictions.

The beet plant is a biennial, but is harvested after one season's growth. Given adequate factory capacity, the delay in response to an increased price or quota for sugar beet is, in consequence, a minimum of nine months and a maximum of 21 months. For example, the amendments to the Act of 1962 occurred in July which resulted in a delay until the following year's planting time (February-June) before farmers in most regions could respond and until the end of 1964 before there was an increase in beet sugar available for consumption. The delay in this case was at least 18 months. Should factory capacity be limiting, the delay may be considerably more, depending on whether the new facilities are an expansion to existing ones or completely new. Since the Jones-Costigan Act of 1934, the development of new processing capacity has followed increases in quota more closely than increases in price, as may be seen in Figure 3.3 for the period since 1948. Price has been relatively stable, except for a small peak in 1963 and a large rise in 1974. By contrast, quota rose sharply in 1961 and 1962, to be followed by a rise in capacity in the 1962-1966 period.

The above introduction has given the background necessary to the development of the econometric models which are introduced in the next section.

Figure 3.3 Quota, Price and Factory Capacity for U.S. Beet Sugar



Procedure

Regions and Crops

In 1974, sugar beet production in the U.S.A. fell an estimated 9.3 percent while the price of sugar, in response to world conditions, climbed during all but the last month of the year. In the immediately preceding years the price paid to beet growers had risen parallel with the index of farmers' input prices, as intended in the Sugar Act. The decline in beet production in 1974 cannot be attributed to a decline in the nominal price of beet but to a decline in the price of beet relative to the prices of products which compete for the same agricultural resources. The works of Just on California[5] and Storr and Warnken[6] for the whole U.S.A. attest to the importance of inter-crop competition in determining sugar beet production. Because beet production is so widely distributed, there is no single crop with which it competes but the situation varies by region. In consequence the U.S.A. has been divided into four regions in this study and a separate supply function has been estimated for each. In addition, a function at the aggregate level has also been estimated.

The division into four regions was already shown in Figure 3.2. The states in each region are as follows:

I. Michigan, Ohio, Minnesota, Iowa, North Dakota, Illinois, Indiana, Wisconsin, New York, Maine;

II. Colorado, Kansas, Wyoming, Texas, Nebraska, Montana, South Dakota;

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[5]Just, R. E. (1974). "Econometric Analysis of Production Decisions with Government Intervention: The Case of California Field Crops," Giannini Foundation, Monograph No. 33, University of California, Berkeley.

[6]Storr N. and Warnken, P. (1974). "The Location of Sugarbeet Production in the U.S.," unpublished manuscript, University of Missouri, Columbia.

III. Utah, Idaho, Oregon, Washington;

IV. California, Nevada, Arizona, New Mexico.

Any such division is rather arbitrary, but the reasons for this particular allocation were mainly geographical location, similarity of competing crops, altitude and presence or absence of irrigation. The Mississippi presents a natural division of the country into a Western portion, where irrigation is practiced, and an Eastern portion, where beet are not irrigated. The states to the East form the first region, notably North Dakota, Minnesota, Michigan and Ohio. There is a central belt of production running from South Montana through Wyoming, Colorado, Nebraska and Kansas. To this belt has been added the small beet-growing area in Northern Texas to give the second region. The third region could be called the Pacific Northwest, namely Washington and Oregon, with the addition of Idaho and Utah. The fourth region comprises California, which is the most important beet-producing state, together with the minor areas of Arizona, New Mexico and Nevada. The four-region division is a simplification of the eight-region division used in the cost surveys conducted under the Sugar Act. In these cost surveys the eight regions were not always consistent with state boundaries, while the four regions and the available time-series data refer to states. Consequently our regions are only approximately consistent with the regions in the cost surveys, but the latter provide very interesting information on the other crops grown by sugar beet producers, as shown in Table 3.2. The Agricultural Stabilization and Conservation Service (ASCS) regions are denoted 1,. . .,8 and our regions I,. . .,IV. In all regions feed and foodgrains dominate the system, with sugar beet representing from 18 to 34 percent of total cropland. Reviewing Table

Table (3.2) Crop Systems on Sugarbeet Farms by Region, 1972

	Crop	Region I				Region II						Region III				Region IV	
		1		2		3		4		5		6		7		8	
		Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
	Sugarbeet	79.5	20.3	133.1	18.0	149.3	31.0	84.5	16.9	115.6	34.1	171.3	33.5	130.2	31.7	416.2	22.3
Feed & Food Grains	Corn	106.0	27.0	6.5	0.9	119.7	24.9	135.9	27.2	47.2	13.9	18.4	3.6	71.0	17.3	107.1	5.7
	Soyabeans	38.6	9.8	17.2	2.3	41.4	8.6	6.7	1.4	12.6	3.7	22.4	4.4	18.7	4.5		
	Wheat	31.6	8.1	323.7	43.8	110.5	23.0	50.8	10.2	8.9	2.6	105.8	20.7	37.3	9.1	167.4	9.0
	Barley	1.6	0.4	158.9	21.5	6.5	1.4	3.6	0.7	75.4	22.2	98.4	19.2	12.2	3.0	162.8	8.7
	Sorghum	-	-	-	-	6.4	1.3	135.1	27.1	-	-	-	-	-	-	94.6	5.1
	Other	1.5	0.4	49.5	6.7	5.5	1.1	0.7	0.1	13.2	3.9	9.7	1.9	4.5	1.1	88.0	4.7
			45.7		75.2		60.3		66.7		46.3		47.9		34.3		34.0
Hay	Alfalfa	4.1	1.0	15.0	2.0	26.7	5.6	21.6	4.3	62.1	18.3	24.4	4.8	42.7	10.4	348.8	18.7
	Other	3.4	0.9	-		11.3	2.3	33.6	6.7	4.5	1.3	29.7	5.8	4.5	1.1	6.2	0.3
			1.9		2.0		7.9		11.0		19.6		10.6		11.5		19.0
Vege-tables	Potatoes	-	-	28.3	3.8	2.0	0.4	-	-	-	-	30.4	6.0	40.1	9.8	7.9	0.4
	Proc. Tomatoes	5.7	1.5	-	-	-	-	-	-	-	-	-	-	-	-	65.1	3.5
	Dry Beans	105.4	26.9	5.5	0.7	-	-	-	-	-	-	-	-	-	-	24.8	1.3
	Other	14.5	3.7	2.0	0.3	1.9	0.4	3.3	0.7	-	-	1.1	0.2	26.0	6.3	57.2	3.1
			32.1		4.8		0.8		0.7		0.0		6.2		16.1		8.1
Misc.	Fruit or Nuts	-	-	-	-	-	-	-	-	-	-	-	-	1.9	0.5	32.6	1.7
	Cotton	-	-	-	-	-	-	23.4	4.7	-	-	-	-	-	-	262.5	14.0
	Other	-	-	-	-	-	-	-	-	-	-	-	-	21.8	5.2	11.2	0.6
			0.0		0.0		0.0		4.7		0.0		0.0		5.7		16.3
Total Cropland		391.9	100.0	739.7	100.0	481.2	100.0	499.2	100.0	339.5	100.0	511.6	100.0	410.9	100.0	1867.3	100.0

Source: Cost Survey by Agricultural Stabilization and Conservation Service kindly provided by E. Jesse.

3.2 by ASCS region, in region 1, Michigan and Ohio, corn and dry beans are the chief alternative crops while in region 2 wheat and barley predominate. In estimation for our region I, corn and wheat were the considered alternatives. In regions 3 and 4, corn, wheat and sorghum are important while in region 5 the chief alternatives are corn, barley and alfalfa. Since the price of alfalfa is highly related to that of corn, for region II corn and wheat were the considered alternatives. In region 6 the chief alternatives are wheat and barley while in 7 they are corn, alfalfa and potatoes. Wheat, corn and alfalfa were considered for inclusion in estimating our region III. In region 8, which is also our region IV, alfalfa, cotton, wheat and barley are important as well as a whole range of minor crops. In this region alfalfa, cotton and corn (as a proxy for all cereals) were considered in estimation. While certain "alternative crops" have now been delineated, it should be noted that just because a crop is a significant proportion of cropland on a sugar beet farm does not guarantee that it competes for resources with sugar beet--complementarity is, of course, also possible.

Models

In specifying the model of supply, the quantity of beet forthcoming may be expected to be a function of past and present sugar prices, the prices of inputs, the recent prices of competitive products, technology and governmental programs; i.e.

$$(3.1) \quad Q_{1t} = f_1(P_{1t}, \ldots, P_{1t-k}; P_{it}; P_{2t}, \ldots, P_{2t-k}; T; G_t)$$

where:

Q_1 = output of beet,

P_1 = the price of sugar beet

P_i = the price level for inputs

P_2 = the price of a competitive crop

T = technology

G = government programs,

t = a time subscript.

Simplifying Equation (3.1) by reasonable assumptions, P_i may be taken as the U.S.D.A. index of input prices which excludes labor since that is generally a family resource. Second, take the price of the alternative product at time t-1, i.e. P_{2t-1}, to be representative of expectations concerning this variable. The actual alternative will be found by estimating with each of the alternatives discussed above. Thirdly, take time as a proxy for technology, since the change in technology has been relatively constant through time. There now remain two problems with respect to the specification of the variables in Equation (3.1), namely the kind of lag to use with respect to the price of sugar beet, P_1, and how to incorporate government programs, G. These will be addressed in that order.

It has already been noted that there are two delays in the response of sugar beet production to higher prices, namely a delay of 9-21 months at the farm level and a possible delay of 2-4 years at the processing level. Both delays may be expected to be of the "inverted v" kind rather than decreasing monotonically through time. However, quantity supplied depends on processing capacity only in years when farmers desire a rapid expansion of output to a new peak level. By observing the tons of beet processed per ton of slicing capacity, such capacity was found to be important in determining output only in 1963-1964 and 1972 out of the last twenty-five years. If 1972 were rated at 100 percent of capacity, 1974 would be only 77 percent of capacity, indicating considerable slack for 1975, especially as several new factories are under construction. Therefore, because capacity is only crudely measurable, rarely limiting and currently sufficient, it will not be directly included in the supply specification. It will be indirectly included, however, since the data will be utilized to determine the most likely overall lag structure. Turning to the on-farm response, the expectation is that price at t-1 will be most important and that current price, P_{1t}, and prices in the more distant past, P_{1t-2} etc., will be of lesser importance. Using Jorgenson's "rationally distributed lag," which has P_{1t}, Q_{1t-1} and Q_{1t-2} on the right-hand side, allows the data to determine the most likely overall lag structure with the possibilities ranging from the geometric lag to the Pascal lag.[7]

Government programs consisted of periodic enforcement of "proportionate share acreages," but these shares have not always been binding, i.e. they have not always limited production. A comparison of planted acreages with the shares, (which were in existence in the years 1955-1960, 1965-1966 and 1970), shows that in only three years (1958-1959 and 1970) were they binding in region I but in most of the years in other regions. Given the two conditions, with and without shares, two models become appropriate. When shares are in force and binding, supply is a function of product price, input prices, technology and share acreage, i.e.

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[7]Griliches, Z. (1967). "Distributed Lags: A Survey," Econometrica, 35, (1), (Jan.), pp. 16-49.

$$(3.2) \quad Q_{1t} = f_2 \, (P_{1t}, \ldots, P_{1t-k}; P_{it}; T; HA_t)$$

where:

HA = the proportionate share in hectares.

When shares are not binding or not even in force, supply is now a function of the price of competing products as well as the beet and input prices, i.e.

$$(3.3) \quad Q_{1t} = f_3 \, (P_{1t}, \ldots, P_{1t-k}; P_{it}; T; P_{2t-1})$$

where:

P_2 = the price of a competing product.

The specification of Equations (3.2) and (3.3) may now be made explicit by assuming a logarithmic form for all variables except time (year) and incorporating the rational lag system. The equations become, respectively,

$$(3.4) \quad \log Q_{1t} = a_1 + a_2 \log P_{1t} + a_3 \log P_{it} + a_4 T + a_5 \log HA_t + a_6 \log Q_{1t-1} + a_7 \log Q_{1t-2} + \log E_{t4}$$

and

$$(3.5) \quad \log Q_{1t} = b_1 + b_2 \log P_{1t} + b_3 \log P_{it} + b_4 T + b_5 \log P_{2t-1} + b_6 \log Q_{1t-1} + b_7 \log Q_{1t-2} + \log E_{t5}$$

where:

E_{t4} and E_{t5} = random disturbances.

It is now convenient to combine the two equations into a single equation, since the number of observations on either model alone is too low for

reliable estimation. The necessary assumptions are: 1) that the coefficients of the input variables are not affected by proportionate shares, i.e. $a_3 = b_3$; 2) that technology is independent of proportionate shares, i.e., $a_4 = b_4$; and 3) that the disturbance terms, $\log E_{t4}$ and $\log E_{t5}$, are independent. Define the binary variable Z, such that Z is 1 when the share is binding and 0 otherwise. This variable is used to a) shift the intercept, b) to change the effect of P_{1t} and c) to introduce HA_t and delete P_{2t-1} when shares are binding. Equations (3.4) and (3.5) become together

$$(3.6) \quad \log Q_{1t} = C_1 + C_2 Z + C_3 \log P_{1t} + C_4 Z \log P_{1t} + C_5 \log P_{it} + C_6 T + C_7 Z \log HA_t + C_8(1-Z) \log P_{2t-1} + C_9 \log Q_{1t-1} + C_{10} \log Q_{1t-2} + \log E_{ct}$$

where:

$\log E_{ct}$ = a random disturbance.

This is the basic model to be estimated with aggregate data for the four regions for the years 1950-1974.

Estimation

The estimation of Equation (3.6) is not simple because the disturbance is very likely to be autocorrelated due to the two lagged dependent variables on the RHS. OLS estimates would be biased and inconsistent. The alternative methods of estimation are instrumental variables, Gupta's two-stage procedure beginning with instrumental variables[8] and maximum

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[8]Gupta, Y. P. (1969). "Least Squares Variant of the Dhrymes Two-Step Estimation Procedure of the Distributed Log Model," International Economic Review, 10, (1), pp. 112-113.

likelihood estimation. The simplest approach, instrumental variables, was chosen, with the possibility of extension to Gupta's second stage. Let P_{1t} be an instrument for itself, P_{1t-2} be an instrument for Q_{1t-1} and P_{1t-3} be an instrument for Q_{1t-2}. Equation (3.6) may then be rewritten:

$$(3.7)\quad \log Q_{1t} = C_1 + C_2 Z + C_3 \log P_{1t} + C_4 Z \log P_{1t} + C_5 \log P_{it} + C_6 T + C_7 Z \log HA_t + C_8 (1-Z) \log P_{2t-1} + d_9 \log P_{1t-2} + d_{10} \log P_{1t-3} + E_{dt}$$

where:

$E_{dt} \sim N(0,6^2)$.

The estimates obtained with instrumental variables are both unbiased and consistent but of unknown efficiency since the degree of efficiency depends on the correlation between the instruments and the variables which they replace.

During estimation it became apparent that a second aspect of government policy had been omitted leading to a bias in the estimated residuals. The Sugar Act not only caused the periodic regulation of acreage but also, when amended, changed the overall quota for domestic beet production. The expansion of quota influenced output independently of price, just as was shown with factory-capacity in Figure 3.3. The following variable was therefore defined to represent changes in quota,

$$(3.8)\quad QUOT_t = (QU_{t-1} - QU_{t-2})/QU_{t-2}$$

where:

QUOT = the quota variable,

QU = quota in thousand short tons

t = a time subscript.

The variable $QUOT_t$ represents the proportional change in quota in the previous year. When quota does not change, the variable is zero and this is advantageous in making projections in which the quota may be fixed or wholly absent. This quota variable was added to the array of independent variables in the penultimate estimates, as may be seen in the section which follows in which the results of estimation are given.

Results

Before considering the results for the different regions, a general result concerning lag-structure will be presented which modified further estimation. The result was that for all regions the coefficient of Q_{1t-2} was less than zero, indicating that the lag was of very short duration and hence that complicated lag structures were unnecessary. In consequence, the rational lag system was rejected in favor of the simple inclusion of three years' prices for beet on the RHS. OLS estimation then became appropriate. Whenever prices at time t and at time t-2 were considered to be of very low importance, judging by the signs and significance of coefficients, they were dropped. The results for each region are now presented.

Region I (Michigan, Ohio, Minnesota, Iowa, North Dakota, Illinois, Indiana, Wisconsin, New York, Maine)

$$\log Q_{1t}{}^{\dagger} = \underset{}{8.6475} + \underset{(1.658)}{0.5338} \log P_{1t} + \underset{(1.132)}{0.3378} \log P_{1t-1} \tag{3.9}$$

$$- \underset{(1.074)}{0.6771} \log PCROP_{t-1} - \underset{(1.641)}{0.8019} \log PIN_t + \underset{(6.403)}{0.0627}\, T$$

$$\bar{R}^2 = 0.932$$

$$DW = 2.040$$

$$N = 20$$

As proportionate shares were binding in only three of the observed years, such years were omitted. The quota variable was not included, as the residuals from Equation (3.9) were in no way related to it and (3.9) is not autoregressive according to the DW statistic.

The significance of the coefficients in Equation (3.9) is generally low, only time being significantly different from zero at the 5 percent level. This result is not surprising as, during the 1960's, Minnesota's Red River Valley was an area of great expansion as the result of deliberate government policy rather than a change in prices. While the separate estimation of Michigan, Ohio and states to the East was considered in order to give more efficient estimates, quotas were binding in

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†The definition of variables for this and succeeding equations is:
Q_1 = thousands of metric tons of beet.
P_1 = price per ton of beet for this region in dollars per short ton.*
PCROP = the USDA crop-price index, 1967 = 100.
PCORN = the U.S. average corn price in dollars per bushel.
PALF = the price of alfalfa hay in dollars per short ton in Los Angeles.
PIN = the USDA index of input prices excluding labor, 1967 = 100.
T = year, i.e. 1966 = 66.
Z = a binary variable for share-binding years.
HA = proportionate share in thousand hectares.
QUOT = proportional change in domestic beet quota from year t-2 to year t-1 reckoned on a base of year t-2.

*Note also that P_{it} actually refers to the price received for the crop of time t-1 since payment is spread over the succeeding year.

the different states in the same group of years and separate estimation was considered unnecessary.

From Equation (3.9) the estimated own-price elasticity of sugar beet over a two-year period is 0.87 and the cross-price elasticity with an index of crop prices is -0.68, i.e. a 1.3 percent rise in the price of other crops will offset the effect of a one percent rise in the price of sugar beet. Input prices are important, having an estimated elasticity of -0.80 which reflects the relatively intensive use of inputs, which sugar beet requires as compared with other crops. The estimated influence of technology at the 1974 output is +6.5 percent per annum, which appears very high, but reflects both improved yields and changes in farm structure.

Region II (Colorado, Kansas, Wyoming, Texas, Nebraska, Montana, South Dakota)

$$\begin{aligned}(3.10)\quad \log Q_{1t} = {} & 11.3334 + \underset{(1.115)}{0.4258} \log P_{1t} + \underset{(1.269)}{0.5117} \log P_{1t-1} \\ & + \underset{(1.568)}{1.3930}\, Z \log P_{1t-1} - \underset{(2.525)}{10.8776}\, Z \\ & + \underset{(1.737)}{0.6758}\, Z \log HA_t - \underset{(1.248)}{0.8331}\, (1-Z) \log PCROP_{t-1} \\ & \underset{(1.612)}{-0.7854} \log PIN_t + \underset{(3.290)}{0.0344}\, T + \underset{(1.541)}{0.4628}\, QUOT_t\end{aligned}$$

$\bar{R}^2 = 0.843$

$DW = 1.690$

$N = 23$

Equation (3.10) is the full model with both share-binding and nonshare years included. There were seven of the twenty-three years in which the quota was binding, hence, with only seven observations on those variables with a Z dummy, it is not surprising that many coefficients

were not significantly different from zero at the 5 percent level. The alternative product price, as in region I, was an index of crop prices, although the price of corn also gave reasonably satisfactory results.

The equation shows very different behavior when shares were binding from that when they were not binding. The intercept term for binding years, Z, has a very large negative value of -10.87 while the slope term for price at t-1 in such years has an unexpected positive sign and a large value. In effect the relationship states that farmers in region II are <u>more</u> price responsive in years when shares are binding, even though they are unable to adjust acreage in such years. According to Storr and Warnken[9] the farmers in this region have a diminishing enthusiasm for beet production, especially as the Great Western Sugar Company has been the chief processor in the region. How such diminished enthusiasm relates to price responsiveness in proportionate-share years is not clear, unless the farmers are risk-averse and only grow beet when its price is relatively certain i.e. in such proportionate-share years.

The own-price elasticity of beet production in Equation (3.10) is 0.94 spread over two years, but is 2.33 when proportionate shares exist. The cross price elasticity with other crops is an estimated -0.83, a similar magnitude to that in region I. The elasticity with input prices is -0.79 and the estimated influence of technology at 1974 output is 3.5 percent per annum. The quota variable, which was included because it reduced autocorrelation, has the expected positive sign and may be interpreted as indicating that a one percent increase in quotas for U.S. beet in year t-1 leads to a 0.46 percent increase in output in year t.

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[9]Op. cit.

Region III (Utah, Idaho, Oregon, Washington)

$$\text{(3.11)} \quad \log Q_{1t} = \underset{}{5.3717} + \underset{(2.544)}{2.6273} \log P_{1t-2} - \underset{(1.841)}{3.3173} Z \log P_{1t-2}$$

$$+ \underset{(1.306)}{4.8769} Z + \underset{(2.263)}{0.8503} Z \log HA_t$$

$$- \underset{(1.754)}{0.5216} (1-Z) \log PCORN_{t-1} - \underset{(1.609)}{1.1974} \log PIN_t$$

$$+ \underset{(1.887)}{0.0240} T + \underset{(1.539)}{0.5636} QUOT_t$$

$\bar{R}^2 = 0.896$

$DW = 1.874$

$N = 23$

Equation (3.11) has more coefficients significantly different from zero than in previous equations. Proportionate shares were binding in seven of the twenty-three years in this region. The lag structure of the equation is very curious. When the sugar beet prices at t and t-1 were included, they were of very low value and of total insignificance; only price at t-2 proved important. This contrasts with our expectation that price at t-1 would be the chief influence on output at time t. Further, the estimated effect on price response of the imposition of binding shares is to counteract completely the effect of price and even to make it negative. Clearly the coefficient of Z log P_{1t-2} is too high, but it may reflect the lack of price response in this region in proportionate-share-binding years. The reason for P_{t-2} rather than P_{t-1} being most important is not obvious, but could reflect changes in factory capacity (not seen in the data on such capacity) or problems of crop rotation which do not allow a rpaid change in crop mixture.

The estimated price elasticity in Equation (3.11) is 2.63 which is much higher than in regions I and II and corroborates the findings of

Storr and Warnken[10] that the farmers in Washington and Oregon are highly price responsive. The estimated cross-price elasticity with corn is -0.52 and the input-price elasticity is (a large) -1.20. Technology, at 1974 output, has a +2.4 percent per annum influence and, also at 1974 output, a one percent increase in U.S. beet quota at 5-1 would lead to a 0.56 percent increase in output at time t.

Region IV (California, Nevada, Arizona, New Mexico)

$$(3.12)\quad \log Q_{1t} = \underset{}{7.4779} + \underset{(1.508)}{0.4923} \log P_t + \underset{(4.796)}{2.2745} \log P_{t-1}$$

$$- \underset{(1.644)}{2.3443} Z \log P_{t-1} + \underset{(0.915)}{2.6860} Z + \underset{(1.728)}{0.5040} Z \log HA_t$$

$$- \underset{(1.028)}{0.3300} (1-Z) \log PALF_{t-1} - \underset{(3.435)}{1.8036} \log PIN_t$$

$$+ \underset{(6.605)}{0.0494} T + \underset{(1.431)}{0.5413} QUOT$$

$$\bar{R}^2 = 0.895$$

$$DW = 2.197$$

$$N = 23$$

Equation (3.12) is the best of the regional equations from a statistical viewpoint. Several of the coefficients have "reasonable" t-values and all bear the correct signs and have "reasonable" magnitudes. As expected, the lag peaks at time t-1 and when price at t-2 was included it bore a coefficient of negative sign. The influence of the proportionate share is to reduce price elasticity to an estimated 0.42, which would seem appropriate for such a yield elasticity. In this region shares were binding in eight of the twenty-three years.

Own price elasticity for beet is estimated to be 2.77 and so high

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[10]Op. cit.

an elasticity is consistent with the opportunities for alternative enterprises in California. The cross-price elasticity is only -0.33 with the price of alfalfa, which probably understates the influence of alternative product prices. Output is extremely sensitive to input prices, the estimated elasticity being -1.80. When the wage rate as a distinct argument was also included, it bore the expected sign but simply resulted in neither prices of other inputs nor the wage rate remaining significant influences on output; hence it was not included, although wage-labor may still be important in some parts of California for weeding and thinning, unlike the situation in all other regions. Technology, as measured by time, has a 5.1 percent influence per annum when estimated at 1974 output. A one percent increase in U.S. beet quota has a +0.54 percent influence on output, again estimated at 1974 output.

Region V (Whole U.S.A.)

$$\begin{aligned}(3.13)\quad \log Q_{1t} = {} & 9.9134 + \underset{(1.396)}{0.4884} \log P_{1t} + \underset{(2.512)}{1.1716} \log P_{1t-1} \\ & - \underset{(1.040)}{0.9081} Z \log P_{1t-1} - \underset{(1.024)}{3.3851} Z + \underset{(1.196)}{0.2960} Z \log HA_t \\ & - \underset{(1.569)}{0.8585} (1-Z) \log PCROP_{t-1} - \underset{(2.565)}{1.0376} \log PIN_t \\ & + \underset{(1.418)}{0.0345} T + \underset{(1.418)}{0.3661} QUOT\end{aligned}$$

$$\bar{R}^2 = 0.921$$

$$DW = 1.863$$

$$N = 23$$

where:

Q_1 = thousand metric tons of sugar in raw value,

P_1 = the farm price of sugar beet in dollars per ton.

Equation (3.13), covering all U.S. domestic beet, is a much more "reasonable" result than might have been expected, considering the importance of different crops as alternatives in different regions. All signs and magnitudes of coefficients conform to expectations, although only the coefficients for beet price at t-1, input prices and time are significantly different from zero at the 5 percent level. The lag places 30 percent of the response to price at time t and the remaining 70 percent at time t-1.

Observing individual coefficients, the overall elasticity with respect to the price of beet is 1.66 and in share-binding years this is reduced to 0.75. The elasticity with respect to land in share-binding years is 0.30. Cross elasticity with respect to the price of other crops is -0.86 and with input prices is -1.04. The rate of technological change, estimated at 1974 output, is 3.5 percent per annum. A one percent increase in domestic beet quota is estimated, at 1974 levels, to give a 0.37 percent increase in output.

A Summary and Some Elementary Projections

In summary, the analysis of time-series with a model allowing for government interventions demonstrated that the supply of beet in the U.S.A. is relatively price elastic. An overall elasticity of 1.66 was estimated, but this disguises the high elasticity of more than 2.6 in the West and North-West and the lower elasticity of approximately 0.9 in the other two regions. Both input-prices and the prices of alternative crops were important influences.

Some elementary projections will now be made to demonstrate the expected behavior of the U.S. beet sector under an array of prices.

These projections are not central to this report and the reader may pass to Chapter IV without any loss of continuity.

Two kinds of projections might be of interest. Firstly, one might project what output would have been in the absence of proportionate shares. Since these shares have not been binding in any region since 1970, such a projection is not very important and will not be made. Secondly, one may project supply for each region for 1975, to show the effect of 1974 prices, and for 1985, to give a perspective on the growth of this sector. Projections for 1975 and 1985 have been made under the assumption that only the price of sugar beet changes and that other prices are at their 1974 levels, including the prices of alternative crops.

Projections for 1975 have been made under the assumed prices of \$40 and \$30 per ton for the 1974 beet crop which are equivalent to a raw sugar price of 23.48 and 17.61 cents per lb, respectively.[11] Projections for 1985 have been under the assumption of constant prices at the 6, 10, 14 and 18 cents per lb. levels or \$10.22, \$17.03, \$23.84 and \$30.66 per ton of beet.

The results of the projections are given in Table 3.3 and Figure 3.4. For 1975 the projected output in regions I and II are somewhat larger than for 1974 and for region III a very slight increase in output over 1974 is forecast. Only in region IV, mainly California, may a dramatic expansion be expected, of the order of +50 percent, and in this region factory capacity will be limiting. Summing the regions,

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[11]Conversion based on: 1) 15.5 percent sucrose in beet, of which 79 percent extracted; 2) 100 parts of raw sugar equivalent to 93.46 parts refined; and 3) returns divided between processor and farmer on a 35:65 basis.

Table 3.3. Projected Outputs

Year	Price		Regional Output				Total VI	Aggregate Output V
	t ¢/lb.	t-1 ¢/lb.	I	II	III	IV	I+II+III+IV	
			------------Thousand Metric Tons R.V.------------					
1975	23.48[1]	19.79	829	851	420	1130[2]	3230	3762[3]
	17.61[1]	19.79	711	753	420	1130[2]	3014	3762[3]
1985	6	6	500	384	117	226	1208	866
1985	10	10	781	588	448	929	1747	2023
1985	14	14	1047	807	1085	2357	5297	3537
1985	18	18	1304	1021	2100	4725	9150	5368
1974 Actual			663	763	470	750	2646	2644

[1]Price equivalences are: 23.48 ¢/lb. ≡ \$40/ton of beet
17.61 ¢/lb. ≡ \$30/ton of beet

[2]Limited by 210 short tons of beet per short ton of slicing capacity.

[3]Limited by 150 short tons of beet per short ton of slicing capacity.

NOTES: I, II, III and IV denote regions. VI denotes the sum of the regions. V denotes the result of aggregate U.S. estimation.

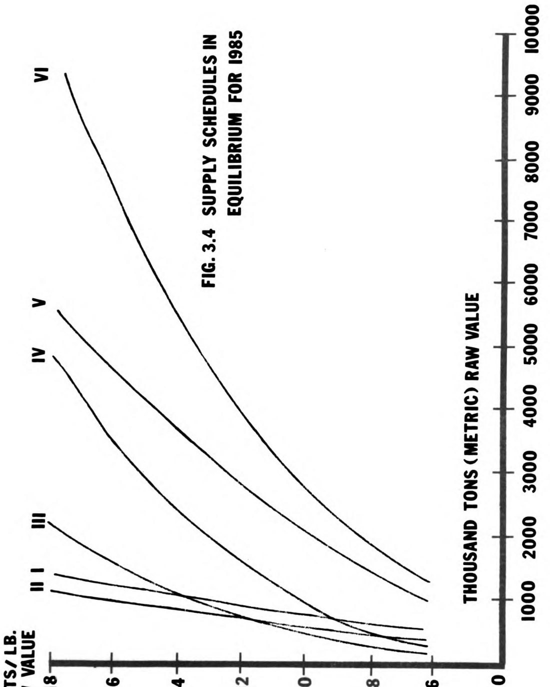

FIG. 3.4 SUPPLY SCHEDULES IN EQUILIBRIUM FOR 1985

(as under VI in the table), at 17.6 cents per pound received during 1975 for the 1974 crop, a 13.9 percent increase in output over 1974 is forecast while at 23.5 cents per pound a 22.1 percent increase is forecast. By contrast, the aggregate function V forecasts a 42.3 percent increase in output which must, however, be considered highly suspect even though this output was limited by a capacity constraint.

For 1985 a 10 cent per lb. price (in 1974 dollars) would lead to an output approximately at the 1974 level in the U.S.A. At 14 cents per lb., the output would be much higher than in 1974. Figure 3.4 shows how region IV, mainly California, would dominate supply at the higher prices, due to its high price elasticity. The aggregate function V leads to substantially lower estimates than does the sum of the regions, VI, and interpretation of either function at high prices should be very guarded since forecast error is higher the further from the observed mean that one moves. However, at the "reasonable" price of 14 cents (1974 value) a doubling of output over 1974 is forecast by summing the regional supplies for 1985 and this is also a 61 percent expansion over the previous record of 1972. The general conclusion is that an expansion of domestic beet production is feasible at prices far less than the 29.5¢/lb. of 1974, namely around 14 cents per lb. in 1974 values.

CHAPTER IV

U.S. DOMESTIC CANE-SUGAR SUPPLY

Introduction

Sugar cane is produced in three mainland and two offshore regions of the U.S.A., the former being Louisiana, Florida and Texas and the latter Hawaii and Puerto Rico. The exact mainland locations may be noted from Figure 4.1. Cane may be grown wherever there are relatively high temperatures, plentiful water and a long frost-free season. Consequently, on the mainland, cane is located in the extreme South near large water masses which afford the necessary protection from frost. In Hawaii and Puerto Rico the absolute size of the islands limits potential sugar production.

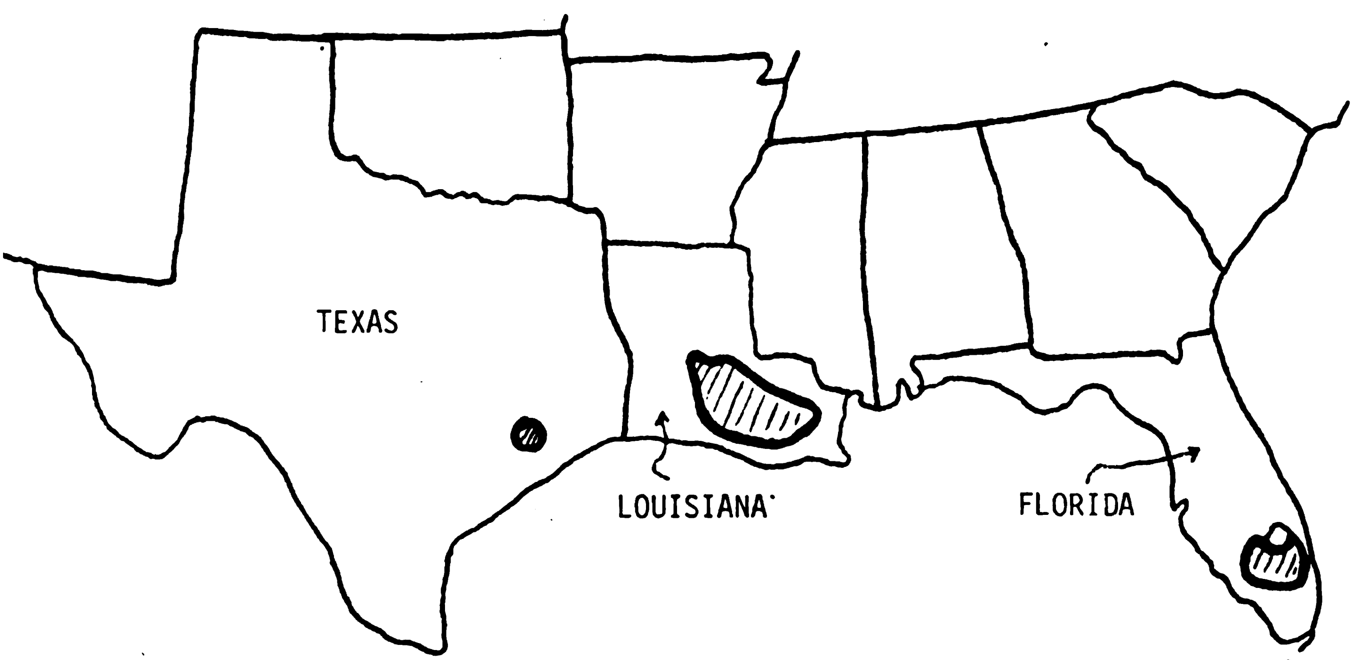

Figure 4.1. Cane Producing Regions of the Mainland United States.

Proportionate shares have regularly been enforced to limit production in Louisiana and Florida, but such measures have not been necessary in Puerto Rico since 1952. In Hawaii shares have never been used and production in Texas is so recent a development of so minor a scale that shares have not yet been necessary there either. The existence of shares in Louisiana and Florida greatly complicates the specification and estimation of time-series models of supply, particularly as the "free-from-share" supply is of great interest for future projection. Preliminary attempts at time-series estimation resulted in nonsignificant coefficients for all price variables. In consequence a cross-sectional approach was chosen, using the data from the cost surveys of the Sugar Division of the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture. The Hawaiian output has been so stable, that time-series analysis was thought unlikely to be of value there also. For Puerto Rico, a previous attempt at time-series estimation by Choudhury[1] met with little success except in finding a significant time trend. A cross-sectional approach has therefore also been utilized for both Hawaii and Puerto Rico. The minor production in Texas has been omitted from the formal analysis in this study.

The primary objective of this chapter is to derive supply relationships for each of the four major cane-growing regions of the U.S. The procedure to be used will be to estimate Cobb-Douglas production function parameters from cross-section data and then to use these parameters with time-series data in synthesizing the aggregate supply response. A

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[1]Choudhury, P. (1967). "An Economic Appraisal of the Aggregate Sugar Supply Response for Selected Major Producing Countries," unpublished Ph.D. dissertation, University of Hawaii.

secondary objective is to examine the ease of substitution between inputs in the sector, particularly labor and machinery, since unskilled labor is still an important input and minimum wage legislation under the U.S. Sugar Act has had an unknown impact on employment. Ease of input substitution will be found by measuring elasticities of substitution and of derived demand, using the Translog production function.

The chapter is developed as follows. A brief sketch of the structure and performance of each region's sugar industry is first given, so that the more formal analysis may be set in its context. This is followed by a discussion and explanation of the procedures which have been used. The third section of the chapter gives the results from estimation and the fourth makes some projections from the estimated equations. Finally there is a summary and some implications of the results.

The Sugar Industry of Each Region

Louisiana

Louisiana has produced sugar cane for sugar since 1795. Production is confined to the alluvial soils of the Mississippi Valley. Because the watertable is high, there is no need for expensive irrigation systems. The factor limiting the wider geographical dispersion of cane is neither water nor land but temperature, particularly the temperature in the harvest period of October-December when the cane is liable to frost damage. There were 27 Louisianan weather stations which had less than four days in November on which freezing temperatures occurred in the period 1951-60.[2] Of these, six were in urban areas,

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[2]Weather Bureau. (1964). "Climatic Summary of the United States." U.S. Department of Commerce, Washington, D.C.

three were on lakes or on the coast, thirteen were in cane-growing counties and five were in counties where cane is not a significant crop.[3] Of the five "odd" counties, one grows virtually no crops and the other four have soybeans as the dominant product.

In Louisiana the harvest period is October to December and the planting period, August to October of the previous year. Two ratoon crops are normally harvested followed by nine months of fallow, which results in a maximum of three crops per four years on any piece of land. The proportion of cane in its first harvest was 42 percent in 1969-71.[4]

The structure of the industry has changed dramatically since the 1940's. In 1948, 5,957 farms harvested an average of 49.9 acres of cane each. In 1973, 1,290 farms harvested an average of 264.5 acres of cane each. In 1948, 84 percent of farms had less than 50 acres of cane whereas by 1973 only 22 percent of farms had less than 50 acres of cane. The dramatic shift in farm size reflects economies of scale, particularly in harvesting, and such economies are demonstrated by the cost surveys of the ASCS[5] and of Louisiana State University.[6] The sugar mills in Louisiana are usually run independently from the primary producer and their number has declined from 59 in 1948 to 39 in 1973.

Figure 4.2 presents acreage and output over the last two decades and Figure 4.3 price and production of seed. Output has fluctuated

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[3]Data on production by county according to the 1969 Census of Agriculture.

[4]Calculated from ASCS survey data.

[5]Agricultural Stabilization and Conservation Service, U.S.D.A. (undated). "Returns Costs and Profits Louisiana 1969-71 Crops." U.S. Department of Agriculture, Washington, D.C.

[6]Campbell, J. (various years). "Returns, Costs and Profits from Sugar Cane Farms." Louisiana State University.

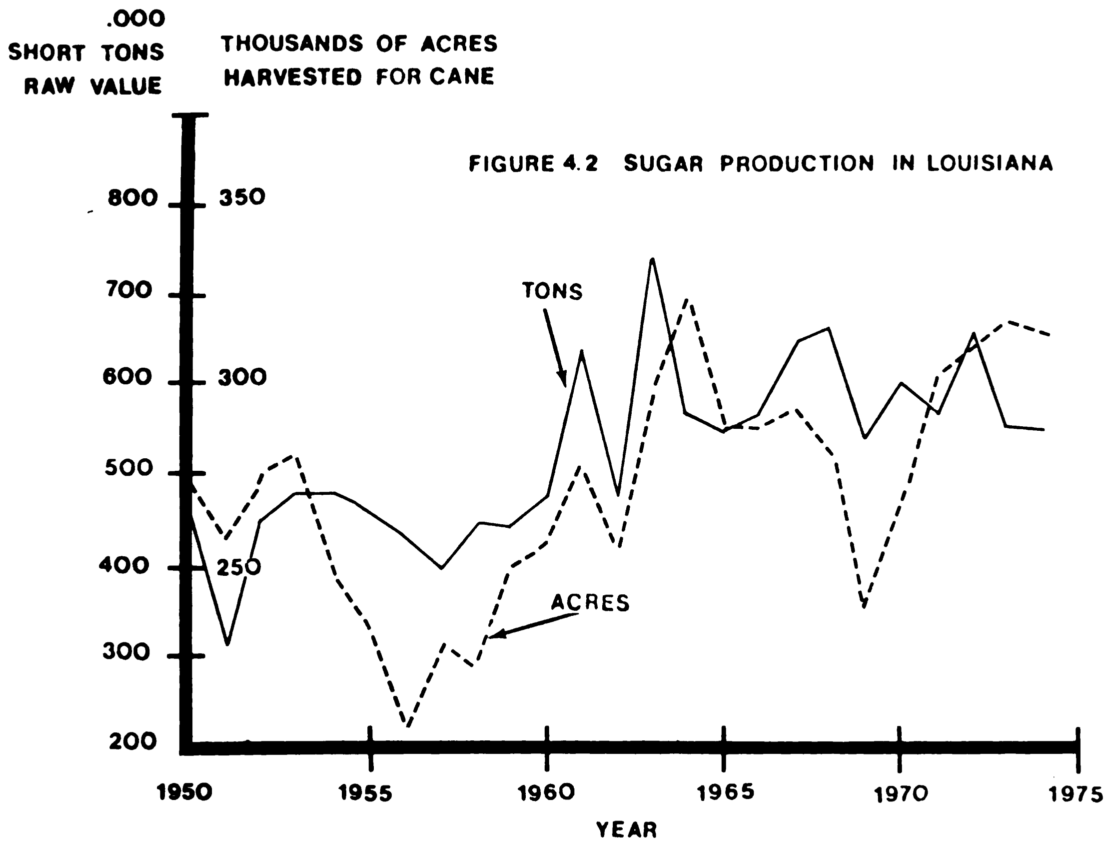


FIGURE 4.2 SUGAR PRODUCTION IN LOUISIANA

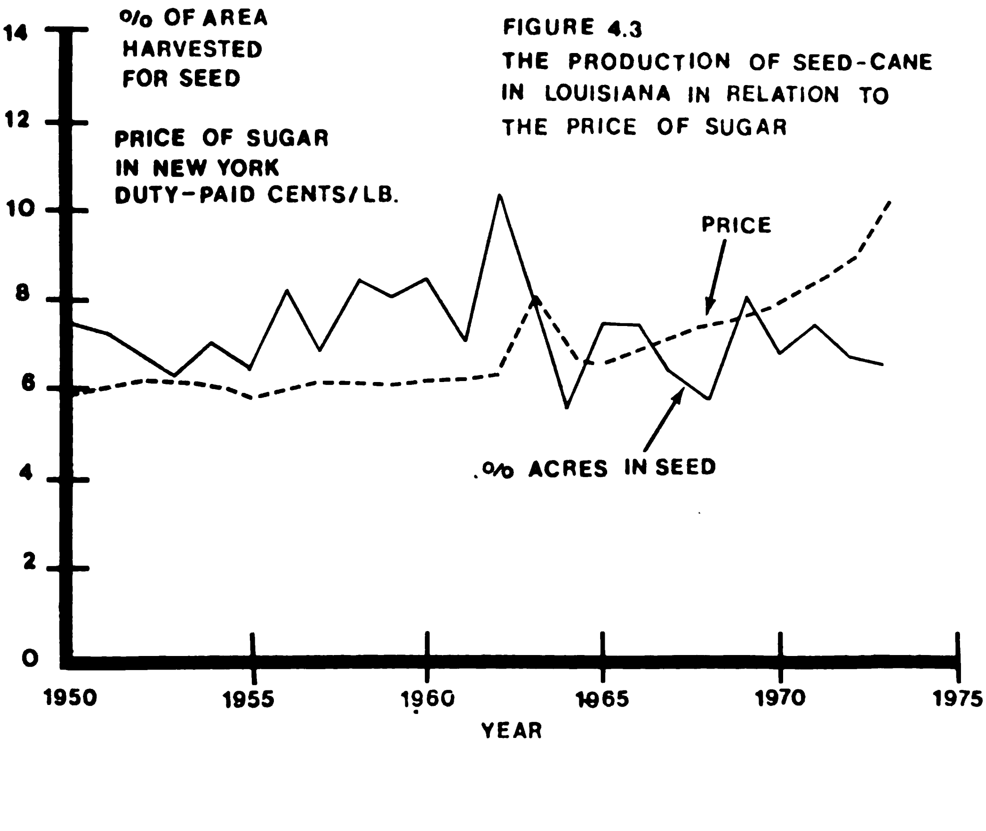


FIGURE 4.3
THE PRODUCTION OF SEED-CANE IN LOUISIANA IN RELATION TO THE PRICE OF SUGAR

from a low of 295,000 tons raw value in 1951 to a high of 759,000 tons raw value in 1963. Acreage harvested for sugar was at a low of 203,300 in 1956 and a high of 325,200 in 1964. Acreage was limited by the imposition of proportionate share in all years except 1960-62, 1964, and 1972 to the present time.

Figure 4.2 gives some idea of investment behavior in those years when controls were relaxed. Acreage reflects intended output. Following the ban on Cuban imports in 1960, acreage only climbed slightly in 1961. However, in 1962 a record acreage of sugar was harvested for seed (see Figure 4.3), reflecting intentions to expand output in response, not to price, but to an expansion in the mainland cane quota from 787,000 to 1,072,000 tons. The new cane came into production in 1964. During the 1971-74 period there has been no expansion comparable to that of 1962-64, despite the absence of shares, which indicates that neither prices nor government policy have been conducive to such an expansion.

Florida

The production of sugar cane in Florida began in 1928 but was of relatively minor importance until the Cuban embargo of 1960 after which there was a rapid expansion. As in Louisiana, neither land nor water is the limiting factor but freedom from frost-damage. In the vicinity of Lake Okeechobee there is relative freedom from frost, but as one moves further from the Lake (to the North) the probability of frost damage rises.[7] The higher the expected price of sugar, the more distant from the Lake the margin of cultivation becomes.

[7] Ballinger, R. A. (1972). "Economic Behavior in the U.S. Sugar Market," California Agricultural Experiment Station Bulletin No. 859.

The planting period in Florida is September to October and the harvesting period is November to May of the following crop year. Two or three ratoon crops would normally be taken before replanting and this is reflected in the 1967-69 average of 25 percent of cane being in its first harvest year.[8] Unlike the situation in Louisiana, where smaller farms are continually being consolidated into larger holdings, sugar production in Florida has always been a relatively large-scale undertaking. The average harvested acreage per farm in 1948 was 1,464 and in 1973 was 1,952. However, whereas up to 1960 most of the cane producers were also processors, thereafter the number of "independent" cane producers increased to be 47 percent of the total by 1969.[9] The number of farms increased from 25 in 1948 to 136 in 1973 and the number of mills increased from three to eight in the same period.

Figure 4.4 presents acreage and output for the last two decades. Acreage was relatively constant in the 1950's, as was output, and the rapid expansion came in the period 1961-64. Acreage harvested for sugar was 56,100 in 1961, 114,300 in 1962, 139,900 in 1963 and 219,800 in 1964. Similarly, output rose from 206,000 raw tons in 1961 to 572,000 tons in 1964. Figure 4.5 plots the proportion of acreage held for seed against time and price. Two peaks occurred in the proportion of acreage harvested for seed. The first, in 1961, was the result, not of price but of an expansion in quota in the 1961 Sugar Act Amendments. The second peak, in 1963, was the result of the high price in that year. Clearly both quota and price have been important in causing new investment to

[8]Calculated from the ASCS survey data.

[9]ASCS, USDA (Undated). "Returns, Costs and Profits Florida 1967-69 Crops," USDA, Washington D.C., p. 5.

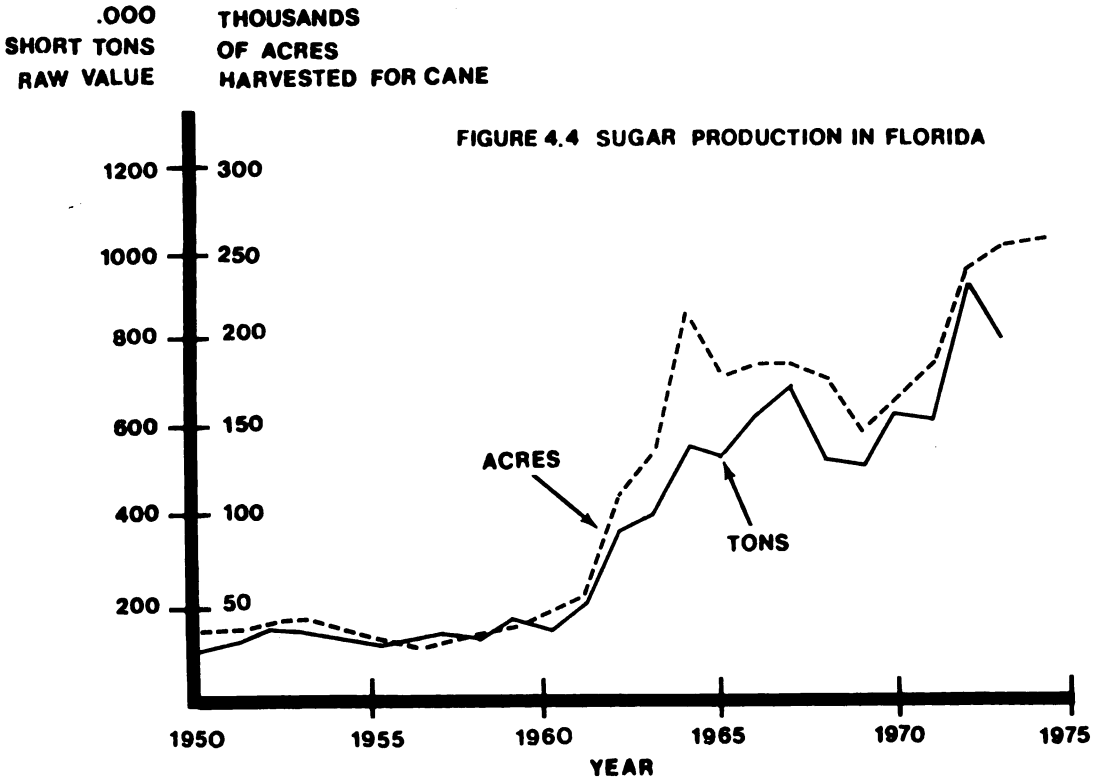
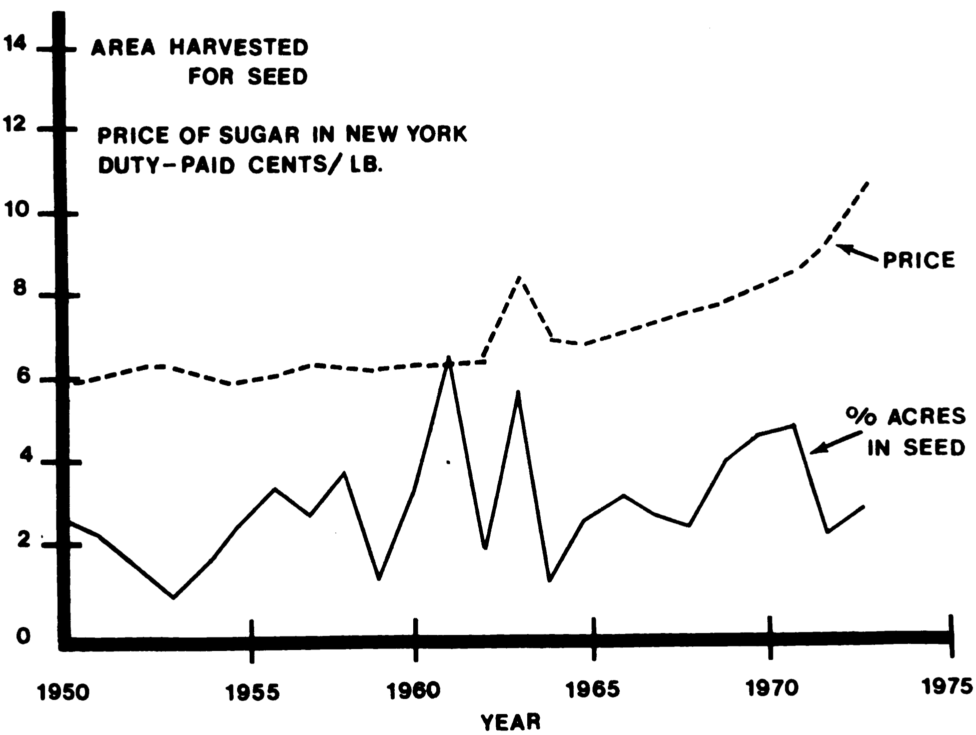


FIGURE 4.4 SUGAR PRODUCTION IN FLORIDA

FIGURE 4.5 THE PRODUCTION OF SEED-CANE IN FLORIDA IN RELATION TO THE PRICE OF SUGAR



occur. The result of a higher proportion of seed-harvesting in one year is an expanded acreage in the next, as is shown in Figure 4.4 for 1962 and 1964. Just as in Louisiana, the lag in investment is of one to two years' duration, depending on the exact timing of the stimulus in relation to the crop year. In the period since controls were removed in 1971, there has been a small increase in acreage but nothing of the order of the earlier expansion.

Hawaii

The production of sugar began in Hawaii early in the 19th century and was encouraged after 1876 by duty-free access to the U.S. domestic market. Production first exceeded one million tons in 1930-31 and has remained at approximately that level ever since.[10] The islands involved in sugar production are Hawaii, Oahu, Kauai and Maui. The area of coastal land suitable for cane growing is limited and there is competition for land at the margin for urban, military and recreational uses as well as for livestock production.[11]

Hawaii is unique among cane-producing regions in having year round planting and harvesting of the crop. The time between planting and harvesting is two years and ratoon crops are also allowed one and a half to two years' growth before harvesting. In consequence of the long growing period, yields per acre in Hawaii are the highest in the world, being over ten tons of raw sugar per acre. It is usual to take several ratoon crops before replanting. In 1973, 393 farms harvested cane as compared with 786 in 1951.[12] However, these farms are mostly not

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[10] Ballinger, "History of Sugar Marketing," op. cit., p. 9.

[11] Ballinger, "Economic Behavior in the U.S. Sugar Market," op. cit.

[12] Earlier figures are not comparable.

independent, but owned by the mills. In 1967-69 only 5.8 percent of sugar was produced by independent growers and 94.0 percent was produced by the farms owned by the mills. The remaining 0.2 percent was the product of a few remaining adherent planters and co-producers.[13] In 1969 there were 24 plantation companies in operation. The average farm in 1973 harvested 275 acres of cane which may be compared with the average of 139 acres in 1951; i.e. there has been a gradual upward drift in farm size.

Figure 4.6 presents acreage harvested and output in the last two decades. Acreage growing is approximately twice the area harvested, except when a strike (as in 1958) or inclement weather interrupts the harvest. Figure 4.6 is of interest only in demonstrating the remarkable stability of the Hawaiian industry over this period. The chief question concerning the industry is not by how much it could expand its output, but at what price would a decline set in. Since Hawaiian production has not been restricted by proportionate shares, any change in acreage is a response to prices, either of inputs or of outputs or of other competitive land-using activities. Although the acreage climbed slightly in the late 1960's, there was no dramatic change in acreage or output following the high sugar price of 1963. Whether the current high price of sugar may have any influence will be a matter for discussion later in this chapter.

Puerto Rico

Production of cane sugar in Puerto Rico dates from the 19th century, but after 1900 there was an influx of U.S. investment which

[13]ASCA, USDA (Undated).. "Returns, Costs and Profits of Hawaiian Sugar Plantations, 1967 to 1969 Crops." USDA, Washington, D.C.

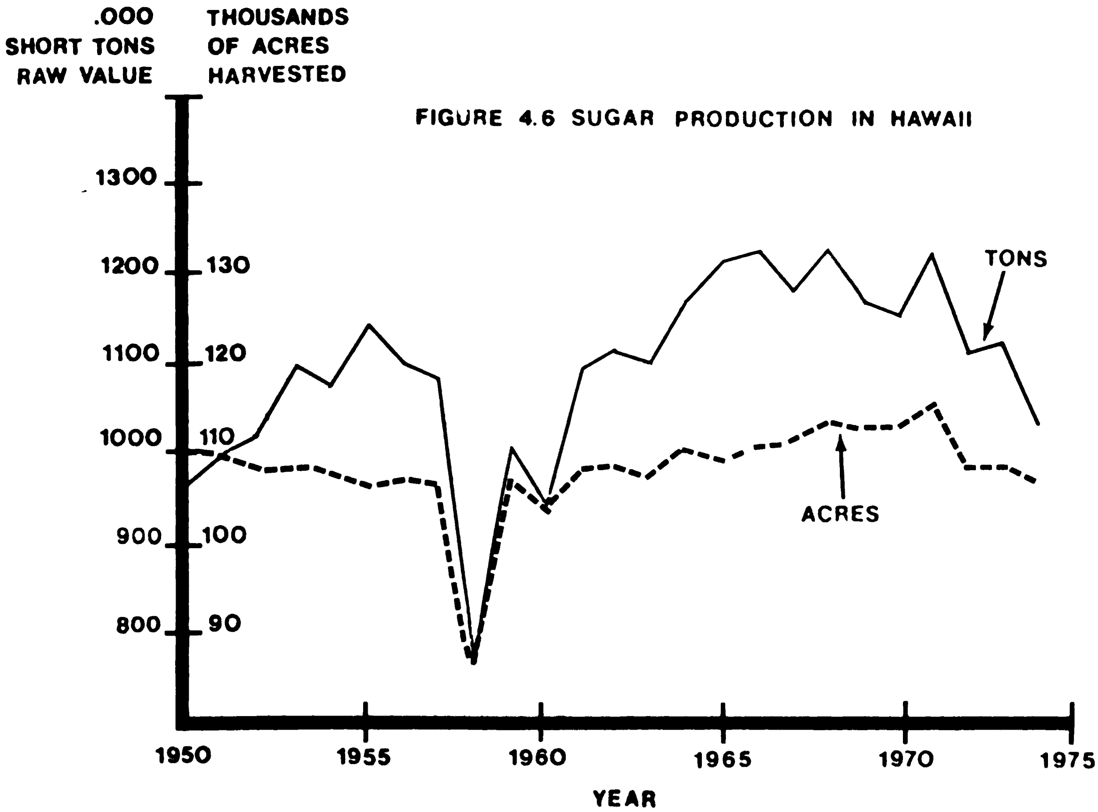

FIGURE 4.6 SUGAR PRODUCTION IN HAWAII

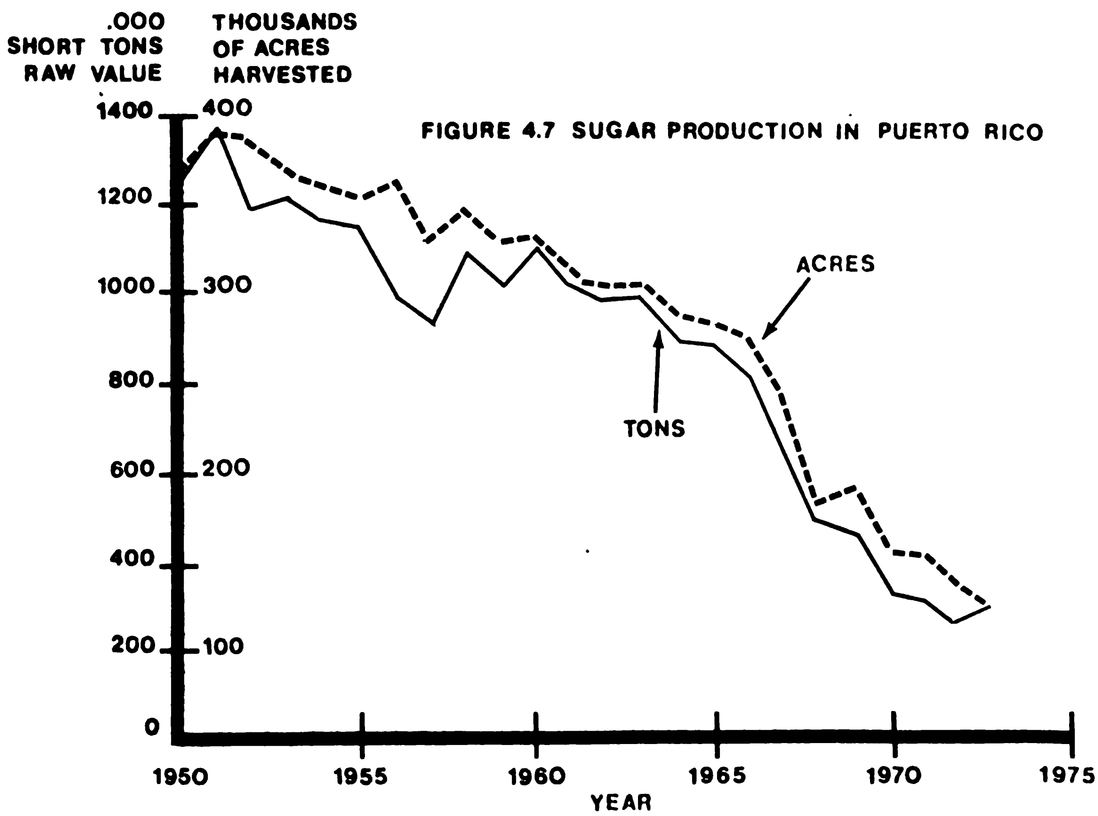

FIGURE 4.7 SUGAR PRODUCTION IN PUERTO RICO

expanded output from 49,000 tons in 1900 to 994,000 tons by 1939. Puerto Rico has never paid any duty in the U.S. market which gave it a distinct advantage over Cuba in certain years. Production reached a peak of 1,372,000 tons in 1951, but since 1961 has declined in every succeeding year to reach a low of 255,000 tons in 1972. In 1973 there was a slight reversal of the trend, with 291,000 tons produced.

The reasons for Puerto Rico's declining production are not well established. Rising wage rates and the slow adoption of mechanization are often cited.[14] Wage rates have risen because of the free entry of Puerto Rican labor into the U.S. mainland. Mechanization has been slow because of the rolling topography of some of the traditional cane lands. At the margin, milk production may be more profitable than cane production.[15] Attempts to explain Puerto Rican production with a time-series model[16] and to project future output with the mechanistic approach of Markov Chains[17] have both been relatively unrewarding. The former showed only a significant time-trend and the latter failed to predict the substantial recent decline in the industry.

Planting occurs in Puerto Rico in both the Autumn and Spring and harvesting of that crop is from December of the following year until July. Two to three ratoon crops would normally be taken on an annual basis before replanting, although more are sometimes taken. In the

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[14]Ballinger, "Economic Behavior in the U.S. Sugar Market," op. cit.

[15]Pringle, G. E. (1969). "A Temporal-Spatial Analysis of Sugar Production and Marketing in Puerto Rico," Ph. D. dissertation, University of Wisconsin.

[16]Choudhury, P. (1967). "An Economic Appraisal of the Aggregate Sugar Supply Response for Selected Major Producing Countries," Ph. D. dissertation, University of Hawaii.

[17]Pringle, op. cit.

1972-73 crop year 2,954 farms harvested an average of 45 acres of cane which yielded 1.93 tons of sugar per acre. Comparable averages for 1950 were 16,525 farms having 23.7 acres each which yielded 3.16 tons of sugar per acre. In 1950-51 60 percent of all cane farms had less than five acres of cane and by 1972-73 this had only fallen to 45 percent. The structure of the industry, namely one of small independent growers, has not changed much in the last two decades. The number of mills has declined slowly from 36 in 1948 to 12 in 1973.

Figure 4.7 traces the declining output and acreage of the industry from 1950 onwards. Note the acceleration in the rate of decline at about 1967, which may be attributed to rapidly rising wages at that time. Restrictions on acreage have not been necessary in Puerto Rico since 1952 and so output is a response to prices rather than quotas. The high price of sugar in 1963 seems to have had little, if any, influence on output in succeeding years.

Procedure

General Approach

The reasons for using a cross-sectional approach have already been mentioned, namely the frequent imposition of proportionate shares, the low variation in output over recent decades and the comparative failure of attempts at time-series estimation by Choudhury for Puerto Rico and by the present author for Louisiana. Under the Sugar Act, cost surveys were conducted every four years in each of the producing regions in order that "fair" prices and wages could be fixed in extensions of the Act. The last such surveys were for 47 farms in Louisiana for 1969-71, 29 farms in Florida for 1967-69, 24 farms in Hawaii for

1967-69 and 35 farms in Puerto Rico for 1969-71. The general results of the surveys have been published by the Sugar Division of the Agricultural Stabilization and Conservation Service.[18] The data consist of the business accounts together with some physical observations such as tons of cane, area in production and man-hours of labor. The prices of individual inputs, except labor, are not recorded and therefore estimation of cost-functions corrected for input prices is precluded. The estimation of cost as a simple function of output would face an additional problem when proportionate shares were in force because short-run costs may rise more steeply for large firms than for small firms resulting in a totally misleading estimate of the shape of the long-run average-cost curve. Figure 4.8 demonstrates such an occurrence in the two-firm case. Each firm is assumed to reduce output by one-third under the proportionate share, from Q^* to Q^o. A line $A^* B^*$ would be estimated under profit-maximizing behavior whereas A^oB^o would be estimated under the proportionate share. When simple cost functions were estimated for each region, no reduction in unit cost with output was observed in Florida and Louisiana, which would be consistent with the situation in Figure 4.8.

Having rejected cost functions, note that production functions do not suffer from the same problems since they relate physical quantities, rather than prices or costs, to output. The production function parameters are invariant to governmental policy. Production functions were therefore fitted to the cross-sectional data. The general model may be written,

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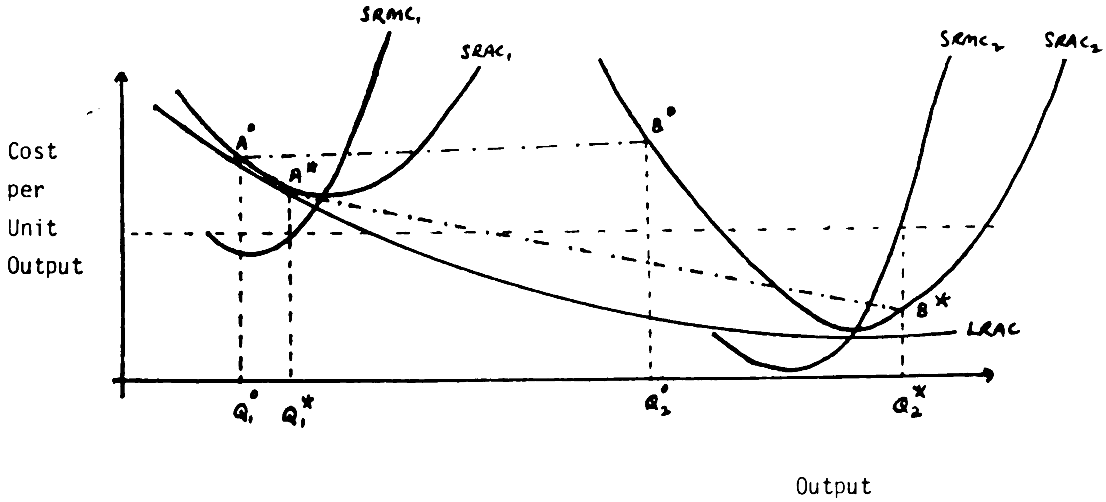
[18] Entitled, e.g. "Returns, Costs and Profits, Louisiana 1969-71 Crops," U.S. Department of Agriculture, Washington, D.C.

Figure 4.8 Two-Firm Example of Cost Relationships



(4.1) $X_{oi} = f_1 (X_{1i}, \ldots, X_{ki}) + e_i$

where:

X_o = output,

$X_1, \ldots, X_k$ = inputs,

e = an error term, (assumed additive),

i = the ith firm (i = 1,. . .,n).

Following estimation one obtains,

(4.2) $X_{oi} - \hat{X}_{oi} = \hat{e}_i$

where:

^ = an estimate.

The coefficients estimated for Equation (4.1) relate to the

average firm in the industry at one point in time. By contrast, the objective of this study is to obtain a relationship suitable for time-projection and for the whole region. Suppose the region is treated as consisting of some multiple of the average firm, one may write,

(4.3) $X_{ot} = n\,\bar{X}_{oit}$

where:

X_{ot} = the regional output,

$\bar{X}_{oit}$ = the average firm's output,

t = a time subscript

n = the number of firms.

Substituting $\hat{\bar{X}}_{oit}$ from (4.1), one obtains

(4.4) $\hat{X}_{ot} = n\,\hat{\bar{X}}_{oit}$

Equation (4.4) is estimable only for the sample years and if input quantities are known. However, assuming profit-maximizing behavior for all inputs expcept land and given the production-function parameters from Equation (4.1), one may write sectoral output as a function of land input per firm and prices of other inputs; i.e.

(4.5) $\tilde{X}_{ot} = nf_2\,(L\bar{N}D_t, P_{x2t}, \ldots, P_{xkt})$

where:

$\tilde{X}_{ot}$ = the new estimate of the sectoral output in year t,

n = the number of firms,

f_2 = a known functional relationship,

$L\bar{N}D_t$ = average land input per firm,

$P_{x2t}, \ldots, P_{xkt}$ = prices of variable inputs in year t.

In the jth year, where $j \neq t$, the utilization of Equation (4.5) would yield

$$(4.6) \quad \tilde{X}_{oj} = qf_2 \, (L\bar{N}D_j, P_{x2j}, \ldots, P_{xkj}),$$

where:

q = the number of average firms in the jth year which are equivalent to the n of the sampled year.

By allocating <u>all</u> of the sector's land to the average firm, q may be eliminated and Equation (4.6) rewritten

$$(4.6)' \quad \tilde{X}_{oj} = f_2 \, (LND_j, P_{x2j}, \ldots, P_{xkj}),$$

where:

LND = total, sectoral land.

$\tilde{X}_{oj}$ is derived purely from cross-sectional data for the t^{th} year and may be expected to differ from actual, sectoral output in the j^{th} year due to the effects of changing technology (represented by time) and of changes in the scale of output for the whole sector; i.e.

$$(4.7) \quad X_{oj} - \tilde{X}_{oj} = f_3 \, (T,S)$$

where:

T = year

S = a scale-measure.

(4.7) will be called the "auxiliary time-series" relationship. Combining Equation (4.6)' and (4.7) leads to the compound relationship for year j

$$(4.8) \quad \tilde{\tilde{X}}_{oj} = f_2 \, (LND_j, P_{x2j}, \ldots, P_{xkj}) + f_3 \, (T,S)$$

where:

$\approx{X}_{oj}$ = estimated output for the sector in year j.

The argument may briefly be summarized as follows:

1. estimate the production-function parameters from cross-section data;

2. assuming profit-maximizing behavior for all inputs except land, which is exogenous, compute sectoral output as the output of the average firm as if it utilized all of the sector's land;

3. use the time-series of residuals from the difference between cross-sectionally estimated output (2) and actual output to estimate the effects of time and scale;

4. combine (2) and (3) to give estimates of any year's output, given land area and input-prices.

Finally, one may impose profit-maximizing behavior with respect to land and synthesize a fully profit-maximizing supply which is free of government intervention. The exact form will be shown later.

This approach to "synthesizing" a supply function is complicated, but aggregation bias may not be as great as might be expected since the constant of aggregation is essentially estimated in the auxiliary time-series regression. Only the results may show whether such complexity is justified. Before returning to actual estimates and elaborating on the above, approaches to estimating the Cobb Douglas and Translog production functions will be described in the next sections. Note that the Cobb-Douglas production function is being estimated for the "synthesizing" procedure above, but the Translog production function is being estimated only in order to find elasticities of substitution and of derived demand for inputs.

The Cobb-Douglas Function

The form of the Cobb-Douglas function when written in logarithms is

$$(4.13)\quad x_{oi} = a_o + a_1 x_{1i} + ,\ldots, + a_k x_{ki} + u_i \qquad (i = 1,\ldots,n)$$

where:

x_o = log of output,

x_r = log of the r^{th} input,

u = the disturbance term

i = a firm subscript.

The function is homogeneous of degree $\sum_{r=1}^{k} a_r$ and the partial elasticity of substitution[19] between pairs of inputs is unitary.[20]

There are several ways to estimate this function, depending on the assumptions which may be appropriate. As, in the present study, the correct set of assumptions was not entirely apparent, results were obtained and compared from different approaches.

The simplest method of estimation, attributed to Klein,[21] is to equate the logarithms of the individual coefficients with the appropriate logarithmic cost-shares. That is

$$(4.14)\quad \log \tilde{a}_r = \frac{1}{n} \sum_{i=1}^{n} \log \left(\frac{P_{ri} X_{ri}}{P_{oi} X_{oi}}\right) \qquad (r = 1,\ldots,k)$$

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[19] Defined as $\sigma_{ij} = \dfrac{d\left(\frac{xi}{xj}\right) \frac{\partial xi}{\partial xj}}{\left(\frac{\partial xi}{\partial xj}\right) \frac{xi}{xj}}$.

[20] See, for example, Henderson, J. and Quandt, R. (1958). Microeconomic Theory. (New York: McGraw-Hill).

[21] Klein, L. R. (1953). A Textbook of Econometrics. (New York: Row, Peterson and Company).

where:

P_r = price of the r^{th} input,

P_o = output price,

X_r = quantity of r^{th} input,

X_o = quantity of output,

i = a firm subscript.

The assumptions necessary to this approach are that firms do not differ in the disturbance associated with the production function but only with respect to their success in equating input prices and marginal value products; i.e. it is assumed that all firms are similar and are distributed symmetrically about the profit-maximizing position. Further, since cost-shares sum to sunity, so must the Cobb-Douglas coefficients and so unitary returns to scale are imposed. Given correct assumptions, Klein's estimator is unbiased and maximum likelihood. In the present context it might be useable with the Hawaiian and Puerto Rican data but not with the Louisianan or Floridan data, since in the latter regions proportionate shares precluded profit-maximizing behavior.

The second, and most common, estimator is that of ordinary least squares (OLS) on the production function itself, an additive, logarithmic disturbance being assumed. Assuming perfect competition, diminishing returns to scale, profit-maximizing behavior and all inputs variable, each firm in the industry will be exactly the same as every other firm since it faces exactly the same set of prices, and estimation is impossible. However, should one or more inputs be fixed or should firms vary in their ability in maximizing profit, there will be differences in inputs and outputs between firms. The marginal condition for profit-maximization for the r^{th} input may then be written

(4.15) $x_{ri} = p_o - p_r + a_r' + x_{oi} + v_{ri} \quad (i = 1,\ldots,n)$

where:

x_r = log of the r^{th} input,

x_o = log of output,

p_o = log of output price,

p_r = log of r^{th} input price,

a_r' = log of the r^{th} coefficient,

v_r = the r^{th} disturbance

i = a firm subscript.

The complete set of equations in the model consists of the production function, Equation (4.13), and the k input equations such as Equation (4.15). The problem which now arises is simultaneity bias when estimating Equation (4.13) alone, since u_i is a compound disturbance and not independent of x_{ri}. In this case "least-squares estimates of the production function parameters based on cross-sectional data will be, in general, biased and inconsistent."[22] On the other hand, should the prices in Equation (4.15) be "expectations," it may be shown that direct estimation of Equation (4.13) has the desired properties of being unbiased and consistent.[23] Summarizing, OLS estimation of the production

[22] Kmenta, J. and Joseph, M. E. (1963). "A Monte-Carlo Study of Alternative Estimates of the Cobb-Douglas Production Function," Econometrica, 31, (3), (July), pp. 363-385.

[23] Zellner, A., Kmenta, J. and Dreze, J. (1965). "Specification and Estimation of Cobb-Douglas Production Function Models," Econometrica, 33, pp. 784-795.

function allows the relaxation of the assumptions of profit-maximization and unitary returns to scale, but may introduce simultaneity bias.

To overcome simultaneity bias, Theil suggested a method of indirect least squares (ILS) which was further examined by Hoch and Kmenta.[24] Suppose the first two inputs in the production function are variable and the others exogenously fixed. Subtract x_{oi} $(a_1 + a_2)$ from both sides of Equation (4.13) to obtain

$$(4.16) \quad x_{oi} (1 - a_1 - a_2) = a_o + a_1 (x_{1i} - x_{oi}) + a_2 (x_{2i} - x_{oi}) + a_3 x_{3i} + ,. . ., + a_k x_{ki} + ui$$

Divide both sides by $(1-a_1 - a_2)$ to obtain

$$(4.17) \quad x_{oi} = \frac{a_o}{1-a_1-a_2} + \frac{a_1}{1-a_1-a_2} (x_{1i} - x_{oi}) + \frac{a_2}{1-a_1-a_2} (x_{2i} - x_{oi}) + \frac{1}{1-a_1-a_2} \sum_{r=3}^{k} a_r x_{ri} + \frac{u_i}{1-a_1-a_2}$$

which may be rewritten

$$(4.18) \quad x_{oi} = b_o + b_1 (x_{1i} - x_{oi}) + b_2 (x_{21} - x_{oi}) + b_3 x_{3i} + ,. . ., + b_k x_{ki} + e_i.$$

where:

$$b_o = (a_o/1-a_1 - a_2)$$

$$b_r = (a_r/1 - a_1 - a_2)$$

$$e_i = (u_i/1 - a_1 - a_2)$$

The ILS estimates of the production-function parameters are:

[24] For references see Kmenta, J. (1964). "Some Properties of Alternative Estimates of the Cobb-Douglas Production Function," Econometrica, 32, (1), (January), pp. 183-188.

$\tilde{a}_o = b_o\ (1/1 + b_1 + b_2),$

$\tilde{a}_r = b_r\ (1/1 + b_1 + b_2), \qquad r = 1,2,. . .,k.$

The profit-maximizing conditions for the first two variable or "endogenous" inputs may now be written as:

$$(4.15)' \quad x_{ri} - x_{oi} = p_o - p_r + a_r' + v_{ri}$$

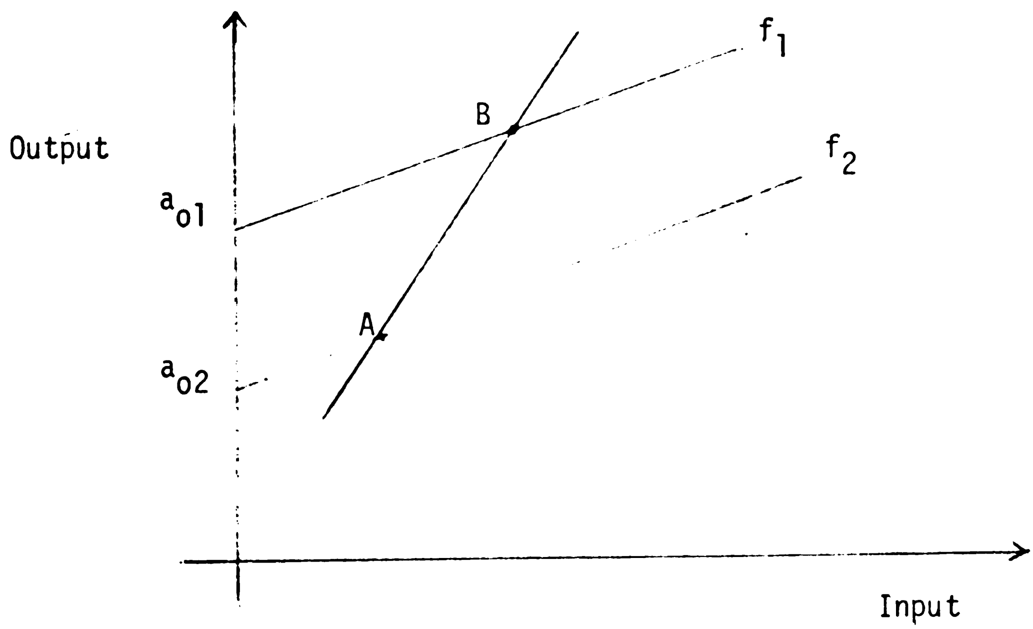
$(x_{ri} - x_{oi})$, unlike x_{ri} in Equation (4.15), is simply a linear function of v_{ri} since all other quantities on the RHS are constants. As long as $E(uv_r) = 0$, ILS gives consistent estimates of the b_r and a_r coefficients. In relation to the present study, land may be treated as exogeneously determined when proportionate shares are in force or, in the short-run, due to previous decisions to plant cane. All other inputs may be considered endogenous to the firm and hence may result in simultaneity bias which leads us to utilize ILS.

There remains one other problem of OLS or ILS which is not shared by Klein's method, that of cross-sectional bias. In both OLS and ILS the "inter" rather than "intra" firm regression is estimated. Should firms differ with respect either to management or other fixed but unmeasured inputs, (such as quality of land), this will be reflected in input-usage. Figure 4.9 demonstrates the situation in the one-input two-firm case.

The inter-firm regression, given the firms at positions A and B, would be AB, whereas the unbiased intra-firm relationships are measured by f_1 and f_2. One way to avert the problem, as suggested by Mundlak in 1961,[25] is to utilize both cross-section and time-series data in an

[25] Mundlak, Y. (1961). "Empirical Production Function Free of Management Bias," Journal of Farm Economics, 41, (1), (February), pp. 44-56.

Figure 4.9 Inter and Intra-Firm Regressions



analysis of covariance framework which essentially gives each firm its own intercept. The model then becomes, in OLS form,

$$(4.19) \quad x_{oit} = a_{oi} + a_1 x_{1it} + , \ldots , + a_k x_{kit} + u_{it}$$

where:

t = year or other period of observation.

Note that the intercept, a_{oi}, is assumed constant for the time-series while inputs and output vary over time. Mundlak's formulation of analysis of covariance and Equation (4.19) are essentially the same, as may be seen in Kmenta's textbook.[26] In the present study, since three years of observations were available in each region, Mundlak's

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[26]Kmenta, J. (1971). Elements of Econometrics (New York: Macmillan), pp. 516-517.

covariance approach was investigated for both OLS and ILS. Finally, each year was given a dummy variable designed to account for weather variation.

In summary, the Cobb-Douglas function was estimated for each region using Klein's method, OLS and ILS. Dummy variables were included to account for individual firm effects and the effect of weather variation.

The Translog Function

The Translog (Transcendental Logarithmic) production function was introduced by Christensen, et al.[27] in 1971. It may be viewed as a generalization of the Cobb-Douglas function with terms both linear and quadratic in the logarithms and which approximates constant elasticity of substitution. It may be written

$$4.20) \quad x_{oi} = a_o + \sum_{r=1}^{k} a_r x_{ri} + \frac{1}{2} \sum_r \sum_j \gamma_{rj} x_{ri} x_{ji} \quad (i = 1, . . ., n)$$

where:

x_o = log of output,

x_r = log of the r^{th} input,

γ_{rj} = a parameter

a_o, a_r = parameters

$\gamma_{rj} = \gamma_{jr}$

i = a firm subscript.

For homogeneity of degree $\sum_{r=1}^{k} a_r$, the restrictions $\sum_{r=1}^{k} \gamma_{rj} = 0$ and $\sum_{j=1}^{k} \gamma_{rj} = 0$ are necessary. In addition, for output to increase

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[27] Christensen, L. R., Jorgenson, D. W. and Lau, L. J. (1971). "Conjugate Duality and the Transcendental Logarithmic Production Function," Econometrica, 39, (4), (July), pp. 255-256.

monotonically with input it is required that the marginal product of each input be positive at all levels of output. The marginal product of the r^{th} input in logarithmic form may be written in general as

$$(4.21)\quad M_r = a_r + \sum_{r=1}^{k} \gamma_{rj} x_j$$

where:

M_r = logarithmic marginal product of the r^{th} input.

For the isoquants to be convex to the origin, the corresponding bordered hessian of first and second derivatives must be negative definite.[28] The partial elasticity of substitution between inputs r and j may be shown to be:

$$(4.22)\quad \sigma_{rj} = | G_{rj} | / | G |$$

where 1 G 1 is the determinant of

$$G = \begin{bmatrix} 0 & M_1 & M_2 & \cdots & M_k \\ M_1 & \gamma_{11}+M_1^2-M_1 & \gamma_{12}+M_1M_2 & \cdots & \gamma_{1k}+M_1M_k \\ M_2 & \gamma_{12}+M_2M_1 & \gamma_{22}+M_2^2-M_2 & \cdots & \gamma_{2k}+M_2M_k \\ M_k & \gamma_{1k}+M_kM_1 & \gamma_{2k}+M_2M_k & \cdots & \gamma_{kk}+M_k^2-M_k \end{bmatrix}$$

and $|G_{rj}|$ is the cofactor G_{rj} in G.

Estimation of the Translog function could be completely analogous to estimation of the Cobb-Douglas function. No report of direct estimation of the production function was found in the literature and when

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[28]For this and the following arguments see Berndt, E. R. and Christensen, L. R. (1973). "The Translog Function and the Substitution of Equipment, Structures and Labor in U.S. Manufacturing 1929-1968," Journal of Econometrics, 1, pp. 81-114.

such an approach was attempted, using OLS, ILS and analysis of covariance procedures, it met with little success. The monotonicity condition was invariably not fulfilled, possibly because of the high degree of multicollinearity which existed.

Klein's method, when applied to the function, leads to the set of k estimating equations.

$$(4.23)\quad M_{ri} = a_r + \sum_{j=1}^{k} \gamma_{rj} x_{ji} + u_{ji} \qquad (r = 1, \ldots, k)$$

where:

u_{ji} = a disturbance term,

i = a subscript for the i^{th} firm

M_r = the cost-share of the r^{th} input under profit-maximizing conditions.

However, in the present context, the assumption of profit-maximization necessary to use Equation (4.23) is inappropriate. When there is a parametric restraint on profit-maximization, such as a proportionate-share on land or past, erroneous investment decisions, the cost-share on the LHS of Equation (4.23) may be rewritten as:

$$(4.24)\quad M_r = \frac{1}{R_r} \frac{P_r}{P_o} \frac{X_{ri}}{X_{oi}}$$

where:

R_r = a parametric restraint and $0 < R_r \leq 1$.[29]

Even if only one input is subject to restraint, the cost-shares of the other inputs will not reflect their logarithmic marginal products.[30]

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[29] Following Hoch's reasoning in Hoch, I. (1958). "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function," Econometrica, 26, (3), (October), pp. 566-578.

[30] Note that Kmenta and Joseph (1963), op. cit. deny this in relation

Although the values of the R's are not normally observable, they may be estimated as the ratio of the (ILS) estimated Cobb-Douglas coefficients to the cost-shares. The Cobb-Douglas coefficients, when correctly estimated, are equal to the profit-maximizing cost-shares and may therefore be directly compared with the actual cost-shares to give the R values. Hence estimation of Equation (4.23) becomes feasible by first correcting the cost-shares and then using them on the LHS of Equation (4.23).

Two restrictions may be imposed on Equation (4.23). Homogeneity requires the restriction $\sum_{j=1}^{k} = 0$, which results in only (k-1) of the set of k equations, of which Equation (4.23) is a member, being independent. Symmetry requires that γ_{rj} be restricted to equal γ_{jr}. Estimation is then usually accomplished with the Iterative Zellner Efficient (IZEF) method on (k-1) of the equations.[31] In the present study, the share of land was deemed the least accurately measured and Zellner Efficient Estimation (ZEF) was used simultaneously on the remaining three equations to give the desired Translog parameters.

The results from estimating the two production functions are given in the third section of this chapter. Before passing to them, the precise relationship between cross-section and time-series for the Cobb-Douglas production function will be elaborated.

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to Klein's estimator. However, $\left(\frac{X_{ri}}{X_{oi}}\right)$ is not independent of X_{ji}, where j is an exogenous input and r is an endogenous input.

[31] Berndt and Christensen, <u>op</u>. <u>cit</u>.

Aggregation, Time and Scale

The approach to aggregation was outlined earlier, but the specific functional form of the "auxiliary time-series" regression, in which the residual is related to time and scale, was not given. The specific forms will now be developed. Note that the procedure was used only with the Cobb-Douglas form since it would have been very complex with the Translog form.

In the empirical work, inputs were divided into land, labor, machinery and fertilizer. The production function, once estimated from cross-sectional data, may be written for the whole sector in year t as:

$$(4.25) \quad \tilde{X}_{ot} = A_o + \hat{\alpha}\log \bar{MC}_t + \hat{\beta}\log \bar{LB}_t + \hat{\delta}\log L\bar{N}D_t + \hat{\gamma}\log F\bar{E}RT_t$$

where:

$\tilde{X}_{ot}$ = estimated regional output,

$\left.\begin{array}{l} \bar{MC} = \text{machinery} \\ \bar{LB} = \text{labor} \\ L\bar{N}D = \text{land} \\ F\bar{E}RT = \text{fertilizer} \end{array}\right\}$ for the average farm,

A_o = a constant,

$\hat{\alpha},\hat{\beta},\hat{\delta},\hat{\gamma}$ = estimated coefficients.

Imposing profit-maximizing conditions, but assuming land to be exogenous, regional output may be made a function of regional land input and the array of input prices, i.e.

$$(4.26) \quad \tilde{x}_{ot} = \frac{1}{1-\mu}\,(C_o + \hat{\delta}\log LND_t - \hat{\alpha}\log PMC_t - \hat{\beta}\log PLB_t - \hat{\gamma}\log PF_t + \mu \log USPQ_t)$$

where:

$\mu = \hat{\alpha} + \hat{\beta} + \hat{\gamma}$,

LND = regional land area,

PMC = the price of machinery,

PLB = the price of labor,

PF = the price of fertilizer,

USPQ = the U.S. sugar price,

C_o = a new constant

t = a time subscript.

Subtracting the estimated output in Equation (4.26) from actual, the time-series residual is defined as:

$$(4.27) \quad e_t^* = x_{ot} - \tilde{x}_{ot}$$

where:

e_t^* = the residual, thus defined.

Since C_o in Equation (4.26) is not known, as it is a newly-defined, aggregate constant, it is convenient to add $\frac{C_o}{1-\mu}$ to both sides of Equation (4.27) to obtain

$$(4.28) \quad e_t^* + \left(\frac{C_o}{1-\mu}\right) = x_{ot} - \tilde{x}_{ot} + \left(\frac{C_o}{1-\mu}\right)$$

Choosing a linear form for the relationship between the LHS of Equation (4.28) and time and output, one obtains:

$$(4.29) \quad e_t^* + \left(\frac{C_o}{1-\mu}\right) = W_1 + W_2 X_{ot} + W_3 T + e_t$$

where:

X_{ot} = output,

$W_1 W_2, W_3$ = parameters

e = a disturbance term,

t = a time subscript.

Combining Equation (4.29) when estimated and (4.26) leads to the compound formulation for time-series projection,

$$(4.30) \quad x_{ot} = \frac{1}{1-\mu} (\hat{\delta}\log LND_t - \hat{\alpha}\log PMC_t - \hat{\beta}\log PLB_t - \hat{\gamma}\log PF_t + \mu\log USPQ_t) + \hat{W}_1 + \hat{W}_2 X_{ot} + \hat{W}_3 T,$$

Equation (4.30) may be rewritten, with both output-measures on the LHS, where output x_{ot} is now simultaneously determined with its log, x_{ot}, hence is denoted $\tilde{\tilde{x}}_{ot}$:

$$(4.31) \quad \tilde{\tilde{x}}_{ot} - \hat{W}_2 \tilde{\tilde{X}}_{ot} = \frac{1}{1-\mu} (\hat{\delta}\log LND_t - \hat{\alpha}\log PMC_t - \hat{\beta}\log PLB_t - \hat{\gamma}\log PF_t + \mu\log USPQ_t) + \hat{W}_1 + \hat{W}_3 T.$$

To explain the behavior of this "compound" function and to justify the choice of a linear, nonlogarithmic auxiliary equation, Equation (4.29), it is simplest to return to the production function from which Equation (4.31) may be considered to be derived. This function is the generalized Cobb-Douglas of Zellner and Revankar.[32] Equation (4.32) demonstrates this function, with time incorporated in the Solow formulation,

$$(4.32) \quad x_{ot} - W_2 X_{ot} = \log A + \alpha\log MC_t + \beta\log LB_t + \gamma\log FERT_t + \delta\log LND_t + W_3 T$$

[32] Zellner A. and Revankar, N. S. (1969). "Generalized Production Functions," Review of Economic Studies, 36, (2), (April), pp. 241-250.

where:

A = a constant,

MC = machinery,

LB = labor,

$FERT$ = fertilizer

LND = land.

The returns to scale of this function are given by the "returns to scale function"

$$(4.33) \quad r(X_o) = \frac{r}{1-W_2X_o}$$

where:

$r(X_o)$ = returns to scale,

r = a constant, (the returns to scale at zero output),

X_o = output.

The expectation is that, given $r > 0$, W_2 will be negative, which implies that returns to scale fall from r at X_o equals zero to zero as X_o rises to infinity.

To derive our "compound" formulation Equation (4.31) from the production function Equation (4.32), the marginal conditions are:

$$(4.34) \quad \frac{\partial X_o}{\partial X_r} = \frac{a_r X_o e^{W_2X_o}}{X_r}$$

where:

X_r = one of the three variable inputs,

a_r = the input coefficient.

Profit maximizing behavior would imply, by comparison,

$$(4.35) \quad \frac{\partial X_o}{\partial X_r} = \frac{a_r X_o}{X_r}$$

The marginal condition Equation (4.35) may be thought of as "approximate" maximizing behavior, the degree of approximation depending on the magnitude of W_2 and X_o.

In the Zellner and Revankar formulation, all input elasticities vary similarly with scale. For example, the input elasticity for land at output X_o is $\frac{\delta}{1-W_2X_o}$, where δ is the land coefficient at zero output. This leads to the profit-maximizing quantity of land being written,

$$(4.36) \quad LND^* = \frac{\left(\frac{\delta}{(1-W_2X_o^*)}\right) \cdot X_o^* \cdot P_o}{PLND}$$

where:

$*$ = a maximizing value,

LND = land

X_o = output,

P_o = the price of sugar

PLND = the price of land.

Because X_o^* depends on LND*, in making projections Equation (4.36) was used iteratively in order to determine the desired quantity of land.

Summarizing this section, aggregation, time and scale are all accounted for by the estimation of the auxiliary time-series regression Equation (4.29). Approximate maximizing behavior is assumed for all inputs except land, but in the projections land allocation may also be adjusted to its maximizing level. Returns to scale are expected to decrease continuously with output in the formulation used, from a maximum of the cross-sectional returns to scale.

Results From Estimation

Production Functions

The results from estimating the Cobb-Douglas function under different sets of assumptions for the four regions will be presented first. Thereafter the Translog results will be presented and discussed.

Cobb-Douglas Results

The first approach to estimation was Klein's method in which the geometric mean cost-share of an input is equated with the coefficient of that input. Table 4.1 lists the results by region. It should be noted that the share of land has been measured as that necessary to fulfill the constraint that the shares sum to unity. A more direct approach was not possible since the cost of land-ownership or rental was very poorly recorded in the surveys. The results are similar in all regions for fertilizer and machinery, at approximately the 0.10 and 0.35 levels, respectively. However, labor as a proportion of total costs rises from 23 percent in Florida to 35 percent in Louisiana, to 47 percent in Puerto Rico and to 56 percent in Hawaii. The share of land, which appears low in all regions due to the bias from the assumption of profit-maximization necessary to this method, follows a converse trend across regions from a high of 28 percent for Florida to a low of 10 percent for Hawaii.

Table 4.2, which lists the OLS results, both with, (called "covariance"), and without dummy variables for each firm, makes an interesting comparison. Firstly, the coefficient of land, as expected, is much larger than in Table 4.1 in all instances. It is particularly large for Florida and Louisiana, which reflects the very large MVP

Table 4.1. Results of Klein's Method

Region	Coefficient				
	Land	Fertilizer	Machinery	Labor	N
Louisiana	0.1899	0.0970	0.3594	0.3537	135
Florida	0.2800	0.0845	0.4059	0.2296	80
Hawaii	0.0088	0.1047	0.3283	0.5582	69
Puerto Rico	0.0641	0.0986	0.3629	0.4744	99

of land when that input is restricted by proportionate shares. Secondly, as the generally low t-values reflect, the estimates are all relatively inefficient and in some cases bear the wrong sign. On this score there is little to choose between the standard and covariance estimates. Two explanations are possible, namely 1) the high degree of collinearity which existed in all cases between land and all other inputs and 2) the simultaneity problem for inputs other than land. Only the covariance estimate for Puerto Rico and the standard estimates for Puerto Rico and Hawaii approach acceptability on the basis of having coefficients which are statistically significantly different from zero and of the expected magnitude and sign. Note also that the covariance model resulted in an increase in returns to scale for Florida and Puerto Rico and a decrease for the other two regions. This dichotomy will appear again later. In all cases the covariance model led to an increase in the land coefficient, suggesting that omitted variables are related to land, e.g., land quality.

Table 4.3 presents the results of ILS estimation in both standard and covariance forms. Because ILS involves a nonlinear transformation, the t-values listed in the table refer to the originally estimated

Table 4.2. Results of OLS

Region	Coefficient									
	Constant	Land	Fertilizer	Machinery	Labor	D_1	D_2	r	$\bar{R}^2$	N
Standard Model										
Louisiana	1.2625	0.7390 (8.928)	0.1272 (3.093)	0.0455 (0.704)	0.0331 (0.619)	---	---	0.945	0.973	135
Florida	3.6220	0.7090 (4.220)	-0.1764 (1.740)	0.2645 (1.611)	0.1148 (2.870)	-0.2238 (0.143)	0.0114	0.912	0.961	80
Hawaii	-2.2497	0.3013 (3.979)	0.0223 (0.317)	0.2995 (2.567)	0.4083 (4.609)	---	---	1.0314	0.909	69
Puerto Rico	0.5002	0.3866 (6.264)	-0.0927 (3.778)	0.2514 (6.282)	0.4779 (9.642)	-0.1252 (3.387)	-0.1447 (3.603)	1.0232	0.986	99
Covariance Model*										
Louisiana	3.0819	0.7826 (5.449)	-0.0207 (0.412)	-0.1311 (1.659)	-0.0912 (0.634)	---	---	0.539	0.987	135
Florida	3.0826	0.9006 (6.595)	-0.1587 (1.895)	0.3377 (1.717)	0.0456 (0.538)	-0.2345 (6.650)	0.0363 (0.990)	1.034	0.993	80
Hawaii	7.6769	0.4314 (3.766)	-0.0447 (0.704)	-0.1206 (1.036)	0.1131 (0.911)	0.0338 (2.626)	0.1131 (0.264)	0.379	0.995	69
Puerto Rico	-0.9371	0.5223 (4.649)	0.0067 (0.182)	0.1305 (1.374)	0.5653 (6.742)	-0.1312 (3.842)	-0.0957 (2.047)	1.225	0.991	99

NOTES: r = returns to scale
D_1 = dummy variable for first observed year
D_2 = dummy variable for second observed year

*The constant is the mean for all firms, since each firm had its own intercept. The standard model is described in Equation (4.13). The covariance model is described in Equation (4.19).

Table 4.3. Results of ILS

Region	Coefficient									
	Constant	Land	Fertilizer	Machinery	Labor	D_1	D_2	r	$\bar{R}^2$	N
				Standard Model						
Louisiana	1.3582	0.6643 (78.168)	-0.0472 (2.022)	0.2038 (6.462)	0.1612 (6.089)	---	---	0.945	0.972	135
Florida[1]	3.8773	0.5567 (7.387)	0.2819 (6.388)	0.0924 (1.130)	0.0070 (0.183)	-0.1140 (2.739)	0.0344 (0.820)	0.938	0.978	80
Hawaii[1]	1.0956	0.1463 (3.945)	0.2008 (8.570)	0.3823 (10.590)	0.1879 (4.261)	---	---	0.917	0.942	69
Puerto Rico[2]	0.3541	0.3052 (6.202)	0.1114 (6.385)	0.2216 (2.334)	0.3806 (9.673)	0.1070 (3.677)	0.1191 (3.750)	1.019	0.989	99
				Covariance Model						
Louisiana	2.6039	0.4522 (22.164)	0.0299 (1.923)	0.0844 (3.591)	0.2832 (8.346)	---	---	0.850	0.996	135
Florida[1]	0.5014	0.4760 (8.637)	0.1753 (5.499)	0.3179 (3.838)	0.1347 (3.882)	-0.1002 (5.694)	0.0323 (1.944)	1.1039	0.997	80
Hawaii	7.1375	0.1516 (2.558)	0.0004 (0.013)	0.1573 (3.017)	0.1580 (2.818)	0.0042 (0.014)	0.0268 (2.828)	0.474	0.997	69
Puerto Rico[2]	0.8891	0.4543 (4.402)	0.0645 (1.994)	0.1974 (2.363)	0.4798 (6.041)	0.1312 (4.365)	0.0975 (2.324)	1.196	0.988	99

[1] Machinery exogenous as well as land.

[2] Only fertilizer endogenous.

NOTE: Since the ILS estimates are nonlinear transformations of the actually estimated equations, the standard errors are difficult to compute. The above t-values refer to the coefficients of the originally estimated equations and not to the ILS coefficients below which they are found.

Also note, that the standard ILS estimator given earlier under Equation (4.18) proved inappropriate in some cases. The estimator was $a_r = b_r\ (1/1 + b_1 + b_2)$. Whenever b_1 or b_2 was negative, the appropriate estimator was found to be $a_r = C_r\ (1/1 - C_1 - C_2)$ where C_r is the absolute value of b_r, $r = 1, \ldots, K$. The reasons for this situation remain unclear.

coefficients and not the ILS coefficients; their values are, however, still of statistical interest. In some regions all variables other than land have been assumed endogenous whereas in other regions only some of the other variables were thus treated (see footnotes). The results in the table reflect a subjective choice of the specification with respect to which variables should be exogenous and which endogenous.

The first noteworthy result is the reduction in size of the land coefficient, as expected. It now lies somewhere between the value from OLS and that from the Klein method. Secondly, the t-values show that ILS led to much more efficient estimates. The increase in efficiency is due to the elimination of simultaneity-bias and also, to some extent, to a reduction in multicollinearity. Thirdly, the results of the covariance model, except for Hawaii, are now more convincing than those for the standard model. The reason for the remarkably low returns to scale in the covariance model for Hawaii is not clear. As with OLS, the covariance approach reduced estimated returns to scale in Louisiana and Hawaii but increased estimated returns to scale in Puerto Rico and Florida.

Summarizing the Cobb-Douglas results, as expected the use of ILS with the inclusion of a dummy variable for each firm (covariance procedure) yielded the most credible results in most cases. Klein's method gave a downward bias to the land coefficient and OLS gave an upward bias to that coefficient. The ILS results (with dummy variables except in the case of Hawaii), were used in synthesizing the aggregate response function. Before returning to that "synthesis," the Translog results will be presented and ease of input substitution determined.

Translog Results

Table 4.4 presents the results of ZEF estimation with the "corrected" cost-share as dependent variable and the individual input levels as independent variables.

The results in Table 4.4 are not by themselves very interesting except to note that the parameters were more efficiently estimated for Hawaii and Puerto Rico than for Louisiana and Florida. The explanation may lie in the proportionate shares existing in the latter two regions. The fact that the values were often negative is of no consequence: it is not necessary for monotonicity of the function, for example, which depends on the cost share always being positive.

The γ_{rj} parameters from Table 4.4 were inverted as shown earlier in Equation (4.22) to give estimates of the elasticity of substitution between pairs of inputs. The results of this inversion are given in Table 4.5.

The simplest interpretation of the elasticities of substitution in Table 4.5 is to note that positive elasticity denotes substitutes and negative elasticity complements. The most likely substitutes, a priori, are labor and machinery and this is confirmed by the estimated value of σ_{CL} for all regions. Similarly, though surprisingly, fertilizer and machinery are estimated to be substitutes in all regions. Considering the other elasticities in turn, fertilizer and labor are estimated to be substitutes in Louisiana and Puerto Rico, but complements in Florida and Hawaii; this result could be associated with the higher wage rates in the latter two regions, as demonstrated schematically in Figure 4.10. At price ratio P_2, which gives X_1 a high price relative to X_2, X_1 and X_2 are on the border of being complements, while

Table 4.4. ZEF Estimated Parameters of the Translog Function

Parameter	Region			
	Louisiana	Florida	Hawaii	Puerto Rico
αF	-0.0541	-0.0560	-0.1706	0.1384
αC	-0.2635	-0.4923	-0.0596	0.0740
αL	-1.0681	-0.2530	0.9598	-0.0279
αD[1]	---	---	---	---
γFF	0.0336 (41.481)	0.1454 (11.515)	0.1523 (13.941)	0.0656 (18.395)
γFC	-0.0020 (1.823)	-0.0388 (1.334)	-0.0387 (5.470)	-0.0201 (9.074)
γFL	-0.0023 (1.176)	-0.0153 (1.717)	-0.0116 (4.253)	-0.0298 (8.676)
γFD	-0.0293 (10.458)	-0.0913 (1.943)	-0.1019 (6.572)	-0.0157 (2.665)
γCO	0.0861 (32.578)	0.2062 (2.672)	0.2185 (25.322)	0.1459 (48.765)
γOL	-0.0056 (1.195)	-0.0171 (0.795)	-0.0987 (27.693)	-0.0971 (26.881)
γCD	-0.0784 (11.744)	-0.1504 (1.204)	-0.0810 (6.104)	-0.0287 (5.378)
γLL	0.3152 (15.662)	0.1218 (14.707)	0.1227 (61.308)	0.1920 (29.891)
γLD	-0.3073 (12.089)	-0.9894 (2.529)	-0.0123 (2.777)	-0.0651 (7.208)
γDD	0.4149[2] (11.892)[2]	0.3311[2] (1.598)[2]	0.1952[2] (5.878)[2]	0.1094[2] (5.405)[2]

Where the simultaneously estimated equations were:

$$M_F = \alpha_F + \gamma_{FF} \log F + \gamma_{FC} \log C + \gamma_{FL} \log L + \gamma_{FD} \log D + e_1$$

$$M_C = \alpha_C + \gamma_{CF} \log F + \gamma_{CC} \log C + \gamma_{CC} \log L + \gamma_{CD} \log D + e_2$$

$$M_L = \alpha_L + \gamma_{LF} \log F + \gamma_{LC} \log C + \gamma_{LL} \log L + \gamma_{LD} \log D + e_3$$

with restrictions $\gamma_{rj} = \gamma_{rj}$ and $\sum_j \gamma_{rj} = 0$ and where:

M_j = the cost-share of the j^{th} input

α_j = a constant for the j^{th} input,

γ_{rj} = a parameter,

F = fertilizer,

C = machinery,

L = labor,

e_j = an error term.

[1]Not calculable unless the restriction $\sum_i X_i = 1$ is imposed.

[2]This value is based on the assumption of zero covariance for γ_{FD}, γ_{MD} and γ_{LD}.

Table 4.5. Estimated Partial Elasticities of Substitution and Own-Price Elasticities of Demand

Parameter	Region			
	Louisiana	Florida	Hawaii	Puerto Rico
σFF	-114.9	69.1	-6.9	-25.5
σFC	97.6	2.8	9.1	6.8
σFL	53.6	-58.2	-6.6	1.8
σFD	2.2	-10.8	-5.8	2.0
σCC	- 96.9	-34.1	-12.4	-51.7
σCL	16.7	51.1	16.3	28.9
σCD	1.2	7.3	-0.9	-1.0
σLL	-6.7	-10.8	-28.8	-20.7
σLD	-2.5	-9.6	3.6	4.1
σDD	1.2	1.8	5.9	-5.1
ηFF	-4.0	+11.0	-1.6	-2.8
ηCC	-9.6	-9.8	-5.1	-11.2
ηLL	-2.1	-1.3	-5.8	-7.7
ηDD	+0.6	+0.8	+1.0	-1.5

where: σ_{kr} = the elasticity of substitution between inputs k and r

η_{rr} = the own-price elasticity of demand for input r

F = fertilizer

C = machinery

L = labor

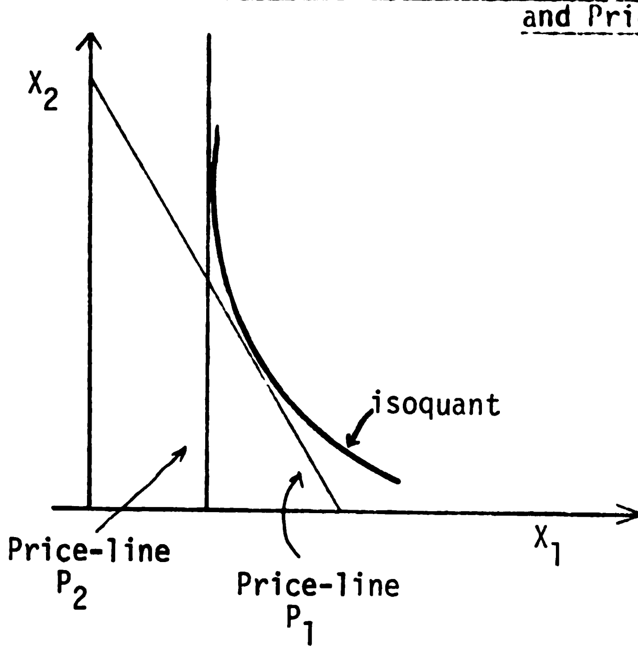
D = land

$\sigma_{kr} > 0$ implies that k and γ are substitutes.

$\sigma_{kr} < 0$ implies that k and γ are complements.

at price ratio P_1 they are substitutes. Such an interpretation implies either that the production function is different across regions or that it has nonconstant elasticity of substitution. Similar results were found, as shown in Table 4.5, for fertilizer and land, being complements in Florida and Hawaii but substitutes in Louisiana and Puerto Rico. Machinery and land were substitutes in Louisiana and Florida but complements in Hawaii and Puerto Rico, whereas exactly the converse result was found with labor and land; there seems to be no obvious reason for this result, although it may be connected with the proportionate shares in force on land allocation on the mainland.

Figure (4.10) Elasticity of Substitution and Price



The <u>own</u> elasticities of substitution are more easily interpreted by converting them to own-price elasticities of demand via the identity[33]

(4.37) $\eta_{rk} = \sigma_{kr} \cdot M_k$

where:

η = price elasticity,

σ = elasticity of substitution,

M = cost-share,

r,k = input subscripts.

These price elasticities are also given in Table 4.5. The expectation was that all such elasticities, except that for land, would be negative, implying lower quantity demanded at higher prices and this was confirmed by the results except in the case of fertilizer in Florida. The case of Florida is disturbing, but further inquiry produced two possible explanations namely 1) the negative correlation between fertilizer use and the quality of land in Florida and 2), the interaction between nitrogen and phosphorus in Florida's soil which induces a phosphorus deficiency, hence lower yields, as more nitrogenous fertilizer is added. Disregarding the result for fertilizer in Florida and the land elasticities for the present, the input elasticities are most similar for machinery across regions, ranging from -5.1 in Hawaii to-11.2 in Puerto Rico. The most interesting elasticities are those for labor, which are much lower for Louisiana and Florida, (-2.1 and -1.3, respectively), than for Hawaii

[33]See Binswanger, H. (1974). "A Cost-Function Approach to the Measurement of Elasticities of Factor Demand and Substitution," <u>American Journal of Agricultural Economics</u>, <u>56</u>, (?), (May), pp. 377-386.

and Puerto Rico, (-5.8 and -7.7, respectively). This suggests that the demand for labor is more inelastic on the mainland than in the off-shore regions and possible explanations would be the unionization of labor in Hawaii, which has resulted in high wages but lower employment, and in Puerto Rico the importance of labor in the production system (45 percent of costs) for which alternative employment on the mainland was, at the time of the survey, increasingly attractive.

The positive own-price elasticities for land in all regions except Puerto Rico were no surprise; they reflect the fixity of land in its present use. More fully, the price of land in the survey years was not determined by its alternative use at the margin but by its endogenously determined MVP in its current use. In considering how much cane to produce, the price of land was not relevant to the producers but only determined as an ex-post identity. In Puerto Rico, by contrast, the price of land appears to be exogenous and further evidence for this view is rapid decline in Puerto Rico's industry suggesting that the MVP of land in alternative uses is higher than in sugar production.

Some final comments on the Translog results are as follows. In general, the estimated price and substitution elasticities are particularly large and the standard errors, while not computable, may also be relatively large for Louisiana and Florida since they were large for the production-function parameters in these two regions. However, elasticities measured at the geometric mean of a cross-section of firms may be expected to be large relative to such elasticities from an aggregate time-series.

A cross-section of firms demonstrates potential elasticities at the micro-level whereas an aggregate time-series demonstrates ex-post elasticities at the macro level. Firms cannot rapidly adjust from one input mix to another, because there are indivisibility problems with different technologies, i.e. a certain scale may be necessary for a certain technology. Family farms, such as many in Louisiana, may be unwilling to bear the risks involved in adjustment to a larger scale. Just as there is an upward bias in aggregated supply response based on individual firms,[34] so elasticities measured at the aggregate level may be expected to be smaller than those measured in a cross-section of firms.

No simple conclusion emerges from Table 4.5 concerning a division of technology into mechanical, which acts exclusively as a labor substitute, and biological, which acts exclusively as a land substitute, and this result confirms that of Binswanger.[35] While labor and machinery are substitutes, so also are fertilizer and machinery. Similarly fertilizer was in some regions a complement to land and in others a substitute. Binswanger's finding, that for U.S. agriculture fertilizer and labor are complements, is neither confirmed nor denied by this study. When the price of labor is high relative to fertilizer, as in Florida and Hawaii, the two may be complements but at lower wage rates they may be substitutes.[36]

The two inputs for which the micro elasticities may most closely reflect their macro counterparts are those for fertilizer and labor,

---

[34]For a review of sources of aggregation bias, see Egbert, A. C. and Kim, H. M. (1975). "Analysis of Aggregation Errors in L.P. Models," American Journal of Agricultural Economics, 57, (2), (May), pp. 292-301.

[35]Ibid.

[36]This leaves entirely open the question of whether fertilizer and labor are complements or substitutes in less developed countries, c.f. Binswanger.

since indivisibilities pose less of a problem than with machinery and adjustment, except in Louisiana, is likely to be relatively complete at the micro-level. The U.S. Sugar Act prescribed minimum wages for Louisiana and Florida, while in Puerto Rico the government and in Hawaii the unions maintain fixed relationships between the price of sugar and the wage rate. Since in all regions machinery and labor are clearly substitutes, the result of an increased wage rate is greater mechanization and less employment. This is particularly true for Hawaii and Puerto Rico, where the estimated labor price elasticities are -5.8 and -7.7, respectively. For total wages to rise when the wage rate rises, a price elasticity of more than -1 is required (i.e., nearer zero) and this condition is not fulfilled in any region. Policy in Puerto Rico has been directed to wage supplements to encourage employment and, given the findings of this study, such a policy should be effective.

Auxiliary Time-Series Regressions

As earlier explained, these were designed to relate a computed aggregate residual to time (technology), output (scale) and a constant of aggregation. The residual was computed from the Cobb-Douglas estimates, assuming profit-maximizing behavior for all inputs except land. Twenty-two years of aggregate data were used, from 1950 to 1973, excluding the years 1962 and 1964 in which large adjustments took place and which will later be used as "normalizing" years for projecting investment behavior. Table 4.6 lists the results.

The results confirmed a priori expectations for Florida and Puerto Rico, but not for Louisiana and Hawaii. While the residual was positively related to time, except in the case of Florida, when regressed

Table 4.6. Results of Auxiliary Time-Series Analysis

Region	Coefficient					
	Constant	Time	Output	$\bar{R}^2$	DW	N
Louisiana	-5.22599	0.04075 (8.557)	---	0.775	1.417	22
	-5.00871	0.02397 (6.045)	0.00153 (6.079)	0.920	0.793	22
Florida	1.96932	-0.00774 (1.219)	---	0.023	0.865	22
	0.21445	0.02696 (1.881)	-0.00101 (2.628)	0.246	1.622	22
Hawaii	1.16341	0.05264 (14.077)	---	0.904	1.587	22
	0.76222	0.04576 (11.784)	0.00075 (3.030)	0.932	1.604	22
Puerto Rico	-7.58525	0.09736 (16.300)	---	0.927	0.730	22
	-4.53536	0.05937 (3.707)	-0.00084 (2.514)	0.942	1.322	22

on that variable alone, it was only negatively related to output in the cases of Florida and Puerto Rico. A negative output coefficient implies diminishing returns to scale, while a positive coefficient denotes the opposite. With increasing returns to scale there can be no equilibrium in a sector with more than one firm and this is clearly a spurious result in the present context. The cause of this unexpected result was probably the very low variation in output in Louisiana and Hawaii in the last two decades which may be contrasted with the considerable expansion in Florida and the large contraction in Puerto Rico. Given the low variation in output in Louisiana and Hawaii and the collinearity of output with time in these regions, the failure to distinguish diminishing returns to scale is not surprising.[35]

Because diminishing returns were necessary to the method of projection to be used, such returns were subjectively imposed for Louisiana and Hawaii. Taking the coefficients for time from Table 4.6 the following subjective auxiliary equations were constructed:

Louisiana: $e_t^* = -4.50 + 0.04075T - 0.0015\ X_{ot}$

Hawaii: $e_t^* = 4.83 + 0.05264T - 0.3330\ X_{ot}$

where:

e_t^* = the computed residual,

T = year (e.g. 1966 = 66),

X_o = output in 1,000 tons,

t = a time subscript.

For Florida and Puerto Rico the results from Table 4.6 were used directly in the projection of supply.

Projections of Supply

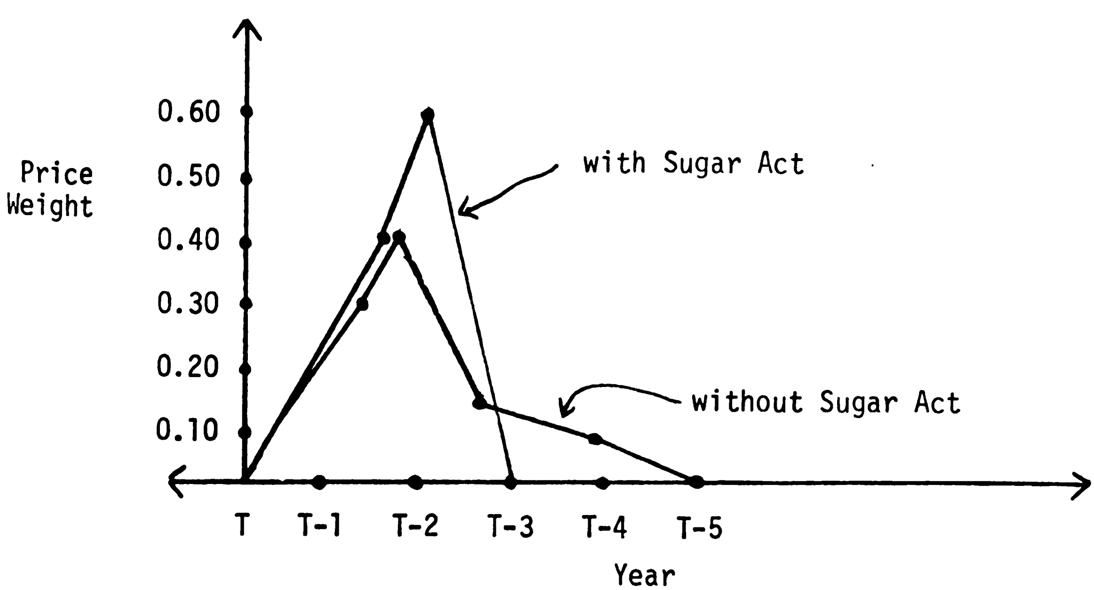
The projections which follow are designed to examine the probable growth or decline of the U.S. cane sugar industry after 1974 under an array of different prices. What would have occurred without the limitations imposed on average under the U.S. Sugar Act is also examined. Several further assumptions are necessary before supply may be projected for each region. Those assumptions which are specific to a particular region will be presented later, while assumptions of a general nature are first reviewed.

---

[37]From the DW statistics in Table 4.6 one deduces that most of the regressions were autocorrelated. Orcutt transformations on the equations did not greatly change the coefficients, however, and autocorrelation is no problem for "predictive" equations.

The first assumptions concern lags and prices, beginning with the lag between the decision to expand the area in cane and the harvesting of the first of that new cane. This lag is likely to be shorter when there is a Sugar Act than when there is none, since the Act reduces inherent risk in investment by guaranteeing at least a minimum price for cane. The biological delay is a minimum of 13 months on the mainland and ranges to 20 months in Hawaii. Because the timing of a price signal in relation to the crop year may be important and there is also a delay in expanding mill-capacity, if necessary, the same lag systems have been used in all regions. Figure 4.11 presents the price weights diagrammatically.

Figure (4.11) Price Weights



The lag is assumed to be of the "inverted-V" kind with the peak occurring in year t-2. With a Sugar Act the V is assumed to be steeper than without such an Act. Formally the lags may be written:

With Act: $P_t^* = 0.40\ P_{t-1} + 0.60\ P_{t-2}$,

Without Act: $P_t^* = 0.30\ P_{t-1} + 0.45\ P_{t-2} + 0.15\ P_{t-3} + 0.10\ P_{t-4}$,

where:

P_t^* = expected price at time t,

P_{t1}, P_{t-1} = actual sugar prices in New York.

The above weighting system is only used to determine acreage in any year. The yield per acre in a particular year is assumed to be a function of the current and last year's prices which are equally weighted. That is:

$$USPQ_t = 0.50\ P_t + 0.50\ P_{t-1}$$

where:

$USPQ_t$ = the yield-determining expected price.

When the Sugar Act was in operation and proportionate share restrictions were removed in the mainland areas, there was a reluctance to expand acreage because of the fear of the reimposition of shares. This "overhang" effect of the shares has been included in the current model by constraining any expansion of land area to the previous maximum if shares were in force in two out of the last four years.

One final price assumption has been made with respect to 1974. In that year the domestic sugar price on the New York market averaged 29.50 cents per lb., but that average disguises a rise from 12.63 cents per lb. in January to 57.30 cents per lb. in November. Since the peak occurred so late in the year, it could not affect current inputs in the industry in the year 1974. In the model, as explained, yield depends on the average price of the current and past years. For 1974 such an average would be 19.90 cents. Because price rose so rapidly in 1974,

producers' expectations were alwyas much lower than the actual price and an expected price of 14.0 cents per lb. has been used in the calculation of yield for this year.

The second set of general assumptions concerns <u>contraction, expansion and the price of land</u>. 1964 saw a general expansion in cane area and the price of land has been normalized so that its price was equal to its MVP in that year. In Puerto Rico, price was assumed to exceed MVP in that year by an amount which led to the observed rate of contraction of land area in that year, as will be later explained. The prices of land per acre thus found were \$140.00 in Puerto Rico, \$112.25 in Florida, \$62.72 in Louisiana and \$49.20 in Hawaii. For years other than 1964, the price of land was inflated parallel to the U.S.D.A. index of input prices except 1) in Hawaii where the abosolute limitation on land areas led to the use of the equation

$$PLND = \text{the larger of} \begin{cases} (0.004)(LND)^2\ (49.20) \\ 40.00 \end{cases}$$

where:

PLND = the price of land

LND = the thousand acres harvested,

and 2) in Puerto Rico where the price of land was inflated parallel to the wage rate in the sugar industry.

Given the price of land in any year and no restrictions on acreage, the desired area in cane was that at which the price of land was equal to the MVP of land in cane production.[38] Should the desired area exceed

[38]The equation was (4.36): $LND^* = \left\{ \frac{\delta}{1 - W_2 X^*_o} \cdot X^*_o \cdot P_o \right\} / PLND$

the existing area, expansion occurred and, should desired be less than actual, contraction occurred if the ex post MVP of land using this year's price of sugar was less than the price of land.[39] The rate of contraction was constrained, because of the perennial nature of cane, to be

$$LND_t = (3\ LND_{t-1} + LND^*_t)/4$$

in all areas except Puerto Rico, and

$$LND_t = (8\ LND_{t-1} + LND^*_t)/9$$

in Puerto Rico, where LND is land area, LND* is desired land area, and t is a time subscript.

The final assumptions concern the <u>starting date and prices for projections.</u> In tracking past production and in projecting what supply would have been without a Sugar Act at the existing prices, the starting year of 1955 was chosen. Projections for the future begin with the 1975 crop, although the "actual" output of the 1974 crop is itself a USDA estimate. Projections have been made to 1985 under the assumption that only the price of sugar changes and not the input prices; i.e. projections are made at real 1974 prices. An alternative would have been to project inflation in prices for each input from past experience, but that would be equally subjective. Projections have been made for the 4 cents per lb. to 18 cents per lb. (domestic, New York) price-range at 1974 prices. The reader is severely cautioned to <u>deflate</u> the sugar price

---

where: * = a maximizing value,
LND = output,
P_o = the price of sugar,
PLND = the price of land.

[39]0.9 times the price of land in Hawaii.

of his conception at some future date to the 1974 level in interpreting these results.

Louisiana

The compound equation utilized may be written:

$$x_{ot} + 0.0015\ X_o = -0.1782 + 0.7505\ \mathrm{lnd}_t - 0.1401\ \mathrm{pmc}_t$$
$$-0.4700\ \mathrm{plb}_t - 0.0496\ \mathrm{pf}_t$$
$$+0.6597\ \log\ (0.5\ P_{ot} + 0.5\ P_{ot-1})$$
$$+0.04075T,$$

where:

x_o = log of sugar (thousand short tons raw value),

X_0 = thousand short sugar tons raw value,

lnd = log of thousand acres,

pmc = log of USDA machinery price index,

plb = log of hourly sugar wage in dollars,

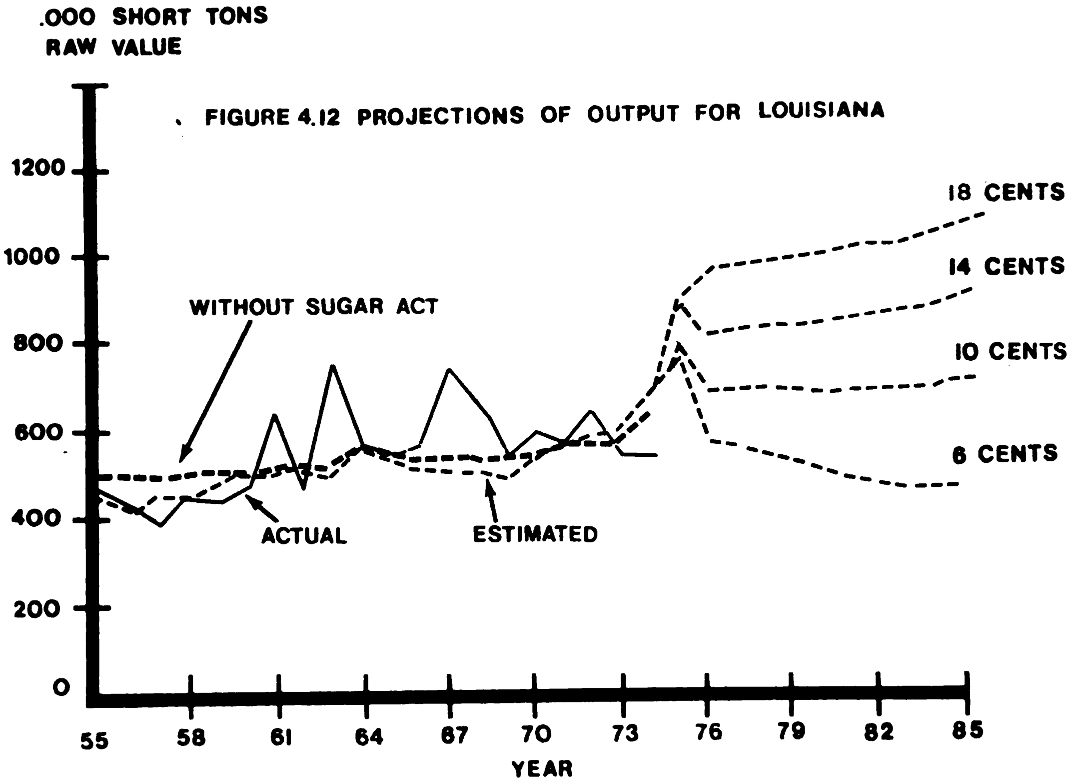
pf = log of USDA fertilizer price index,

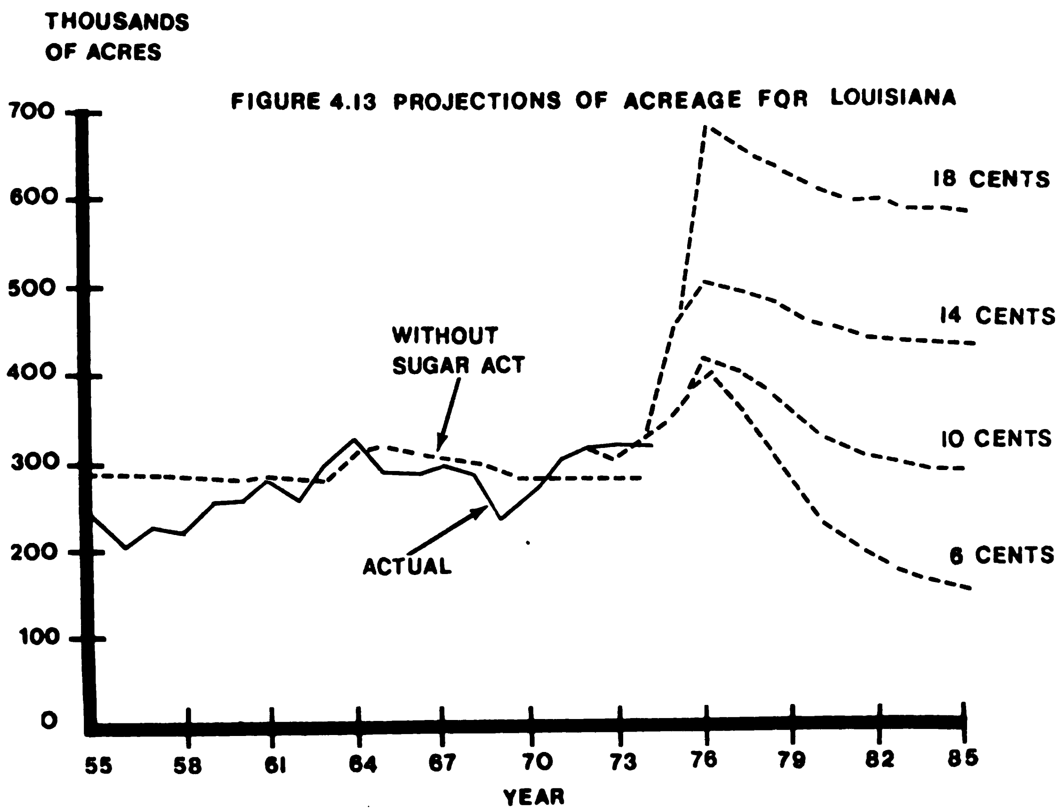
P_{ot} = New York domestic sugar price in cents per lb.,

T = year (e.g. 1966 = 66)

t = a time subscript.

Figures 4.12 and 4.13 present the results for output and acreage harvested respectively. Both in terms of output and acreage the model seems to be a reasonable fit. The large fluctuations in actual output reflect weather variation rather than changes in yield or acreage. When yield equations were fitted directly to the cross-section data, dummy variables for individual years accounted for 29 percent of the total


.000 SHORT TONS
RAW VALUE
FIGURE 4.12 PROJECTIONS OF OUTPUT FOR LOUISIANA
1200
1000
800
600
400
200
0
18 CENTS
14 CENTS
10 CENTS
6 CENTS
WITHOUT SUGAR ACT
ACTUAL
ESTIMATED
55
58
61
64
67
70
73
76
79
82
85
YEAR


THOUSANDS
OF ACRES
FIGURE 4.13 PROJECTIONS OF ACREAGE FOR LOUISIANA
700
600
500
400
300
200
100
0
18 CENTS
14 CENTS
10 CENTS
6 CENTS
WITHOUT
SUGAR ACT
ACTUAL
55
58
61
64
67
70
73
76
79
82
85
YEAR

variation for 1969-71.[40] Similarly, attempts at direct time-series estimation of yield had weather and time as the only significant influences.

Perhaps of greatest interest from a historical viewpoint are the estimated output and acreage in the absence of a Sugar Act. While in the late 1950's there would have been approximately a 10-20 percent increase in output and acreage, from 1961 onward there would have been little difference in output in the absence of a Sugar Act as compared with actual output. This suggests that proportionate shares in Louisiana were not highly limiting but reflected producers' intentions relatively closely.

The projections show an expansion to 760,000 tons and at least 350,000 acres at all prices above 5 cents per lb. in 1975, following the high prices of 1974. Thereafter, at prices above 10 cents, the higher levels of output would be maintained, while at prices less than 10 cents there would be a subsequent decline in acreage which would only be partially compensated by increases in yield over time. Note however that at 14 cents or less the peak output would occur in 1975 while peak acreage would not be found until the following year, 1976. This again reflects the extraordinarily high price in 1974. By 1985 projected outputs are 472,000 tons at 6 cents, 729,000 tons at 10 cents, 925,000 tons at 14 cents and 1,086,000 tons at 18 cents; c.f. estimated 1974 output of 683,000 tons. Similarly acreages in 1985 would be 151,000 at 6 cents, 287,000 at 10

---

[40] $$(X_0/LND) = \underset{(3.306)}{30.0133 + 0.2009}\,(F/LND) + \underset{(1.619)}{0.0401}\,(MC/LND) + \underset{(0.926)}{0.0195}\,(LB/LND) + \underset{(3.642)}{5.4061}\,DUM\,69 + \underset{(3.579)}{5.3645}\,DUM\,70 - \underset{(3.929)}{0.0023}\,LND$$

$\bar{R}^2 = 0.359$ N = 135

where X_0 is tons of cane, MC is machinery expenditure, LND is land acres, LB is labor expenditure, DUM 70 is a dummy for 1970, F is fertilizer expenditure, DUM 69 is a dummy for 1969.

cents, 434,000 at 14 cents and 591,000 at 18 cents in 1985; c.f. estimated 1974 acreage of 325,000. In general Louisianan output is projected to be relatively inelastic, as will later be further demonstrated by comparisons with the projections for the other regions.

Florida

The compound equation for Florida was

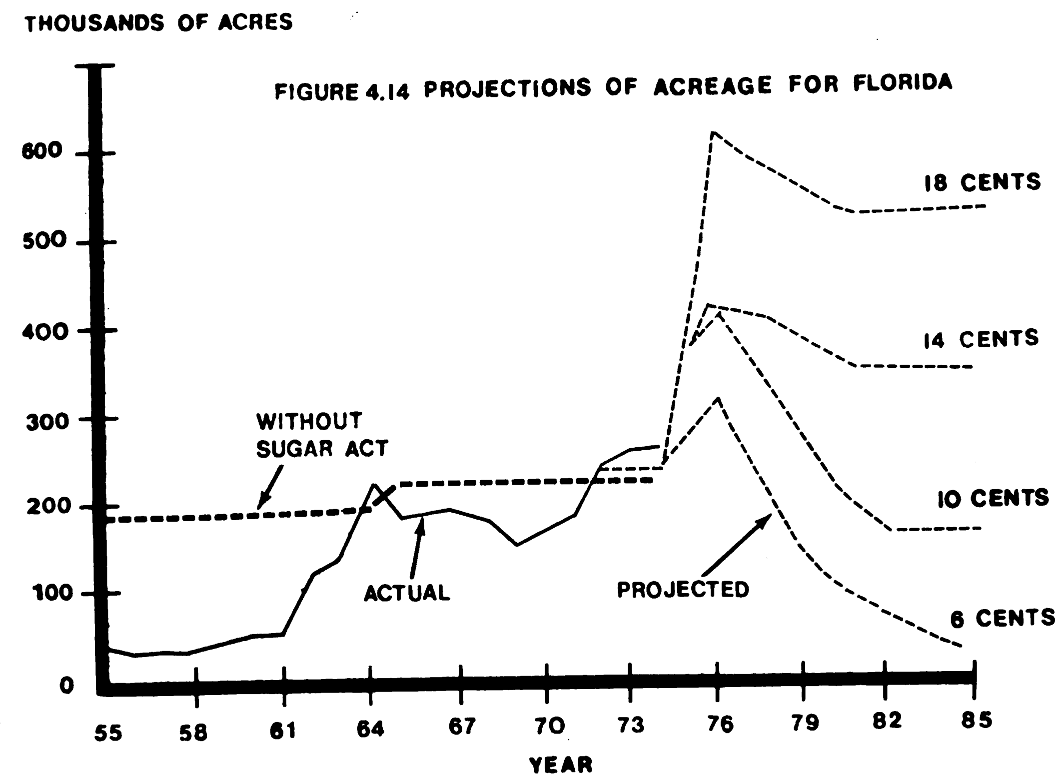
$$x_{ot} + 0.001006\ X_{ot} = 1.5621 + 1.2794\ \mathrm{lnd}_t - 0.8545\ \mathrm{pmc}_t - 0.3620\ \mathrm{plb}_t - 0.4712\ \mathrm{pf}_t + 1.6872\ \log\ (0.5\ P_{ot} + 0.5\ P_{ot-1}) + 0.02696\ T,$$

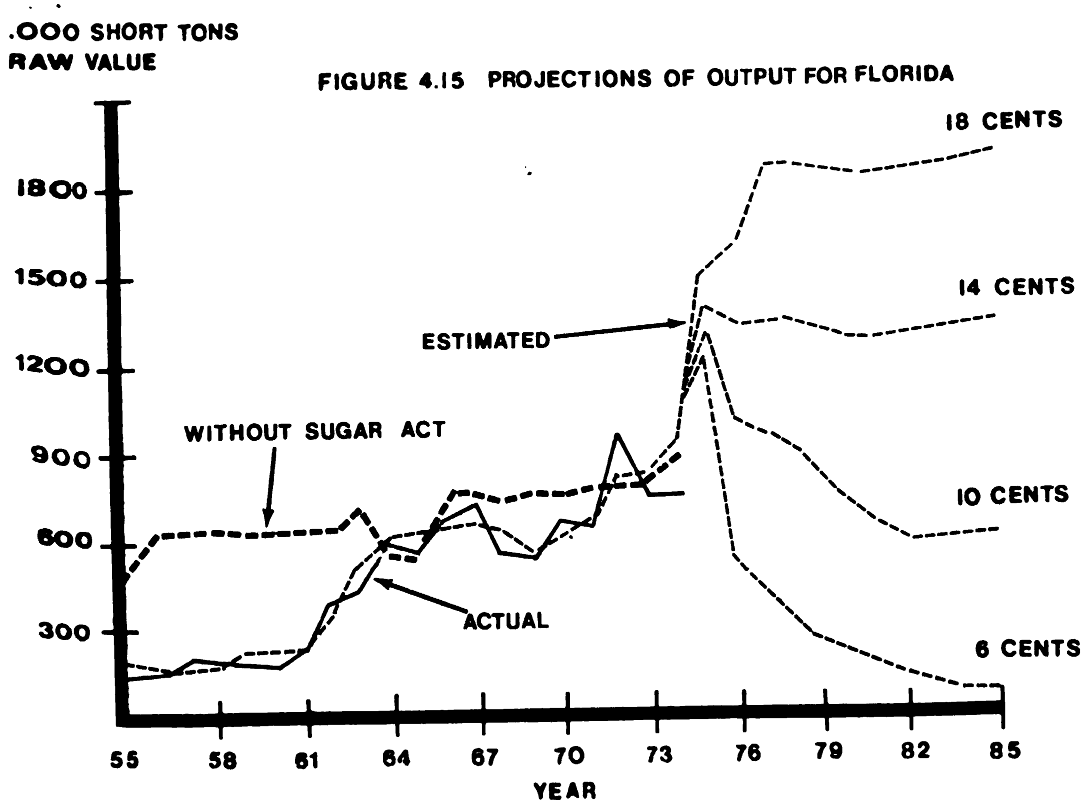
where notation is exactly as for Louisiana.

Figures 4.14 and 4.15 present the results on output and acreage harvested. The actual and projected quantities follow a very close pattern which, to some extent, reflects the minor importance of weather in determining Floridan output.[41] Had there been no U.S. Sugar Act from 1955 onward, acreage and output would have reached their 1964 levels by 1956. During the 1965-71 period, when proportionate shares were in force, Floridan output, unlike Louisianan, was limited by these acreage restrictions. It appears that during 1964, when no restrictions were in force, investment in further land preparation occurred so that, when restrictions were removed for 1972, this extra land was brought into use for the first time.

The constant-price projections demonstrate the further potential for expansion which is believed to exist in Florida. As in Louisiana,

[41] Weather dummies only accounted for 4.8 percent and 1.5 percent of the variation in output in 1968 and 1969 as compared with 1967.


THOUSANDS OF ACRES
FIGURE 4.14 PROJECTIONS OF ACREAGE FOR FLORIDA
600
500
400
300
200
100
0
18 CENTS
14 CENTS
10 CENTS
6 CENTS
WITHOUT
SUGAR ACT
ACTUAL
PROJECTED
55
58
61
64
67
70
73
76
79
82
85
YEAR


.OOO SHORT TONS
RAW VALUE
FIGURE 4.15 PROJECTIONS OF OUTPUT FOR FLORIDA
18 CENTS
14 CENTS
10 CENTS
6 CENTS
1800
1500
1200
900
600
300
ESTIMATED
WITHOUT SUGAR ACT
ACTUAL
55
58
61
64
67
70
73
76
79
82
85
YEAR

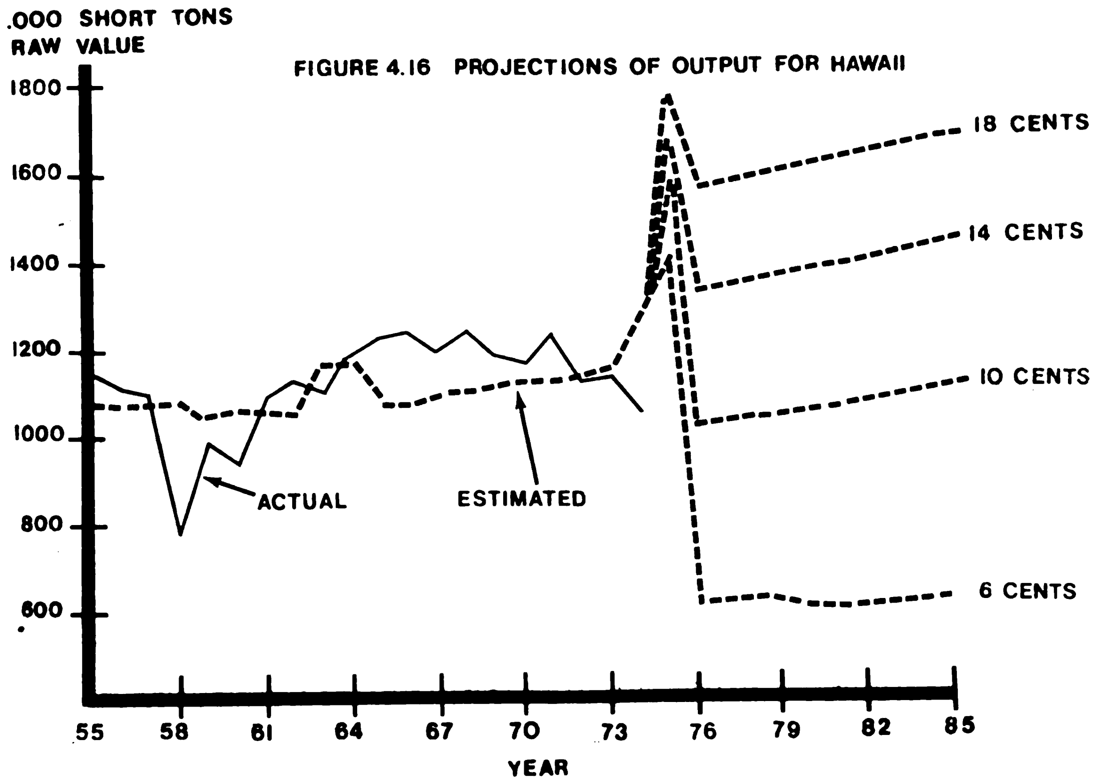
<u>acreage</u> is projected to peak at prices less than 15 cents in 1976 whereas <u>output</u> is projected to peak in 1975. At 14 cents per lb. the expansion would be approximately maintained at about 1,400,000 tons whereas at 10 cents there would be a subsequent contraction to 600,000 tons by 1985 and at 6 cents to a mere 45,000 tons by 1985. At 18 cents per lb. the projected expansion is very great, reaching 1,604,000 tons by 1976 and 1,935,000 tons by 1985; c.f. estimated 927,000 tons in 1974. Acreage projections are similar to those for output, reaching in 1985 533,000 at 18 cents, 355,000 at 14 cents, 167,000 at 10 cents and 27,000 at 6 cents; c.f. estimated 1974 acreage of 239,000. The supply in Florida may indeed be said to be elastic, as will be shown in the later inter-regional comparisons.

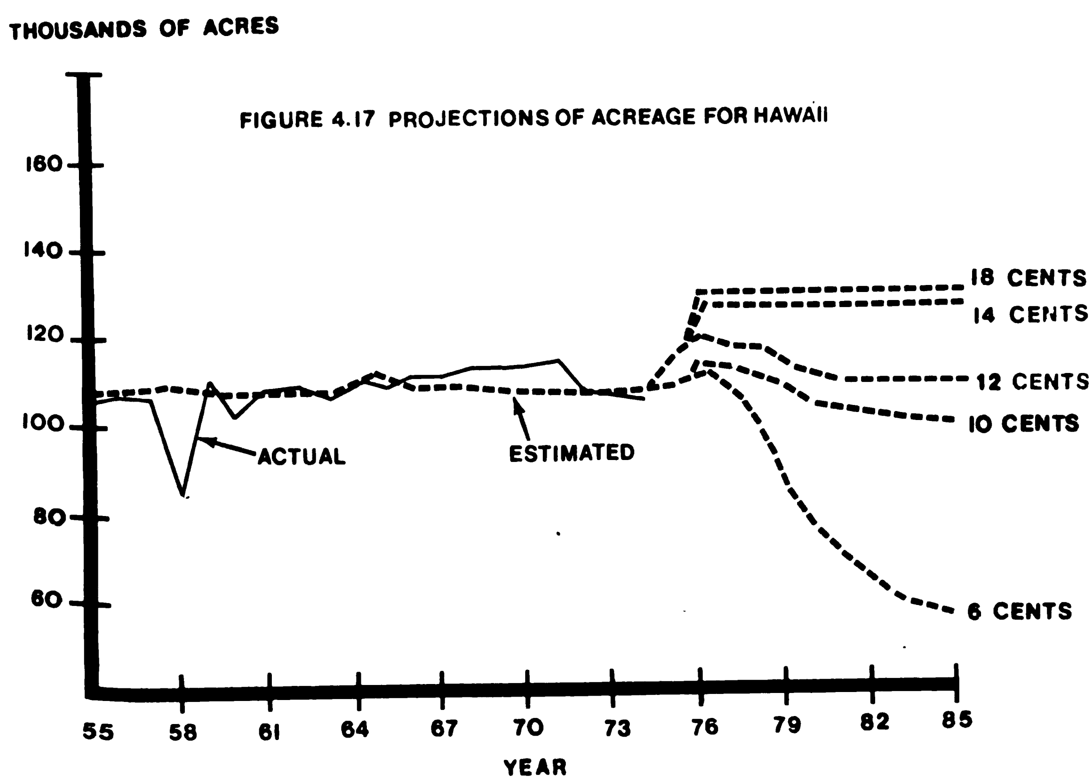
Hawaii

The compound equation for Hawaii is

$$x_{ot} + 0.003\ X_{ot} = 9.6522 + 0.6439\ \mathrm{lnd}_t - 1.6826\ \mathrm{pmc}_t - 0.8349\ \mathrm{plb}_t - 0.8838\ \mathrm{pf}_t + 3.4014\ \log(0.5\ P_{ot} + 0.5\ P_{ot-1}) + 0.05264\ T,$$

where notation is exactly as for Louisiana. Figures 4.16 and 4.17 present the results. The actual and estimated outputs show rather different patterns, while acreage has been remarkably stable and hence not difficult to model. In the cross-section analysis for 1967-69 weather variables were not a significant influence on output and so do not explain the underestimated output from 1964 to 1972. However, the outputs of 1958, 1959 and 1960 were affected by a strike and it is not surprising that our model does not take this into account.


.000 SHORT TONS
RAW VALUE
FIGURE 4.16 PROJECTIONS OF OUTPUT FOR HAWAII
1800
1600
1400
1200
1000
800
600
18 CENTS
14 CENTS
10 CENTS
6 CENTS
ACTUAL
ESTIMATED
55
58
61
64
67
70
73
76
79
82
85
YEAR


THOUSANDS OF ACRES
FIGURE 4.17 PROJECTIONS OF ACREAGE FOR HAWAII
160
140
120
100
80
60
18 CENTS
14 CENTS
12 CENTS
10 CENTS
6 CENTS
ACTUAL
ESTIMATED
55
58
61
64
67
70
73
76
79
82
85
YEAR

Output is projected to peak at all prices in 1975, thereafter declining in greater or lesser degree. The 1975 peak ranges from 1,500,000 tons at 6 cents per lb. to 1,800,000 tons at 18 cents per lb. This may be compared with our estimated 1974 output of 1,275,000 tons and the USDA estimate of 1,040,000 tons. After falling at all prices in 1976, (all the way to 600,000 tons at 6 cents per lb.), output then rises slowly due to yield-increasing technology at prices of 10 cents or more, whereas at 6 cents per lb. the output is relatively stable. Acreage shows a much less responsive pattern than output, which demonstrates that the expected response is in yield and not in acreage since the latter is subject to severe limitation. At all prices acreage peaks in 1976 but drifts downward thereafter at the lower prices. By 1985 acreage is projected to be 56,000 at 6 cents, 101,000 at 10 cents, 129,000 at 14 cents and 132,000 at 18 cents; c.f. our 1974 estimated acreage of 109,000. Output in 1985 is projected to be 608,000 tons at 6 cents, 1,110,000 tons at 10 cents, 1,455,000 tons at 14 cents and 1,695,000 tons at 18 cents; c.f. our estimated 1974 output of 1,275,000 tons. Our projections show an inelastic expansionary response with respect to acreage, but a relatively elastic response in output due to changes in yield. These projections result from the low importance of land in the estimated production-function.

Puerto Rico

The compound equation for projection is

$$\begin{aligned} x_{ot} + 0.00084\ X_{ot} = & - 7.9779 + 1.7588\ \mathrm{lnd}_t - 0.7642\ \mathrm{pmc}_t \\ & - 1.8575\ \mathrm{plb}_t - 0.2497\ \mathrm{pf}_t \\ & + 2.8715 \log (0.5\ P_{ot} + 0.5\ P_{ot-1}) \\ & + 0.0594\ T, \end{aligned}$$

where notation is exactly as used for Louisiana. Figures 4.18 and 4.19 present the results. Actual and estimated outputs follow similar patterns, except that the rate of decline is overestimated up to 1962 and somewhat underestimated in later years. Our model predicts a slight expansion from 1962-64 whereas in actuality such an expansion did not occur. However, the turning point in output in 1972 was shown by the model. Acreage in the model shows a continuous decline, (as there has been in actuality since 1958), but is subject to the same problems of under and over-estimattion as output.[41] Weather variation may explain a small part of the discrepancy between actual and estimated output, since dummy weather variables were significant at the 2.5 percent level in the cross-section analysis, contributing five percent and four percent to the explanation of output in 1970 and 1971, respectively.

Since at 6 cents per lb. there were difficulties in solving the model, output was assumed to be zero at that price and projections were made only at prices of 8 cents per lb. or more. It should also be noted that, becuase of its close connection with the price of sugar, the price of labor was linearly related to the price of sugar in making the projections.[42] The high price of 1974 is projected to halt the decline in acreage in 1975 and very slightly reverse it in 1976. Thereafter, at prices less than 16 cents per lb., the acreage would continue its previous decline, while at higher prices the acreage would expand to reach

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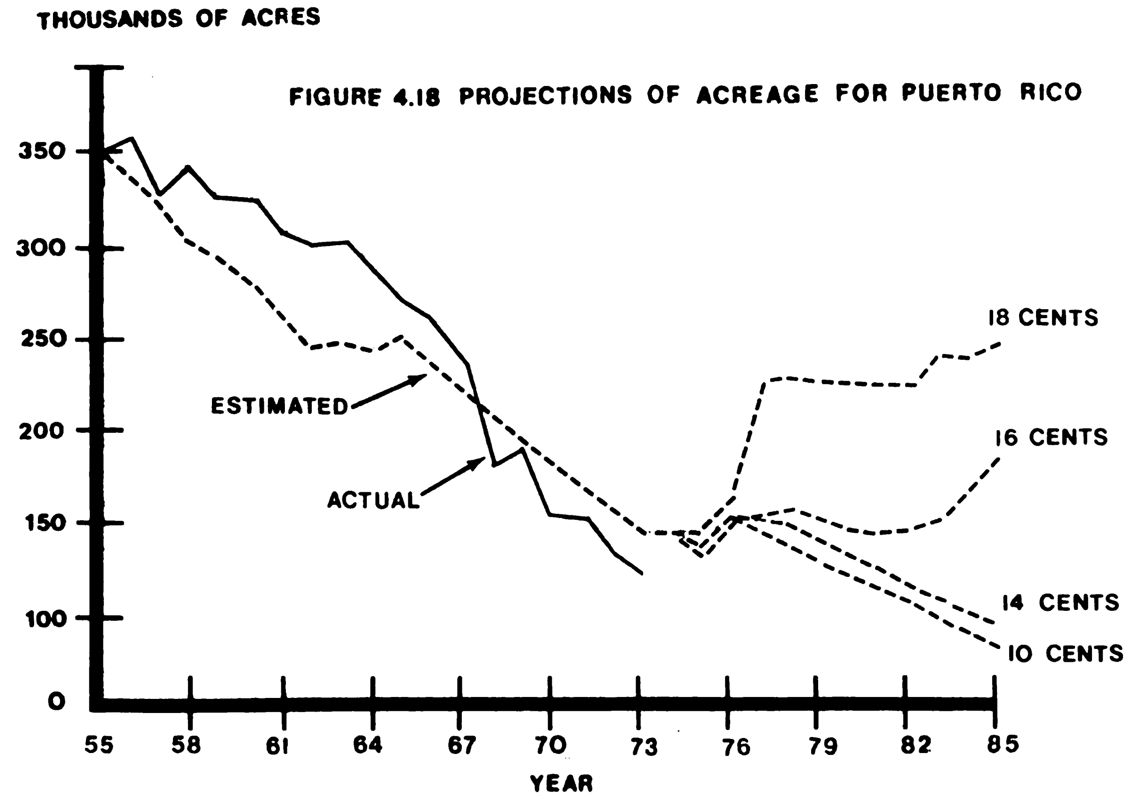
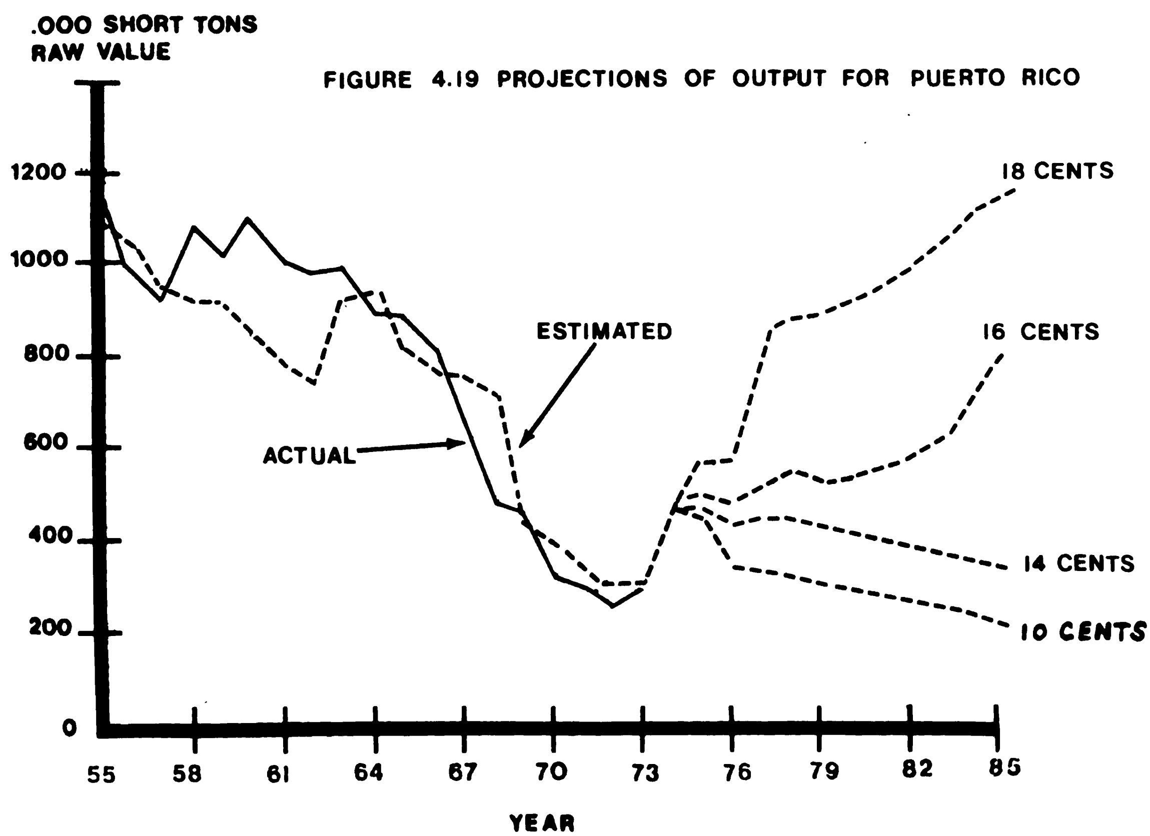
[41]This could be due to the sigmoid relationship between adoption of an innovation (i.e. giving up sugar production) and time.

[42]Namely $PLB_t = (USPQ_t / 7)$ where PLB is the wage rate in \$/hr. and USPQ is the average of prices at t and t-1.


THOUSANDS OF ACRES
FIGURE 4.18 PROJECTIONS OF ACREAGE FOR PUERTO RICO
350
300
250
200
150
100
0
ESTIMATED
ACTUAL
18 CENTS
16 CENTS
14 CENTS
10 CENTS
55
58
61
64
67
70
73
76
79
82
85
YEAR


.000 SHORT TONS
RAW VALUE
FIGURE 4.19 PROJECTIONS OF OUTPUT FOR PUERTO RICO
1200
1000
800
600
400
200
0
ESTIMATED
ACTUAL
18 CENTS
16 CENTS
14 CENTS
10 CENTS
55
58
61
64
67
70
73
76
79
82
85
YEAR

a new plateau in 1977. Output would follow a pattern similar to acreage except that, with yields increasing over time, output is projected to climb slowly at prices of 16 cents or more. The estimated acreage for 1985 is 82,000 at 10 cents, 95,000 at 14 cents, 178,000 at 16 cents and 248,000 at 18 cents; c.f. our estimated 1974 acreage of 146,000 and an actual 1951 peak of 392,000 acres. Estimated outputs in 1985 are 210,000 tons at 10 cents, 342,000 tons at 14 cents, 808,000 tons at 16 cents and 1,370,000 tons at 18 cents; c.f. our estimated 1974 output of 465,000 tons and a peak of 1,372,000 tons in 1951. In summary, our projections demonstrate a recovery in the Puerto Rican industry only at prices of 16 cents or more.

Regional Comparisons and Aggregate Supply

Figure 4.20 compares the projected supplies in 1985 in the different regions over the price range of 4 to 18 cents per lb., (prices in 1974 dollars and input prices held constant except for land in Hawaii and labor in Puerto Rico). All schedules are upward sloping at all prices, but those for Florida and Puerto Rico are doubly curved due to returns to scale in these regions approaching unity at low outputs. Considered at 10 cents per lb. the supply elasticities are (for 1985) 0.00 for Puerto Rico, 0.75 for Louisiana, 0.99 for Hawaii and 4.23 for Florida.[43] One should be cautious in interpreting these elasticities, but they do reflect the underlying inelasticity of Puerto Rican supply, the high elasticity of Floridan supply, and the intermediate elasticity of supply in Louisiana and Hawaii.

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[43]Reckoned as $\left(\frac{\%\text{ change in output}}{\%\text{ change in price}}\right)$ using the change from 9 cents to 11 cents on a 10 cent base.

PRICE
IN NE
DUTY

FIGURE 4.20 PROJECTED SUPPLY-SCHEDULES FOR 1985 (IN 1974 DOLLARS)

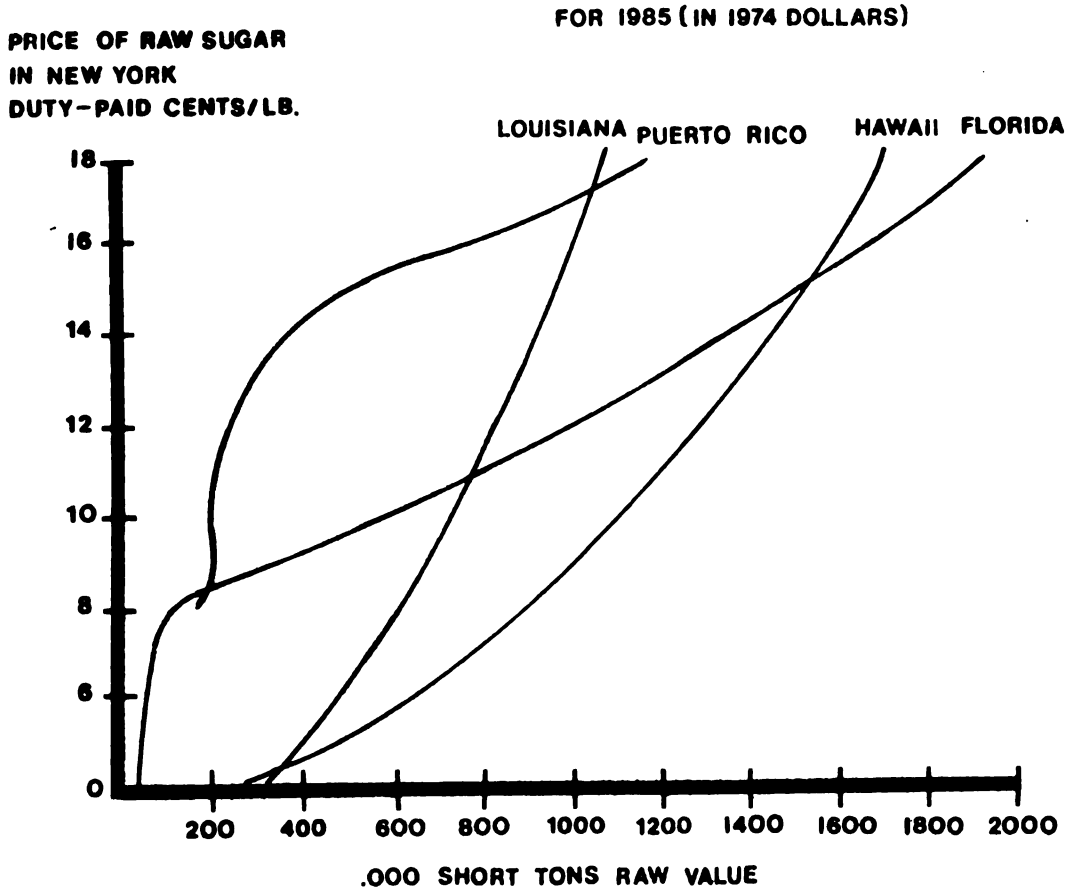

FIGURE 4.21 AGGREGATE SUPPLY-SCHEDULE FOR U.S. CANE-SUGAR (1985)

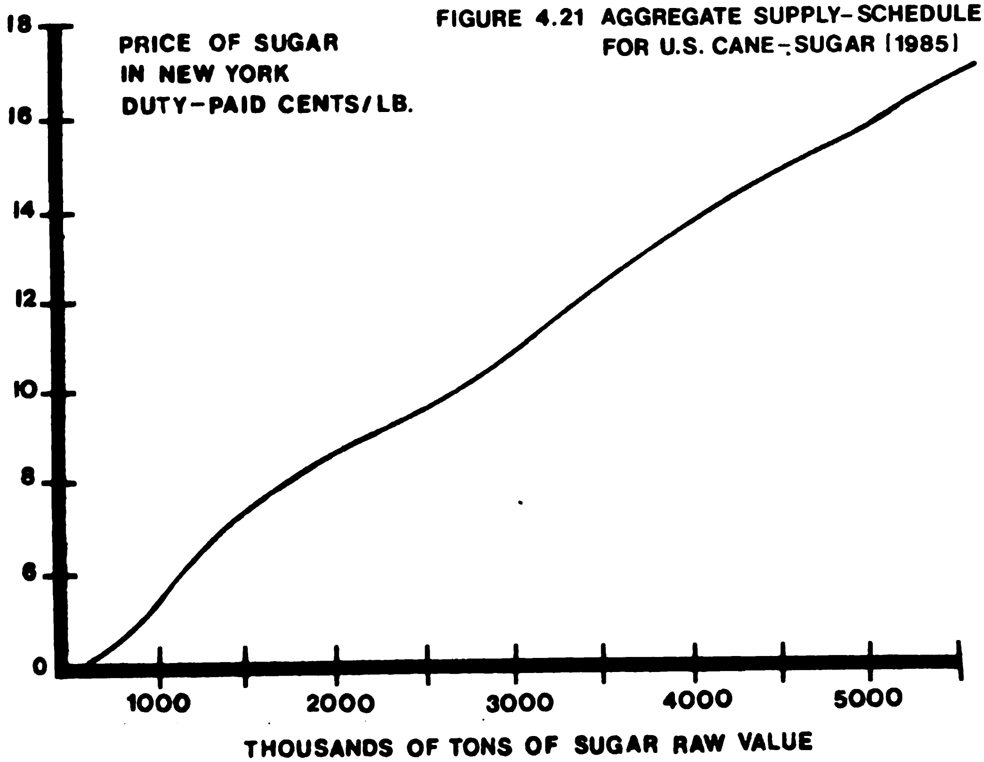

Table 4.7 summarizes the supply-schedules and gives a grand total which is also presented in Figure 4.21. The aggregate supply curve is virtually a straight line with an estimated elasticity at 10 cents per lb. of 1.59 in 1985.

Table 4.7. Projected Supply of U.S. Cane-Sugar in 1985 in Thousands of Short Tons, Raw Value

Price in Cents per lb. New York	Florida	Hawaii	Louisiana	Puerto Rico	Total
3	14	121	221	0	356
4	22	280	308	0	610
5	31	449	391	0	871
6	45	608	472	0	1,125
7	63	753	544	0	1,360
8	92	886	611	163	1,752
9	311	1,006	672	203	2,192
10	615	1,112	729	209	2,665
11	831	1,203	781	201	3,016
12	1,013	1,294	835	254	3,396
13	1,202	1,380	880	289	3,747
14	1,352	1,455	925	342	4,074
15	1,514	1,525	967	512	4,518
16	1,671	1,586	1,011	808	5,076
17	1,795	1,645	1,049	1,016	5,505
18	1,935	1,695	1,086	1,183	5,899

Summary and Implications of Chapter IV

In this chapter, supply functions for the cane producing regions of the U.S.A. were synthesized from both cross-sectional and time-series data. The Cobb-Douglas production function was the basic unit of abstraction. Projections were made to 1985 which showed that in all regions ma

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output may be expected to rise considerably in 1975. However, the expansion is likely to be greatest in Florida and least in Puerto Rico. Supply elasticities were estimated to be 0.00 for Puerto Rico, 0.75 for Louisiana, 0.99 for Hawaii and 4.23 for Florida. A price of 16 cents per pound was found to be necessary to stem the long-run decline in Puerto Rico's industry, while at such a price total output of the domestic U.S. would approximately double. An examination of the ease of substitution of different inputs, using the Translog production function, showed that labor and machinery were definitely substitutes in all regions, particularly in Hawaii and Puerto Rico. Minimum wage laws, if effective, and union agreements of a similar nature therefore tend to reduce employment, especially in Hawaii and Puerto Rico.

CHAPTER V

THE EUROPEAN BEET SUGAR SUPPLY

Introduction

The production of sugar from beet originated in France during the Napoleonic blockade early in the 19th century. Since then, with periodic expansions and contractions, beet has been the major source of sugar for continental Europe. In the United Kingdom, by contrast, imported cane sugar has always been more important than domestically produced beet sugar. While the continental countries protected their domestic producers, the British protected their colonial suppliers (such as the West Indies).

The only important producer of beet sugar outside Europe is the U.S.A., although minor quantities of beet are produced in Canada, Chile, China, Iran and Japan. The producing countries of Europe may be divided into the EEC (9.24 million metric tons in 1974), the U.S.S.R. (8.53 million metric tons in 1974), Eastern Europe (4.42 million metric tons in 1974) and the remainder of (Western) Europe (2.54 million metric tons in 1974[1]). As a whole, Europe produced 26.96 million metric tons of sugar in 1973 and consumed 31.57 million tons, i.e., was 85% self-sufficient in sugar.

[1]Figures from International Sugar Organization are approximate since some 1974 quantities not yet reported.

This research concentrates particularly on the supply of sugar within the EEC. Just as in the U.S.A., controversy exists on the desirable size of the domestic sugar industry. As earlier explained in Chapter I, the EEC and the U.S.A. are the two major world groups whose policies are liable to change through the democratic process. In this thesis, therefore, particular attention has been paid to modeling supply in these countries so that projections may be made under a variety of policies representing different degrees of protection.

The general model of the supply of beet may be written,

$$(5.1) \quad QB_t = f_{QB}\,(PB_{t-1},\ PLB_t,\ PFERT_t,\ PALT_{t-1},\ T_t)$$

where QB = quantity of sugar from beet,

PB = farm price of beet,

PLB = rural wage rate,

PFERT = the price of fertilizer,

PALT = the price of a competing crop,

T = technology

and t = a time subscript

Assuming f_{QB} to be log-linear for all variables except technology and that there is a <u>desired</u> level of output, QB_t^*, to which adjustment is partial, one may write,

$$(5.2) \quad \log QB_t^* = \beta_0 + \beta_1 \log PB_{t-1} + \beta_2 \log PLB_t + \beta_3 \log PFERT_t + \beta_4 \log PALT_{t-1} + \beta_5 T_t + E_{t1}\ .$$

Specifying the relationship between desired and actual output as,

(5.3) $\log QB_t - \log QB_{t-1} = \gamma(\log QB^*_t - \log QB_{t-1}) + E_{t2}$,

where $0 \leq \gamma < 1$.

(5.2) may be rewritten as,

(5.4) $$\log QB_t = \beta_0\gamma + \beta_1\gamma \log PB_{t-1} + \beta_2\gamma \log PLB_t + \beta_3\gamma \log PFERT_t + \beta_4\gamma \log PALT_{t-1} + \beta_5\gamma T_t + (1-\gamma) \log QB_{t-1} + \gamma E_{t1} + E_{t2} .$$

If E_{t1} is not autocorrelated,[2] (5.4) may be estimated by OLS to give unbiased and efficient estimates of the coefficients.

During estimation some minor changes were made to (5.4) as appropriate. Whenever $(1-\hat{\gamma})$ was not different from zero at the 5% level of significance, it was dropped from further consideration. Time was used as a proxy for technology, T_t. Domestic prices were used for the Common Market countries and international (dollar) prices of sugar were used for the remaining countries, including the U.S.S.R.

The presentation of background information, policies and the results of estimation are in the order: EEC-six, EEC-three, remainder of Western Europe and Communist Europe.

Policy and Production in the EEC-Six

Prior to the introduction of the Common Sugar Policy in 1968, a variety of national policies existed. In general, the countries aimed at internal self-sufficiency which, in the French case, meant

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[2]See Chapter III for a discussion of estimation when E_{t1} is autocorrelated.

self-sufficiency for the Franc Zone. Because the statistical analysis begins in 1953, thumbnail sketches of national policies for the 1953-68 period are presented below.

France

In most years there was a national quota on production and a guaranteed price for this tonnage. Production which exceeded the quota was exported and its price not guaranteed, although the first 300,000 tons received a 30% subsidy on the difference between the domestic and international prices. The quota was usually in the range of 1.50-1.57 million metric tons which may be compared with a basic quota under the EEC policy in 1968 of 2.4 million metric tons. Since both the price and quota were higher under the EEC policy, it is not surprising that the production also rose from 1.5 million metric tons in 1962-63 to 2.7 million metric tons in 1972-73.

West Germany

An annual plan for the supply of sugar was initiated in 1951. Under the plan, quotas for refineries were fixed for the coming year and the refiners were expected to make contracts with the growers in accordance with their quota requirements. The price of sugar beet was fixed by governmental edict, but other prices were allowed to vary. After 1968 the price of sugar declined to the grower, but production increased due to an increase in the quota.

Belgium (and Luxemburg)

Since 1951 the industry has been controlled by the growers' association which has fixed quotas and negotiated contracts with the refineries. Sugar in excess of the quota has received only a very low price. Since 1968, price, quota and production have all risen substantially.

Netherlands

Prior to the formation of the EEC, the industry was the least controlled of the six. Normally there was no quota on production except in years of exceptionally high production, (e.g., 1959-60). Production was indirectly regulated by a controlled retail price for sugar and a minimum price for sugar beet for the farmer.

Italy

A bewildering mixture of policies was used in the 1953-68 period, some of which were restrictive and some expansionary. Prior to 1956 Italy produced more sugar than could be consumed domestically and for the 1956-59 period there was voluntary restriction of production. However, in 1959 there was a large surplus and the government introduced quotas for the 1960 and 1961 seasons. In 1962 the High Court declared the quotas illegal, but since then there has been a shortfall in production and no necessity for restrictions. In fact, subsidies were instituted and the subsidies were continued under the EEC policy of 1968, but production still falls short of domestic consumption. Once farmers had lost confidence in sugar they diversified into fruit production and hence could no longer be persuaded to switch back to sugar production in the short run.[3]

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[3] F. Pignalosa, FAO, Rome, personal communication, August 1974.

The Common Sugar Policy of 1968

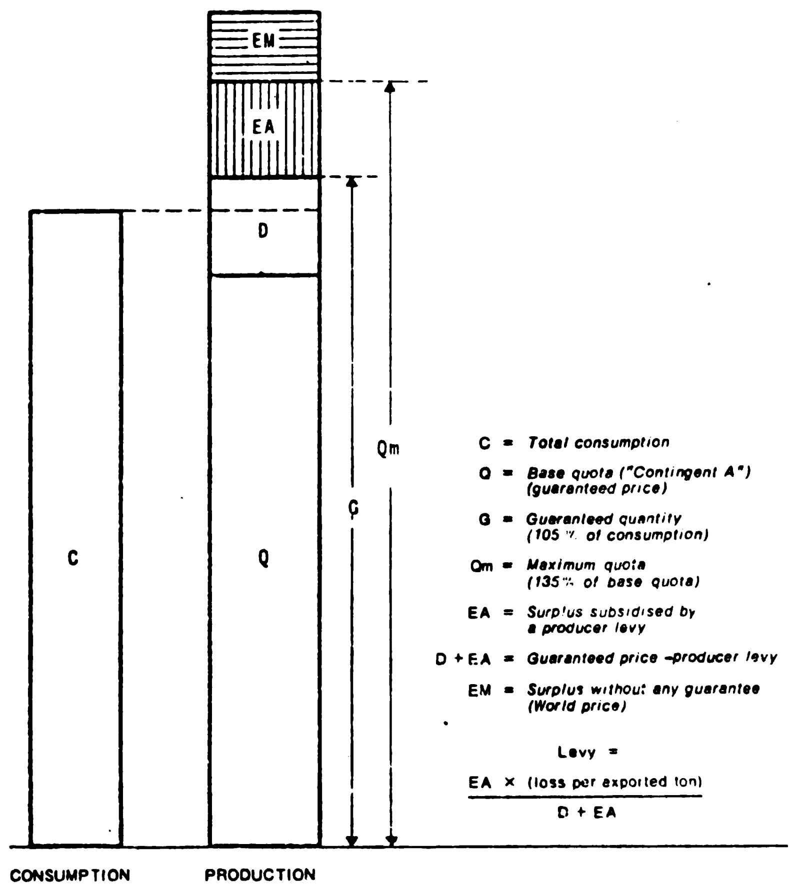
Just as for other products, the protection of the EEC sugar industry is achieved by the use of a variable levy (on refined sugar). Each year the Community agrees a target price for white sugar and sets an intervention price of from 5 to 7% less than the target price. The price for refined sugar is maintained at least at the intervention price through purchase by the Community. Imports are subject to a variable levy which is such that their price, when delivered, is equal to the target price. Since the policy began in 1968, there have effectively been no imports, except those which came from the French Dependencies of Reunion, Martinique, etc. There have also been some imports from Eastern Germany since these cannot be excluded from EEC markets.

Unlike the policy for other products of an agricultural nature, sugar production is restricted by an elaborate system of quotas which limits guaranteed prices for sugar beet to certain quantities in each country. Each country has a basic or "A" quota equal to approximately 95% of that country's domestic consumption and a second or "B" quota equal to an additional 40% of domestic consumption (45% in 1974). Within each country these quotas are translated into quotas for the processors of sugar beet who, in turn, make contracts with farmers for certain quantities. The processors, and via them the farmers, receive different prices for production in the A and B quotas. Production in the A quota receives a fully guaranteed price. Production in the B quota which exceeds domestic requirements (i.e., almost all of it), is exported and a levy is charged to the processors (and via them the

producers of beet) to finance the export, assuming international sugar prices to be less than EEC prices. The levy has an upper limit so that production within the B quota of more than a certain quantity receives, in effect, a minimum guaranteed price. During 1974 production within both the A and B quotas would have been exported, since the international price for sugar exceeded the domestic price, and to stabilize the domestic price a tax on exports was instituted. In more normal years, should production exceed the B quota, it has no price guarantee and all such production, called "C" quota, has to be exported.

The OECD[4] has represented the sugar policy by the following diagram.

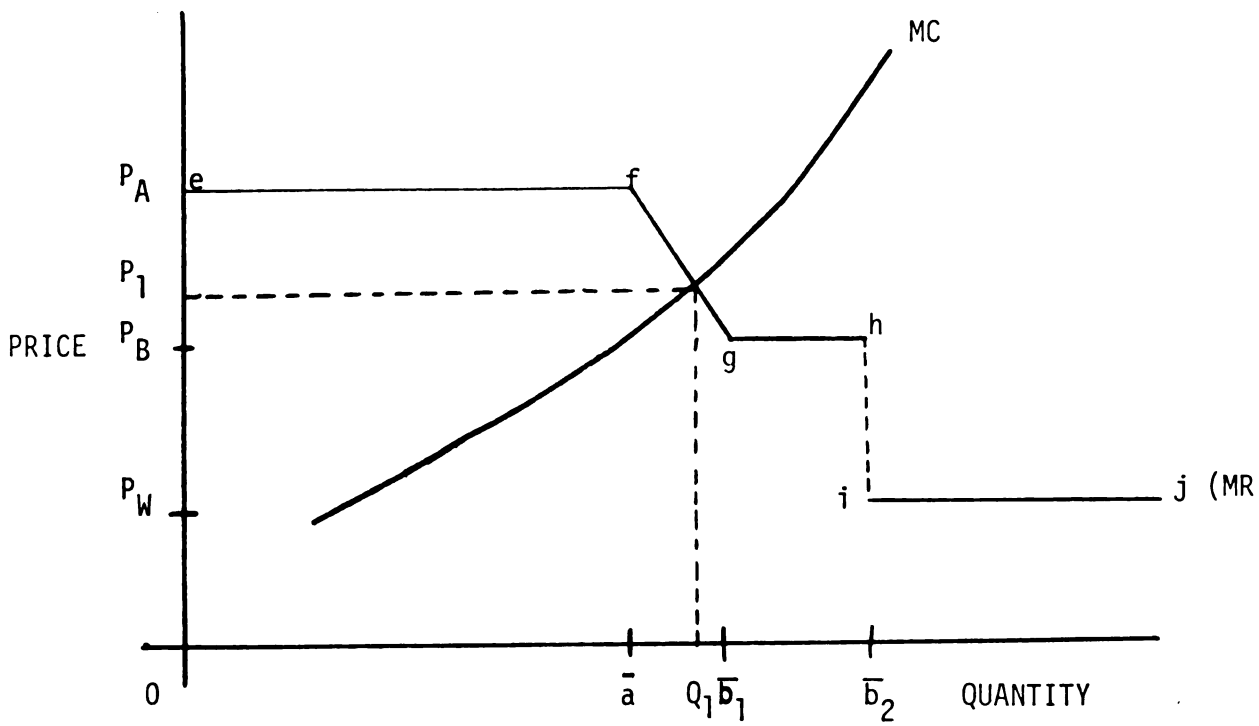
Figure 5.1. Quotas in EEC Sugar Policy



[4]OECD (1973). "Supply Control in Agriculture." (Paris: Organization for Economic Cooperation and Development).

The economic interpretation of the policy for the individual farm is represented in Figure 5.2.

Figure 5.2: Situation Facing Individual Farm Under EEC Sugar Policy



The marginal return curve, efghij, has a downward-sloping portion from f to g and a discontinuity from h to i. From zero output to output $\bar{a}$, price P_A is guaranteed as this represents the A quota. For production between $\bar{a}$ and $\bar{b}_1$, the producer receives P_A less 40 percent of the levy necessary to export the given quantity of sugar in excess of $\bar{a}$ (i.e., less 40 percent of $(P_A - P_W)$, where P_W is the world or export price). Note that the other 60 percent of the levy required to export this sugar is paid by the processor. For production between $\bar{b}_1$ and $\bar{b}_2$, the minimum guaranteed price P_B is paid and for production in excess of $\bar{b}_2$ there is no guaranteed price, but only the world price of P_W is received. Note that in 1974 the world price, P_W, was actually higher than the domestic A quota price, P_A, (once processing margins were deducted, since there is no trade in raw beet). Given the marginal cost curve MC, the producer maximizes profit by producing Q_1 for which the marginal return is P_1.

Figure 5.2 may equally be interpreted as the aggregate situation facing all of a country's farmers. Given a time series of P_1/Q_1 coordinates for one of the countries, it would be possible to map the supply response. Such a procedure was attempted, but there were certain inconsistencies in the data[5] and only a few years since the policy began, so that such an approach was not fruitful. However, it is known that all countries, with the exception of Italy, have consistently produced somewhere within the B quota, which suggests a marginal cost of production in the 10-17 unit of account per 1000 kilograms of beet range, approximately 3.5-5.5 U.S. cents per pound of sugar on farm. Table 5.1 lists the production, prices and quotas for the EEC-Six over the 1968-73 period.

Before presenting the results, it should be noted that the estimates will understate supply by a small margin under policies different from that currently existing. The price variable utilized was the <u>average</u> producer return whereas the correct (but unmeasurable) variable would be the <u>marginal</u> return. In Figure 5.2, the average return under the conditions shown would lie between P_A and the marginal

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[5]On occasion the average price exceeded the A price, an impossibility.

Table 5.1. **Production of Sugar, Quotas and Farm Sugar Prices in the EEC-Six, 1968-73**

Year	Belgium	France	Germany	Netherlands	Italy
	(Production in thousands of metric tons, raw value)				
1968	526	2191	1814	661	1186
1969	618	2503	1903	203	1268
1970	551	2479	1890	657	1096
1971	772	2945	2155	771	1153
1972	617	2744	2040	695	1184
1973	718	2916	2253	765	1040
	(Quotas in thousands of metric tons, raw value)				
A Quota	550	2400	1750	550	1230
B Quota	231	1010	737	231	517
Total	718	3410	2487	718	1747

Year	All Countries Exc. Italy		Italy	
	A quota	B quota	A quota	B quota
	(Price per 1000 kg. of beet in units of account)			
1968	17.00	10.00	18.46	11.46
1969	17.00	10.00	18.46	11.46
1970	17.00	10.00	18.46	11.46
1971	17.00	10.00	18.95	11.95
1972	17.68	10.40	19.63	12.35
1973	17.86	10.50	20.28	12.85
1974	18.84	11.08	21.70	13.95

Source: EEC (1974). Agricultural Markets, No. 8, Brussels: European Economic Community.

For 1975 prices were increased 15% and quotas also expanded.

return, P_1. The degree of understatement of supply under a different policy depends on the magnitude of the difference between marginal and average returns under the current policy, which is believed to not be very large. The results which follow were selected from a larger set of equations which was estimated. The choice was based on the sign and significance of individual coefficients.

France

$$(5.5) \quad \log Q_{1t}^{\dagger} = 14.6422 + \underset{(3.507)}{1.6392} \log P_{1t-1} - \underset{(2.396)}{2.0999} \log PFERT_t + \underset{(0.331)}{0.0053}T$$

$\bar{R}^2 = 0.757$

$DW = 2.321$

$N = 22$

In the French equation, quantity of sugar produced annually was made a function of the price of beet, the price of fertilizer and time. Wheat was believed a priori to compete with sugar beet for land, but a wheat variable proved to have a coefficient of a very low magnitude and not significantly different from zero. The

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†The variables for this and the following equations are defined as follows:

Q_1 = quantity of sugar in thousand metric tons, raw value
P_1 = domestic on-farm price of sugar beet in national currency
P_2 = the price of a farm product competitive with sugar beet
PIN = an index of agricultural input prices
PFERT = the domestic price of fertilizer
T = time defined as the last two digits of the year, e.g., 1967 = 67

Figures in parentheses are t values.

equation above implies a supply elasticity of 1.64 with a large input elasticity for fertilizer of -2.10.

West Germany

$$\log Q_{1t} = \underset{}{6.8313} + \underset{(1.492)}{0.8699} \log P_{1t-1} - \underset{(0.793}{0.6098} \log P_{2t-1} \tag{5.6}$$

$$- \underset{(0.219)}{0.0968} \log PFERT_t + \underset{(2.615)}{0.0260T}$$

$\bar{R}^2 = 0.716$

$DW = 2.634$

$N = 22$

In the West German equation, the supply of sugar is a function of the price of beet, the price of wheat (P_2), the price of fertilizer and time. Only the coefficient of the time variable is significantly different from zero at the 5% level, but all coefficients have the expected signs and magnitudes and the result shown is corroborated by the equation which was estimated with land as the dependent variable. The equation appears from the DW statistic to be negatively autocorrelated but this will not have biased the coefficients and an Orcutt transformation was deemed unnecessary. The equation gives an own price elasticity of 0.87, somewhat lower than for France. The cross price elasticity with wheat of -0.61 suggests that the production of beet in West Germany is sensitive to the price of wheat.

Belgium

$$(5.7)\qquad \log Q_{1t} = 3.9886 + \underset{(1.932)}{0.2978} \log (P_{1t-1}/PIN_t) + \underset{(1.455)}{0.2064}\ DUM + \underset{(4.088)}{0.0385T}$$

$\bar{R}^2 = 0.681$

$DW = 2.831$

$N = 22$

In the Belgian equation, the supply of sugar was made a function of the on-farm price of sugar, the input price index, a dummy variable for the years in which the EEC policy was in force (DUM), and time. As in the West German equation, only the coefficient for time is significantly different from zero at the 5% level, but the signs are as expected and the coefficients of expected magnitudes. The production of beet in Belgium was highly responsive to the beginning of the EEC policy and consequently, as the change in policy was radical, a dummy variable for the policy was included. Prior to 1968 the industry was tightly controlled and, following a spurt in the late 1960's, it seems to have reverted to a condition of low price elasticity. The estimated own price elasticity is 0.30 (deflated by input price index). This estimate of low price elasticity was invariant to alternative specifications of the equation, including those in which wheat featured as an alternative product.

Netherlands

$$\log Q_{1t} = \underset{(3.496)}{20.1777 + 1.1401} \log P_{1t-1} - \underset{(2.383)}{0.2902} \log P_{2t-1} \tag{5.8}$$

$$- \underset{(3.481)}{3.8655} \log PFERT_t + \underset{(4.337)}{0.0433T}$$

$\bar{R}^2 = 0.831$

$DW = 1.943$

$N = 22$

In the Dutch equation, supply of sugar is a function of own price, the price of fertilizer (PFERT), the price of potatoes (P_2), and time. All coefficients are significantly different from zero at the 5% level. The supply elasticity with respect to sugar price is relatively high, being 1.14 and the cross elasticity with potato price is -0.29. The supply of sugar is extremely sensitive to the price of fertilizer. the elasticity being estimated at -3.87.

Italy

$$\log Q_{1t} = 2.4342 + \underset{(1.234)}{0.5741} \log P_{1t-1} - \underset{(0.242)}{0.0306} \log P_{2t-1} \tag{5.9}$$

$$- \underset{(0.914)}{0.5487} \log PIN_t + \underset{(0.923)}{0.0156T} + \underset{(1.388)}{0.3222} \log Q_{1t-1}$$

$\bar{R}^2 = 0.558$

$N = 22$

h = n.a.[6]

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[6] n.a. = not available. A test for autocorrelation, when a lagged dependent variable is a regressor, is Durbin's h test. However, in the current context, the value of the coefficient of log Q_{1t-1} is such that the test is infeasible. See Durbin, J. (1970). "Testing for Serial Correlation in Least Square Regression When Some of the Regressors are Lagged Dependent Variables," Econometrica, 38 (3), (May), pp. 410-421. The 5 percent level of significance occurs at $h \geq 1.66$.

In the Italian equation, supply of sugar is a function of own price, the price of apples (P_2), input prices, time and quantity supplied in the previous year. The whole equation shows a significant relationship as measured by the F statistic and, while the individual coefficients are of low significance, the signs agree with a priori expectations and the magnitudes are corroborated by the land equations estimated. The equation is of a partical adjustment kind, with adjustment estimated to be 68 percent complete on an annual basis. Short run elasticities are estimated to be 1.23 for own price, -0.03 for the price of apples and -0.55 for the price of all inputs. Long-run elasticities are 32 percent higher than these values.

Equations and policy considerations for the three new members of the EEC are now given before making some brief inter-country comparisons of supply equations for the whole EEC.

Policy and Production in the EEC-Three

Denmark, Ireland and the United Kingdom became members of the EEC in February 1973 and have since that date been adjusting their agricultural policies to the Common Agricultural Policy. This adjustment is in stages and due to be complete by 1977. The data used for estimation cover the years 1950-72 and brief sketches of national policies for that period are given below, since they affect specification and estimation.

Denmark

A quota, representing domestic requirements, was fixed annually and price was guaranteed for this quota. Any excess production, resulting from variation due to weather conditions, was sold on the world market and the producer received the world market price. Quotas on total

production led effectively to quotas on individual farms via the contracts made between the processors and producers. Production regularly exceeded domestic consumption by a small, but fluctuating, margin. Generally, production was of the order of 300,000 tons of raw equivalent per annum.

Ireland

In the past, the government did not intervene in Irish sugar production except to the extent of limiting the development of new factories via the granting of licenses. Contracts were made annually between the farmers and manufactureres. Production, of approximately 150,000 tons per annum, did not fulfill domestic requirments. It is interesting to note that during the 1960s Ireland possessed a small U.S. sugar quota and both exported and imported sugar simultaneously.

United Kingdom

Domestic production was limited by a quota on acreage which reserved approximately two-thirds of consumption for imports from Commonwealth countries under the Commonwealth Sugar Agreement, (begun in 1951). Producers received guaranteed prices for their beet and all beet was processed by the state-owned British Sugar Coporation. Under the new EEC regulations, the 1.4 million tons of raw sugar imported from the less-developed Commonwealth countries will continue to be imported. The degree of expansion of domestic beet production under the higher EEC prices and quotas is as yet not clear. Certain authors[7] anticipated a

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[7]Sturrock, F. G. and Thompson, M. C. (1972). "Sugarbeet: A Study of Sugar Production in the U.K. and Feasibility of Expansion,"

25% increase in production, but in the 1974-75 season an increase in plantings was offset by disease problems which resulted in an actual decline in production from 1973-74.

Considering the relative simplicity of the respective policies, no further explanation is attempted except to remark that, because of acreage restrictions, yield equations were estimated for the United Kingdom (i.e., land area in beet was treated as exogenously determined).

The estimated equations were as follows:

Denmark

$$\log Q_{1t} = \underset{}{9.7879} + \underset{(2.866)}{1.2972} \log P_{1t-1} - \underset{(0.823)}{1.6465} \log PIN_t + \underset{(0.187)}{0.0093}T \qquad (5.10)$$

$\bar{R}^2 = 0.206$

$DW = 2.257$

$N = 22$

The Danish equation is not an especially good statistical fit, partly because variations in production followed world and not Danish prices. However, it is expected that this equation will prove useful in projecting supply under the EEC policy in which domestic and international prices are more independent. The estimated supply elasticity is relativey high at 1.30. No alternative product was included in estimation, but supply is sensitive to input prices, the estimated elasticity being -1.65.

Economic Report No. 7, Department of Land Economy, Cambridge. Also Harris, S. and Smith, I. (1973). "World Sugar Markets in a State of Flux," London: Trade Policy Research Centre.

Ireland

$$\text{(5.11)} \quad \log Q_{1t} = 3.3057 + \underset{(6.359)}{0.0250T}$$

$\bar{R}^2 = 0.652$

DW = 1.759

N = 22

The Irish equation simply relates output to time. More complicated functions were estimated but were all rejected on both a priori and statistical grounds. No alternative product competing with sugar beet for land could be clearly identified. Price, when included, had the opposite sign from that expected. The equation suggests that price had little to do with Irish supply, but that, rather, production was allowed to expand slowly within current factory capacity.

United Kingdom

$$\text{(5.12)} \quad \log (Q_{1t}/L_{1t}) = 2.5713 - \underset{(0.311)}{0.3847} \log L_{1t} + \underset{(0.874)}{0.4363} \log P_{1t} - \underset{(1.339)}{0.2684} \log PIN_t + \underset{(2.812)}{0.020T}$$

$\bar{R}^2 = 0.563$

DW = 2.418

N = 22

and where

L = land area.

The British equation relates yield, the only decision-variable on output which the farmer had, to land area in beet, the price of sugar to farmers, the price of inputs and time. Of these variables on the right-hand side, only the coefficient of time is significantly different from zero at the 5% level. However, the signs and magnitudes of the other coefficients conform to a priori expectations. Diminishing returns to extra land are indicated and the over-all returns to scale are estimated to be 0.78, which suggests that expansion of the industry may be rather limited for physical reasons. On the other hand, the equation implies an MVP for land in the $60-100 per acre range, which is somewhat higher than current rents and suggests a considerable expansion when land restrictions are removed at EEC sugar beet prices. The actual expansion depends on the MVP of land for other uses and such an "alternative-use" MVP would have to be estimated for meaningful projections. The equation gives a yield elasticity with respect to price of 0.44. Were all inputs variable and all input supplies perfectly elastic at current prices, the supply elasticity would equal (1/1-r), where r is returns to scale. In this case supply elasticity would be 4.60 and this may be treated as an upper bound.[8] (See Table 5.2 for a summary of estimated elasticities for EEC).

Supply from Other Western European Nations

This section and that which follows are briefer than those on the EEC, due both to less data and less interest in policies. Table 5.3 lists the remaining beet producers of Western Europe and gives production, consumption and self-sufficiency for 1974.

Only in Turkey and Spain was production in excess of 500,000 tons in 1974 and Austria was the only net exporter of sugar in that year. The

[8] In the complete model the following elasticities were assumed for the U.K.: sugar price, 1.00; fertilizer price, -0.50.

Table 5.2. Summary of Estimated Elasticities for EEC

Country	Elasticity		
	Own Price	Input Price	Alternative Prod. Price
Belgium	0.30	-0.30	-
Denmark	1.30	-1.65	-
France	1.63	-2.09#	-
W. Germany	0.87	-0.10#	-0.61 (wheat)
Ireland	-	-	-
Italy	0.57	-0.55	-0.03 (apples)
Netherlands	1.14	-3.87#	-0.29 (potatoes)
United Kingdom	0.44*	-0.27*	-

#fertilizer price rather than index of input prices

*for yield only

Table 5.3. Production, Consumption and Self-Sufficiency in 1974 for Other Western European Countries

Country	Production	Consumption	% Self-Sufficiency
	('000 Metric Tons Raw Value)		
Austria	403	383	105
Finland	82	216	38
Greece	187	240#	78
Portugal	9	270#	3
Spain	667*	1000#	64
Sweden	301	382	79
Switzerland	72	287	25
Turkey	834	898	93

#estimated

*includes 29 thousand tons from cane

general aims of policy in these countries have been self-sufficiency (Austria, Turkey), to increase self-sufficiency (Greece, Spain), farm welfare through protection (Sweden), strategic considerations (Finland and Switzerland) and reliance on colonial supplies (Portugal).

An attempt at modeling supply was made only in the cases of Spain, Turkey and Greece, supply in the other countries being assumed fixed or made merely time dependent in the complete model. In Spain the industry is closely controlled by governmental agencies which regulate tonnage, price and location. The level of beet production has been relatively stable while cane production has not yet proved successful in any part of the country. There is a quota on total production of 92% of domestic demand, but this has never been binding. All estimated equations using the farm sugar price proved to be nonsignificant and had a priori incorrect signs. The only reliable equation was:[9]

$$(5.13) \quad \log Q_{1t} = 3.2773 + \underset{(6.366)}{0.0475}\, T$$

$\bar{R}^2 = 0.664$

$DW = 1.176$

$N = 21$

In Turkey the industry is controlled by the Sugar Corporation which fixes prices at all levels. There is a quota, which is equal to

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[9] Q_1 = thousand metric tons of sugar, raw value.

T = year, e.g., 1966 = 66.

P_1 = the on-farm sugar price.

PLAB = the agricultural wage scale.

110% of domestic consumption, designed to ensure self-sufficiency in most seasons. The only equation which gave "reasonable" results was:

$$(5.14) \quad \log Q_{1t} = \underset{(1.026)}{1.5617 + 0.0004} \log (P_{1t-1}/PLAB_t) = \underset{(1.924)}{0.0343} \, T + \underset{(1.891)}{0.4090} \log Q_{1t-1}$$

$\bar{R}^2 = 0.788$

$L = -0.264$

$N = 20$

In Greece the sugar industry was only established in 1961 and has expanded almost every year since. Estimated equations with price included had nonsignificant coefficients and the following time relationship was deemed more appropriate for projections:

$$(5.15) \quad Q_{it} = -750.0545 + \underset{(5.189)}{12.8000} \, T$$

$\bar{R}^2 = 0.722$

$DW = 1.357$

$N = 11$

Supply from U.S.S.R. and Eastern Europe

The situation in 1974 for the U.S.S.R. and Eastern Europe is depicted in Table 5.4. There was a relatively low degree of self-sufficiency in these countries, only Czechoslovakia and Poland being (minor) net exporters in 1974. Before the Cuban embargo of 1960, imports to Eastern Europe came largely from Western Europe (e.g., U.K. and Italy), but this situation was completely changed in the post-1960 period. Table 5.5 shows the importance of Cuban exports to the

Table 5.4. Production, Consumption and % Self-Sufficiency in 1974 for Communist Europe

Country	Production	Consumption	% Self-Sufficiency
	('000 Metric Tons Raw Value)		
Albania	19	36	53
Bulgaria	210#	550#	38
Czechoslovakia	750	653	115
East Germany	570	750	76
Hungary	290	500	58
Poland	1600*	1550*	103
Roumania	560#	575#	97
U.S.S.R.	8526	11250	76
Yugoslavia	425#	620#	69

#1973

*estimated

region for the years 1964, 1959 and 1974. Such exports always exceeded two million tons, mostly going to the U.S.S.R. However, over the same years there were agreements covering three million tons to the U.S.S.R. alone. The approximate prices for these exports were 4 cents per lb. in 1961, 6 cents per lb. 1965-70, between 6 and 11 cents per lb. in 1971-73, 11 cents per lb. in 1973-74 and 20 cents per lb. after mid 1974.[10] It appears that Eastern Europe was a residual market for Cuban exports, willing to accept up to approximately four

[10]Sources: I.S.O. (1963). Op. cit.; Personal Communication with Personnel in U.S.D.A., E.R.S.; New York Times, 26th January, 1975.

Table 5.5. Cuban Exports to Communist Europe ('000 Metric Tons Raw Value)

Country	1964	1969	1974
Albania	11	0	13
Bulgaria	87	205	190
Czechoslovakia	52	224	160
East Germany	81	253	276
Hungary	0	17	51
Poland	32	28	28
Roumania	0	69	78
U.S.S.R.	1937	1352	1975
Yugoslavia	43	67	50
Total	2243	2215	2821

million tons annually but only importing less than three million tons per annum. The importance of Cuban exports during this period was that they allowed domestic consumption to rise dramatically, e.g., from 27.7 kg. per head in the U.S.S.R. in 1959, to 44.5 kg. per head in 1974. Market forces are at work in Communist as in other countries with respect to international trade (via the market for foreign exchange) and the response to higher import prices by these countries might be expected to be lower imports and some domestic rationing. However, demand is likely to be very inelastic since the political consequences of rationing so "basic" a commodity as sugar could be considerable. Just as the U.S.S.R. has imported wheat in the 1970s, so it has for the past decade imported sugar to maintain per capita consumption. In 1974 the U.S.S.R. imported only from Cuba, but in 1973 it imported 1,208 thousand tons from other sources (including 458,000 tons from Brazil).

The above discussion leads to the hypothesis that the Communist countries of Europe are responsive to world sugar prices both in encouraging domestic supply and discouraging domestic demand. Demand considerations are discussed in Chapter VII, but below the results of estimating supply functions for four of these countries are presented as well as a time-dependent equation for the five remaining countries as a group.

Czechoslovakia

$$\log Q_{1t} = 5.2340 + \underset{(0.089)}{0.0066} \log P_{1t-1}{}^{\dagger} + \underset{(0.867)}{0.2159} \log Q_{1t-1} \tag{5.16}$$

$\bar{R}^2 = 0.000$

$h =$ n.a.

$N = 21$

East Germany

$$\log Q_{1t} = 5.2028 + \underset{(2.214)}{0.2710} \log P_{1t-1} + \underset{(0.677)}{0.1419} \log Q_{1t-1} \tag{5.17}$$

$\bar{R}^2 = 0.232$

$h =$ n.a.

$N = 21$

$^{\dagger}P_1$ is world free-market price in cents per lb.

Poland

$$(5.18)\quad \log L_{1t}^{\dagger} = 1.6528 + \underset{(2.455)}{0.0931} \log P_{1t-1} + \underset{(1.244)}{0.0037}\, T + \underset{(3.197)}{0.6679} \log L_{1t-1}$$

$\bar{R}^2 = 0.643$

$h = 1.071$

$N = 21$

U.S.S.R.

$$(5.19)\quad \log Q_{1t} = 1.9919 + \underset{(1.264)}{0.1273} \log P_{1t-1} + \underset{(1.455)}{0.0227}\, T + \underset{(2.514)}{0.5971} \log Q_{1t-1}$$

$\bar{R}^2 = 0.839$

$h =$ n.a.

$N = 21$

Rest of Eastern Europe

$$(5.20)\quad Q_{1t} = -1984.2778 = \underset{(6.952)}{51.4591}\, T$$

$\bar{R}^2 = 0.693$

$DW = 1.340$

$N = 22$

$^{\dagger}L_1$ is land area in thousand hectares.

Taking the results in order, Czechoslovakia showed negligible price response, its production being stable over the period of observation. East Germany gave a significant (5%) price coefficient, although representing an elasticity of only 0.27 in the short run and 0.32 in the long run. Poland gave nonsignificant results with quantity equations but the land equation (as shown) gave a small but significant short-run price elasticity of 0.09 which would be 0.28 in the long run. The U.S.S.R. gave an elasticity, (not significantly different from zero at 5% level), of 0.13 short run and 0.32 long run. Finally, the output of the remaining five countries was strongly time dependent.

In summary, Communist Europe is an important importer of sugar and not just from Cuba. The hypothesis that domestic supply in these countries was related to world sugar prices could not be rejected for (at least) East Germany and Poland. Estimated price elasticities were of the order of 0.3.

Summary

In this chapter equations were derived for predicting the supply of sugar from the major European producers as a function of the price of sugar, the prices of agricultural inputs, technology and the prices of competitive products. Particular attention was devoted to a discussion of the sugar policy of the EEC, as this affected specification and was relevant to policy runs of the complete model in which free trade was analyzed. Estimated price elasticities of supply were of the order 0.3 - 1.6 for the EEC countries and approximately 0.3 for most of the Communist countries.

CHAPTER VI

THE INTERNATIONAL SUPPLY OF CANE SUGAR

Introduction

As was discussed in Chapter I, cane sugar is produced by a large number of countries within certain latitudes and it accounted for 59% of total world sugar production in 1973. However, since beet production is mainly concentrated in Europe and North America and the sugar domestically consumed, raw cane sugar is overwhelmingly dominant in international trade. This chapter reports the results of estimating supply functions for all of the world's major cane producers (excluding the U.S.A. which was covered in Chapter IV). The chapter begins with theory and models, then passes to data, estimation and results and concludes with a discussion and summary.

Theory and Models

The characteristics of cane supply to be modeled may be described as technical, economic and political, although their exact division into such categories is not possible. Beginning with the technical, the growing period for cane from the young shoot is one to two years and thereafter ratoon crops may be harvested every one to two years until the yield declines so much that replanting becomes necessary (from three years to thirty years after planting). The perennial nature of cane production requires that its supply be modeled in two steps. Firstly, the investment decision may be modeled, i.e., the decision to plant cane, and secondly the decision on quantity to produce per hectare of cane may be modeled. These decisions are taken in different periods and hence may be modeled independently, even though yield per hectare may be dependent upon the total area in production. This contrasts with the approach to modeling the production of beet, an annual, and some theoretical considerations on separation of supply into "yield" and "area" decisions are discussed in Appendix A. If cane production is viewed as mainly involving an investment decision to plant, the key to understanding the cyclical nature of sugar prices may have been found. In Chapter I the six to nine year cycle of price in the world "free market" was discussed. This cycle is the result both of lags in investment decisions and the fixity of assets once invested. Investments in planting cane and in mills are made in response to high prices. The delay between the price signal and new output is of the order of two to five years. Should price fall, once the new investment has been made, the opportunity cost of the cane and mills is very low, hence production will be maintained as long as variable costs are covered by returns. Such an occurrence is sometimes called "asset fixity" and the capital which, before investment, was viewed as "putty," after investment may be termed "clay."

An additional inducement to a cyclical supply, or, more correctly, a cyclical <u>expansion</u> of supply, is political in nature. The sugar industry in most countries operates under government regulation. Producers receive the pooled price of sugar from all markets, both domestic and international; i.e., they receive the <u>average</u> rather than the <u>marginal</u> return. Since the average return exceeds the marginal

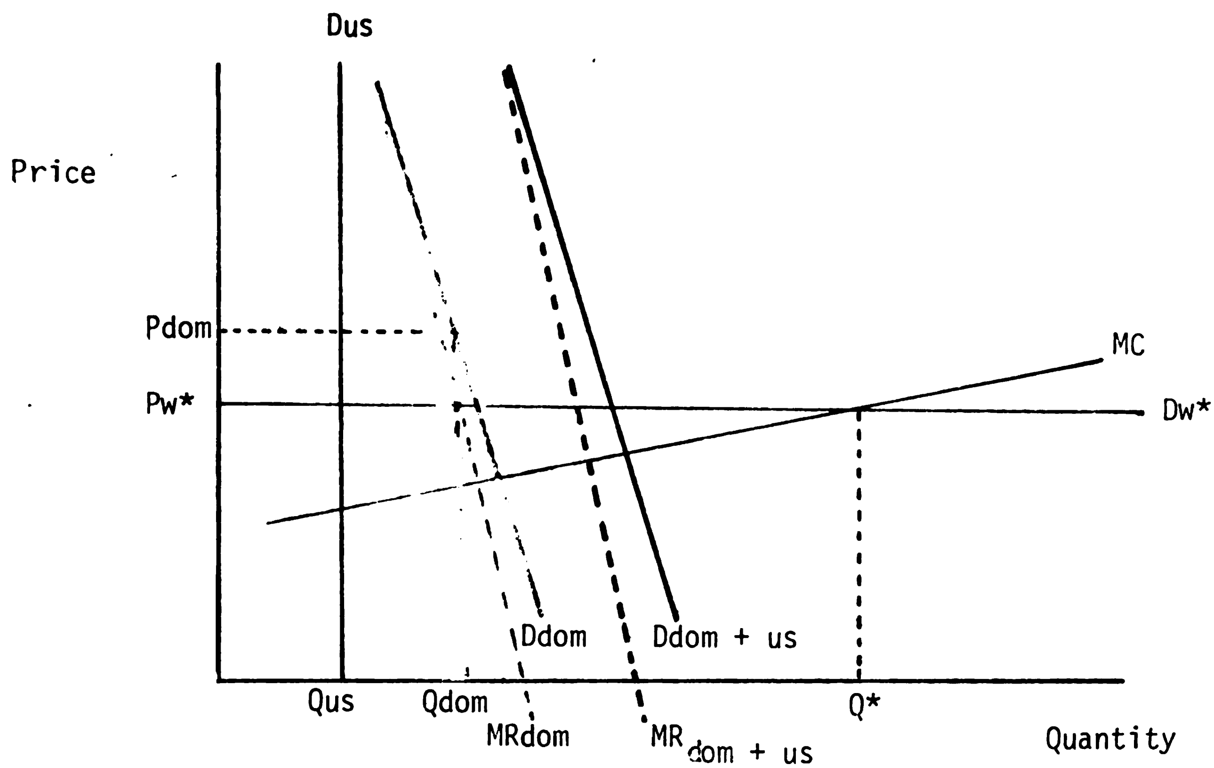
return, producers would expand production until marginal costs and average return were equated unless (as is the case), there were governmental restrictions on output. Such restrictions may be on land, on output, or on both. This regulation reduces the uncertainties facing the producer but also further delays the response to high international prices and mitigates against contraction when prices fall.

As a preliminary to supply estimation for all countries, a relatively detailed study of supply in Brazil was made. Brazil was chosen as it is the largest single producer of cane sugar in the world, accounting for 15% of all cane sugar production in 1973. Production in Brazil is regulated by the Institute of Alcohol and Sugar (IAA) which was established in 1933. The IAA has the power to fix prices and allocate quotas and is the sole exporter of sugar. The situation governing supply and demand in Brazil, were national profits to be maximized, is examined from a static viewpoint in Figure 6.1.

The figure portrays the situation when Brazil has a U.S. quota. shown as the completely price-inelastic demand Dus. In addition, there is a domestic demand, Ddom, and an expected world "free market" demand of DW*. Should the IAA act to maximize "Brazilian profits" in toto, it would fix the quota on production at Q* where marginal costs and returns are equal and which would result in a domestic price of Pdom, somewhat above the world price. Producers would receive some mix of world, domestic and U.S. prices.

As PW*, the expected world price, and MC, the marginal cost curve, cannot be identified, Figure 6.1 does not lead to an estimable system of equations. In addition, for Brazil there is strong evidence that the

Figure 6-1 Brazilian Supply and Demand System



Key: Dus is U.S. quota-demand

Ddom is domestic demand

Ddom + us is domestic plus U.S. demand

MRdom is marginal return in domestic market

MRdom + us is marginal return in domestic and U.S. markets

Pdom is domestic price

Qdom is domestic quantity demanded

MC is marginal cost of production

Dw* is expected free-market demand

Pw* is expected free-market price

Qus is quota supply to U.S.

quota has regularly been fixed at an output above Q* -- producers have first planted their cane and then brought political pressure to increase the quota accordingly. This may be contrasted with the more rigid quota system of Australia, where profit maximization may well have been the chief influence in fixing the quota.

Because it was not possible to identify the appropriate behavioral assumption for each country, no such assumption could be incorporated in the cane-investment equations. Some exploratory work with a partial adjustment model confirmed the finding of Choudhury[1] that such a model was not very suitable for cane supply. Similarly, polynomial lag models did not perform much better. Instead, attention was concentrated on developing a simple investment function capable of generating price cycles through the lags in investment and fixity of assets. The general relationship between hectares of cane and a set of prices may be written,

(6.1) $HAt = f_{HA} (PPt^*, Pmx_t, PIN_t^*, PALT_t^*)$

where: HA = hectares of cane

PP* = expected average or "pool" price from all markets

Pmx_t = maximum value of PP* ever existing

PIN* = expected input price

PALT* = expected price of a product competing with sugar cane for resources

and t = year

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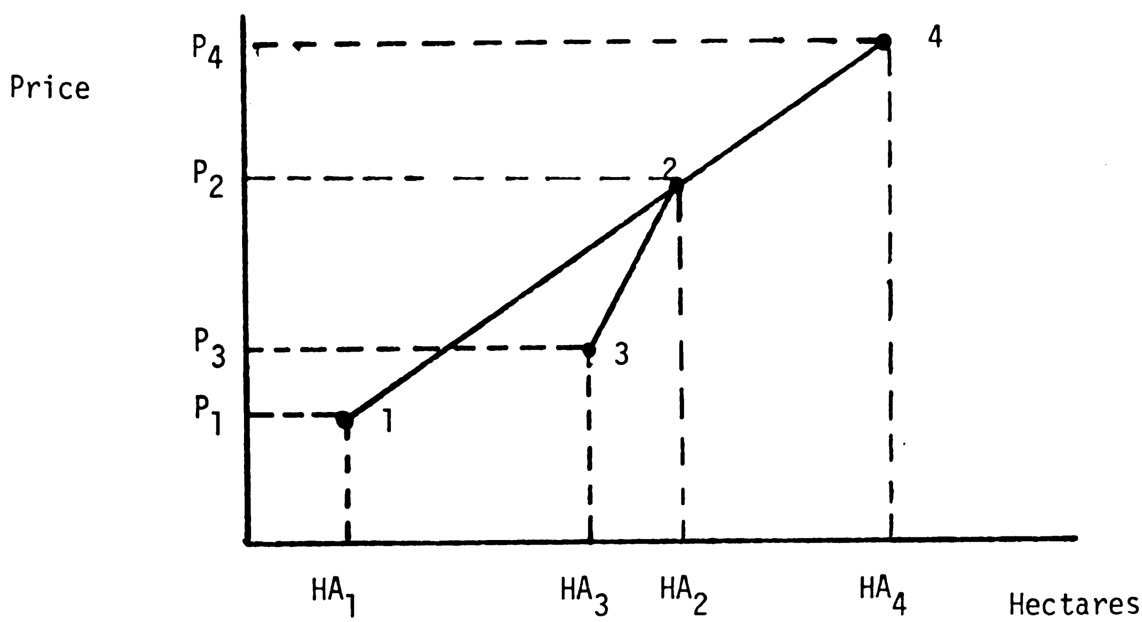
[1]Choudhury, (1967). Op. cit.

Note that all prices are in "real" terms. The expected effect of asset fixity is that response to a rising price, whenever price exceeds the previous maximum, will be more elastic than response to a fall in price.

Figure 6.2 demonstrates the "ratchet effect" which is the consequence.

Figure (6-2) Asymmetric Investment Function



Suppose price P_1 results in the planting of HA_1 hectares of cane. Price then rises to P_2 which leads to an increase in planting to HA_2. Price then falls to P_3 but, due to the low opportunity cost of the cane and fixed facilities, the area in cane falls only to HA_3 and there is no return along the expansionary part of the function. If price then rises to P_4, there is an expansion to HA_4 along the path 3..2..4.

To make f_{HA} in Equation (6.1) conform to these asymmetric requirements and to make expected prices estimable, the following assumptions were made.[2] Dropping PIN_t^* and $PALT_t^*$ to simplify the exposition, rewrite (6.1) as

$$(6.2) \quad (HA_t/PP_t^*) = \beta_0 + \beta_1 \, (PP_t^*/Pmx_t)$$

which states that the ratio of cane area to expected price is a linear function of the ratio of expected price to previous highest price. Now assume that adjustment to the cane area/price ratio is only partial so that,

$$(6.3) \quad (HA_t/PP_t^*) - (HA_{t-1}/PP_{t-1}) = [(HA_t/PP_t^*)^{\#} - (HA_{t-1}/PP_{t-1}^*)].$$

Equation (6.3) is the familiar partial adjustment model, where # denotes a desired value and $0 \leq \gamma < 1$. Combining Equations (6.3) and (6.2) leads to,

$$(6.4) \quad (HA_t/PP_t^*) = \beta_0\gamma + \beta_1\gamma(PP_t^*/Pmx_t) + (1 - \gamma) \, (HA_{t-1}/PP_{t-1}^*).$$

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[2]The development here is analogous to that in Griliches, Z. et al. (1962). "Notes on Estimated Aggregate Quarterly Consumption Functions," Econometrica, 30, (3), pp. 491-500.

The next step is to make PP* explicit. Usually the lag between first harvest and planting is two years and it was assumed that price expectations were 75% derived from price at t-2 and 25% from price t-1, i.e.,

(6.5) $PP_t^* = 0.25\ PP_{t-1} + 0.75\ PP_{t-2}$.

Equation (6.5) is equivalent to a particular kind of the inverted-v lag well known in investment studies,[3] although it is further modified in the present work by the incorporation of a partial adjustment system as well. Where cane growing rather than harvested was used as the basis for HA_t, the lag was assumed to be of only one year's duration, i.e.,

(6.5)' $PP_t^* = PP_{t-1}$.

One way of viewing the combination of Equation (6.5) with the partial adjustment system (6.3) is to consider Equation (6.5) as the biological lag and (6.3) as the technical delay in expanding mill capacity. The ability of Equation (6.4) to generate price cycles under the condition of a continuously expanding demand is discussed in Appendix B, where analogies with a cobweb system are reviewed. The elasticity of area in cane from Equation (6.4) may be found by clearing PP_t^* to the right-hand side and taking the necessary derivatives. Should $PP_t^* \geq Pmx_t$, i.e., price be rising and greater than or equal to its previous maximum, the derivative of area with respect to price is,

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[3]"Inverted-v" lags were introduced in De Leeuw, F. (1962). "The Demand for Capital Goods by Manufacturers: A Study of Quarterly Time Series," Econometrica, 30, (3), (July), pp. 407-423.

(6.6) $\partial HA_t/\partial PP_t^* = \beta_0\gamma + \beta_1\gamma + (1 - \gamma)\ (HA_{t-1}/PP^*_{t-1})$.

Should PP^*_t be less than Pmx_t , the area elasticity is,

(6.6)' $\partial HA_t/\partial PP^*_t = \beta_0\gamma + 2\beta_1\gamma\ (PP^*_t/Pmx_t) + (1 - \gamma)\ (HA_{t-1}/PP^*_{t-1})$.

Since it is expected that $\beta_1 < 0$, the derivative (6.6)' will be smaller than that in (6.6) and the corresponding elasticity, defined as $[(\partial HA_t/\partial PP^*_t)\ (PP^*_t/HA)]$, will be smaller. This is consistent with Figure (6.2).

Before estimation, input prices and the price of a competitive product may be reincorporated into Equation (6.4), assuming the same lags for these two prices as for sugar, which leads to,

$$(6.7)\quad (HA_t/PP_t^*) = \beta_0\gamma + \beta_1\gamma\ (PP_t^*/Pmx_t) + \beta_2\gamma\ (PP_t^*/PIN_t^*) + \beta_3\gamma\ (PP_t^*/PALT_t^*) + (1 - \gamma)\ (HA_{t-1}/PP^*_{t-1}) + E_t.$$

In Equation (6.7) an error term has also been incorporated, as a preliminary to estimation. The properties of this error term are very difficult to ascertain. No doubt (HA_t/PP^*_t) is autocorrelated and the partial adjustment procedure may or may not have reduced this autocorrelation. As noted in Chapter III, estimation by OLS of an equation such as (6.7) which has an autocorrelated disturbance and which has a lagged dependent variable on the right-hand side will not normally give consistent estimates. Our knowledge of the behavior of E_t is such that it has been assumed not to be autocorrelated, in which case OLS gives consistent and asymptotically efficient estimates.[4] OLS estimation

[4]See Kmenta, J. (1971). Op. cit., pp. 487.

of Equation (6.7) for each of the countries was the basis of our results on cane investment.[5]

Yield may be hypothesized to be a function of sugar price, input price, area harvested and technology, i.e.,

$$(6.8) \quad YLD_t = f_{YLD}\ (PP_{t-1},\ PIN_{t-1},\ HA_t,\ T_t).$$

where YLD = yield of sugar per hectare

PP = sugar price

PIN = input price

HA = hectares of cane

T = technology

t = a time subscript

and all prices are in real terms.

In Equation (6.8) prices at t-1 have been assumed to be those relevant. Assuming f_{YLD} to be linear and adding an error term λ_t, one obtains

$$(6.9) \quad YLD_t = \alpha_0 + \alpha_1 PP_{t-1} + \alpha_2 PIN_{t-1} + \alpha_3 T + \alpha_4 HA_t + \lambda_t.$$

This yield equation was estimated by OLS for each country.

Summarizing this section, for each country equations for cane-investment (Equation (6.7)) and yield (Equation (6.9)) were estimated by OLS. As input prices and prices of alternative products proved nonsignificant or had spurious signs in almost all cases, the final system could be considered to be Equations (6.4) and (6.9).

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[5]There is an implicit restriction on the long-run investment elasticity in this approach which limits its maximum to a value of unity. This can be shown by multiplying Equation (6.6) by the inverse of (6.4).

Data and Results

Data on the major variables were obtained from the F.A.O.,[6] statistical yearbooks of the various countries and from a variety of national sugar periodicals.[7] The data which were collected included price series for labor, machinery and fertilizer and any available information on planned or current expansion of facilities. However, such data added little to the reliability of the estimates from the statistical viewpoint and are therefore omitted from further consideration. Because input prices were omitted from the most reliable equations, it was necessary to deflate all prices into real (1974) U.S. dollars. In addition, since domestic sugar prices were difficult to obtain at wholesale, only export prices from the principal markets [U.S.A., Commonwealth and Free Market (f.o.b. New York)] were used to derive the pooled price received by each country for its sugar. For countries which were importers (e.g., Japan), the free-market price was used. For some countries data on land area were not available and in such cases the investment Equation (6.4) was estimated with quantity of sugar in place of hectares of cane and no yield equation was estimated.

Table 6.1 presents the results for the 28 countries (or regions) from estimating the cane-investment Equation (6.4). The data related to the period 1948-72, hence 22 observations were normally included after dropping three observations to initialize the lags in response. The proportion of variance in (HA_t/PP^*_t) explained by the equations was

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[6] Production Yearbook, Op. cit.

[7] Reviewed at the I.S.O. in London and the French Manufacturers' Organization in Paris.

Table 6.1. Cane Investment Equations

Country	$\beta_0\gamma$	S.E.	$\beta_1\gamma$	S.E.	$(1-\gamma)$	S.E.	$\bar{R}^2$	h*	N	Mean PP^*_t/PMX_t	Mean HA_t/PP^*_t	Short-Run Investment Elasticity	Long-Run Investment Elasticity
Aregentina	46.3158	(8.9646)	-30.0537	(8.3464)	0.5232	(0.1114)	0.812	3.804	22	0.706	38.773	0.296	1.007
Australia	48.1616	(7.9826)	-46.7868	(8.1325)	0.4947	(0.0942)	0.942	3.330	22	0.676	31.179	0.011	0.539
Barbados	3.2378	(0.7911)	- 2.3512	(0.5529)	0.5287	(0.1368)	0.936	1.659	20	0.778	2.897	0.383	0.835
Bolivia & Chile[1,2]	58.9871	(14.3634)	-74.5606	(20.0553)	0.6203	(0.1069)	0.864	2.217	22	0.571	38.123	-0.066	0.212
Brazil	290.3890	(45.2711)	-241.9839	(43.2507)	0.4613	(0.0963)	0.859	2.479	21	0.684	225.626	0.281	0.676
China-Taiwan	30.2881	(4.1425)	-25.1200	(3.9378)	0.1628	(0.1223)	0.831	2.494	19	0.546	19.738	0.308	0.424
Colombia	6.7489	(1.8868)	- 5.8283	(1.8700)	0.6892	(0.1060)	0.835	1.916	22	0.700	7.806	0.508	0.807
Cuba	376.2057	(61.1289)	-345.4885	(60.1326)	0.3508	(0.1178)	0.865	0.003	22	0.648	229.154	0.039	0.485
Dominican Republic[3]	37.2931	(5.2282)	-31.0342	(5.1204)	0.2584	(0.1175)	0.763	0.576	22	0.732	19.519	-0.159	0.579
Fiji	7.2134	(1.9072)	- 6.8717	(1.9063)	0.6651	(0.1041)	0.933	1.365	22	0.746	5.585	0.121	0.726
Guatemala	5.6735	(1.1770)	- 3.0368	(0.9926)	0.2308	(0.1610)	0.423	2.542	20	0.769	4.300	0.464	0.844
Guyana	10.0230	(2.7105)	- 8.0917	(2.5244)	0.3789	(0.1612)	0.736	0.352	20	0.772	5.990	-0.034	0.701
India[3]	588.7980	(54.1298)	487.3653	(52.0954)	0.2630	(0.0825)	0.875	1.798	22	0.619	385.866	0.225	0.526
Indonesia	39.0081	(5.4300)	-41.6582	(6.4813)	0.3459	(0.1010)	0.890	0.447	19	0.517	26.041	0.190	0.244
Iran[1]	74.4989	(24.5818)	-91.2884	(33.5141)	0.7404	(0.1031)	0.892	2.761	21	0.559	72.284	0.359	0.508
Jamaica	9.5953	(2.5407)	- 6.6875	(2.3215)	0.5217	(0.1332)	0.648	1.913	22	0.768	9.140	0.448	0.840
Japan[1,2]	95.2820	(29.2527)	-116.5271	(39.6954)	0.7026	(0.1036)	0.888	3.356	21	0.559	85.844	0.295	0.455
Mauritius	18.2007	(2.2087)	-14.2713	(1.7425)	0.3833	(0.0878)	0.951	1.693	22	0.755	11.807	0.100	0.716
Mexico	26.9632	(10.8648)	-26.1228	(12.5095)	0.9135	(0.9752)	0.881	0.153	22	0.794	47.773	0.610	0.931
Nicaragua	4.2091	(1.2245)	- 4.0584	(1.2804)	0.7847	(0.1279)	0.728	1.073	22	0.853	2.965	-0.131	0.836
Peru	5.9025	(1.5847)	- 4.0266	(1.1918)	0.5922	(0.1235)	0.699	1.057	22	0.774	6.664	0.543	0.874
Philippines	24.8275	(12.8026)	-24.5710	(12.5926)	0.9157	(0.1316)	0.741	-0.498	22	0.670	25.364	-0.679	0.178
South Africa	63.6174	(8.4031)	-63.9327	(8.8258)	0.1909	(0.1110)	0.937	1.876	22	0.670	25.364	-0.679	0.178
Thailand	45.5105	(5.5183)	-42.5551	(6.6123)	0.2379	(0.1152)	0.714	0.278	21	0.657	22.773	-0.217	0.368
Trinidad & Tobago	8.2546	(1.0249)	- 6.3265	(0.8302)	0.3563	(0.0903)	0.925	1.812	22	0.781	5.0796	0.036	0.736
Venezuela	11.3660	(3.5270)	- 9.8064	(3.4543)	0.8135	(0.0949)	0.893	-1.388	22	0.901	5.925	-0.451	0.877
Central America[1]	41.3728	(16.1140)	-40.1663	(17.2084)	0.8231	(0.0972)	0.934	2.582	22	0.741	44.691	0.417	0.850
Paraguay & Uruguay	22.2308	(3.8777)	-24.4171	(4.6067)	0.5789	(0.0894)	0.917	1.228	21	0.559	18.548	0.306	0.461

[1] Dependent variable is Q_t/PP^*_t rather than HA_t/PP^*_t.

[2] Includes some sugar-beet also.

[3] Hectares growing and not hectares harvested used.

[4] Durbin's h is a test for serial conolation for large samples. h is a standard normal deviate for which the 5% level of significance for a one-tail-test has $h \geq 1.66$

generally favorable and the standard errors of the coefficients (S.E.) were generally small in relation to the coefficients. However, according to the h-statistic, many of the relations were significantly autocorrelated. As expected, $\beta_0\gamma$ was in all cases positive, $\beta_1\gamma$ was in all cases negative and $(1 - \gamma)$ was in most cases significantly different from zero (at the 5% level). As $\beta_1\gamma$ was in all cases significantly (5% level) different from zero, asymmetric response to high ($PP_t^* \geq Pmx_t$) as compared with low ($PP_t^* < Pmx_t$) prices may be said to have been universally present. At the right-hand side of Table 6.1 are listed the short- and long-run investment elasticities at their means for the sample period. These elasticities were derived from the derivatives (6.6)' and (6.6) respectively. The short-run elasticities range in value from -0.679 for South Africa to 0.610 for Mexico and the long-run elasticities range from 0.212 for Bolivia and Chile to 1.007 for Argentina. The long-run elasticities seem to be "reasonable" in magnitude, but the seven negative short-run elasticities, implying an increase in supply as price falls (over a limited range), require some explanation. The large negative values for South Africa and Venezuela are probably spurious, although some fixed-asset theories would be consistent with an expansion of output when prices fall once fixed assets had been committed.[8] The other four negative short-run elasticities are close to zero and not therefore of great importance. Indeed, the important features are that the long-run elasticities are of acceptable magnitude and <u>larger</u> than the short-run elasticities.

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[8]Johnson, G. L. and Quance, L. (1972). <u>The Overproduction Trap in U.S. Agriculture</u>. Baltimore: Johns Hopkins Press for Resources for the Future, Inc.

Some comparisons may be made with the results from other researchers. Choudhury,[9] using OLS estimation of geometric lags, found only two of his nine chosen countries to have significant long-run price elasticities, those being 1.13 for Mexico and 2.29 for Nicaragua. The present results are lower in magnitude. Ilag[10] found an elasticity of 1.09 for the Philippines (c.f., 0.92 here). Fan[11] gave estimated supply elasticities for Taiwan in the range 2.47 - 2.75 (c.f., 0.42 here). Hughes[12] projected an unrestricted elasticity of supply of 3.5 for large farmers in Brazil in 1969 (c.f., 0.67 here). All of these results indicate, if anything, that the elasticities estimated in this research are conservative.

It is outside the scope of this research to report on specific influences on supply other than price and to discuss in detail policy and projected capacity for each country. For such information the reader is directed to the Attachê Reports made available by the Foreign Agriculture Service of the U.S.D.A. and to the International Sugar Organization's "World Sugar Economy"[13] of which a new edition is

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[9] Choudhury, P. (1967). Op. cit.

[10] Ilag, L. M. (1970). An Econometric Analysis of the Impact of the U.S. Sugar Program on the Philippine Sugar Industry. Unpublished Ph. D. Dissertation, Purdue University.

[11] Fan, C. L. (1967). Determination of Sugar Supply Functions in Taiwan. Unpublished Ph. D. Dissertation, University of Hawaii.

[12] Hughes, H. (1971). Analysis of Sugar Cane Production in Sao Paulo. Unpublished Ph. D. Dissertation. University of Missouri-Columbia.

[13] International Sugar Organization. (1963). The World Sugar Economy: Structure and Policies. London: International Sugar Organization.

being compiled. To further justify the estimated investment equations, however, Figure 6.3 plots actual and estimated area/price ratios for four of the world's largest exporters, Australia, Brazil, Cuba and the Philippines. Turning points are well captured and magnitudes are convincing in all four cases. It is interesting to contrast the cyclical nature of HA_t/PP^*_t in the three other countries with the stability of this ratio for the Philippines, this result being due to Philippine access for most of its sugar to the high-priced and relatively stable U.S. market during this period.

Table 6.2 presents the estimated yield equations for the 23 countries which had data on both area and yield. The price of fertilizer was omitted from the table since it was never significantly different from zero at the 5% level and often had a spurious sign: the constant, α_0, was adjusted accordingly. The influence of price at (t-1) was also mostly of low significance and omitted. The two important effects were a time trend, as a proxy for technology and other omitted influences, and diminishing returns to the cultivation of a larger area of cane.

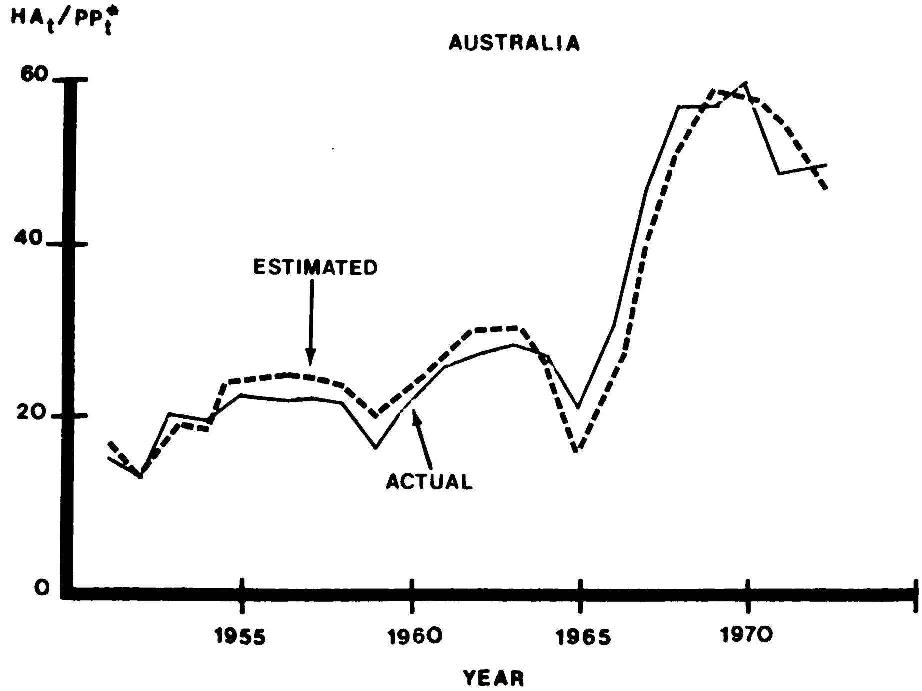
Combining area and yield equations gave estimates of over-all supply, although yield had only a minor influence on responsiveness to alternative prices. Table 6.3 presents short-run elasticities of supply computed by combining yield and area equations at an export price of 6 cents per lb. (in 1974 dollars) and using 1972 as a base year. Long-run elasticities are not listed, since they reach a maximum of unity at high prices.

Table 6.2. Yield Equations for Cane[1]

Country	α_0	α_1	t value	α_3	t value	α_4	t value	$\bar{R}^2$	DW	N
Argentina	-5.2074	0.0935	(1.389)	0.1345	(8.050)			0.843	2.289	22
Australia	-1.8927			0.2082	(2.720)	-0.0061	(0.511)	0.638	1.954	22
Barbados	18.2167			-0.1582	(4.138)			0.459	2.020	22
Brazil	2.88714			0.1334	(4.083)	-0.0016	(2.388)	0.839	1.572	22
China-Taiwan	9.9606			-0.0243	(0.775)			0.000	2.267	19
Colombia	-14.7805			0.4723	(4.072)	-0.1124	(2.117)	0.781	0.531	22
Cuba	8.1566			-0.0275	(0.948)	-0.0014	(1.462)	0.120	1.610	22
Dominican Republic	3.4060			0.0462	(2.148)			0.147	0.723	22
Fiji	6.9350									
Guatemala	-10.5203			0.2703	(8.134)	-0.0843	(2.807)	0.860)	1.084	20
Guyana	13.0229			-0.0856	(4.923)			0.550	1.754	20
India	-0.7090			0.0312	(5.401)			0.573	1.439	22
Indonesia	18.6995			-0.1890	(5.695)			0.636	1.013	19
Jamaica	-1.1829	0.4254	(2.177)	0.1135	(3.763)	-0.0356	(1.922)	0.412	0.863	22
Mauritius	11.8884			0.1747	(2.474)	-0.1992	(2.266)	0.166	2.368	22
Mexico	-4.2860			0.2095						
Nicaragua	-7.5807	0.2549	(2.164)	0.1636	(4.150	-0.0426	(1.268)	0.787	1.850	22
Peru	21.7978			0.0262	(0.309)	-0.1626	(2.833)	0.536	0.667	22
Philippines	1.0448			0.1297	(7.496)	-0.0132	(7.694)	0.794	1.069	22
South Africa	-2.2989			0.2132	(3.229)	-0.0169	(1.517)	0.467	1.735	22
Thailand	-6.1961	0.0567	(1.827)	0.1180	(5.683)			0.868	1.098	21
Trinidad & Tobago	0.1150	0.2804	(1.649)	0.0621	(1.340)			0.269	1.757	22
Venezuela	-12.3893			0.3240	(6.788)	-0.0491	(2.481)	0.829	1.008	22

[1]The equation was $YLD_t = \alpha_0 + \alpha_1 PP_{t-1} + \alpha_2 PFERT_{t-1} + \alpha_3 T + \alpha_4\ HA_t$; α_2 was not significantly different from zero in all cases.

FIGURE 6.3 ACTUAL AND ESTIMATED AREA/PRICE RATIOS FOR FOUR COUNTRIES



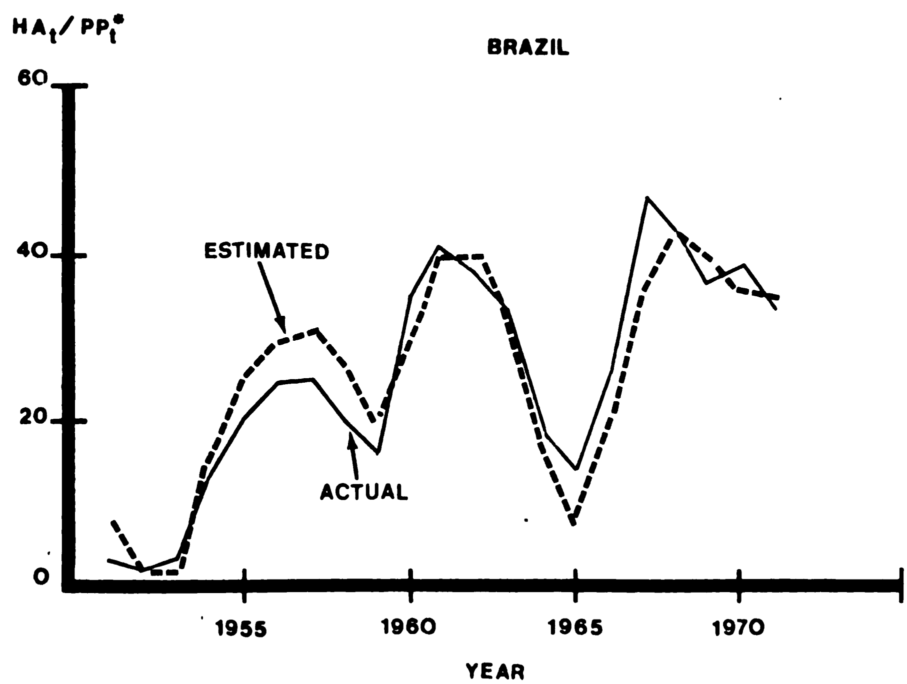
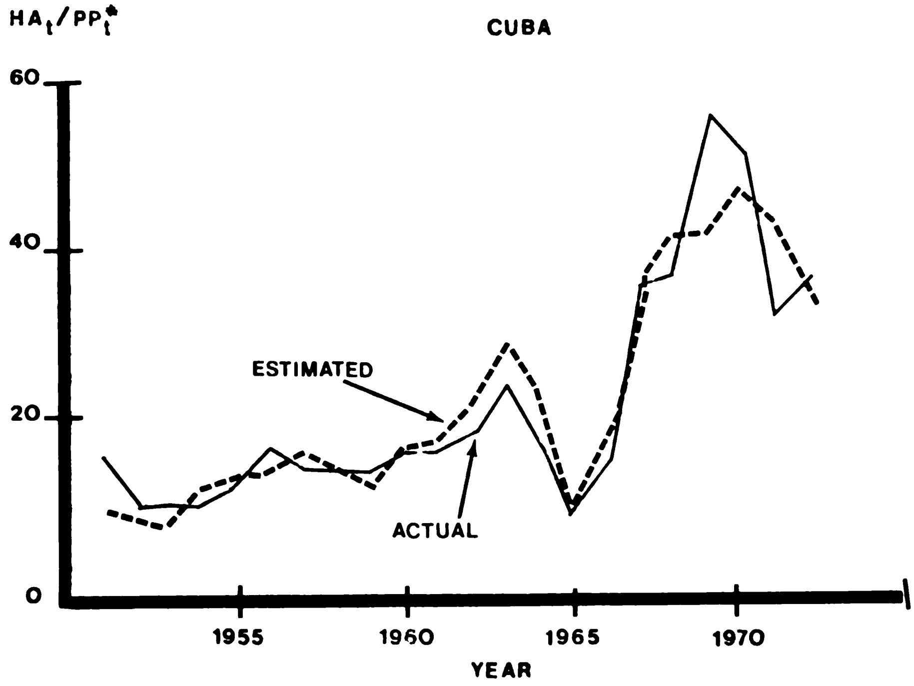


FIGURE 6.3 ACTUAL AND ESTIMATED AREA/PRICE RATIOS FOR FOUR COUNTRIES



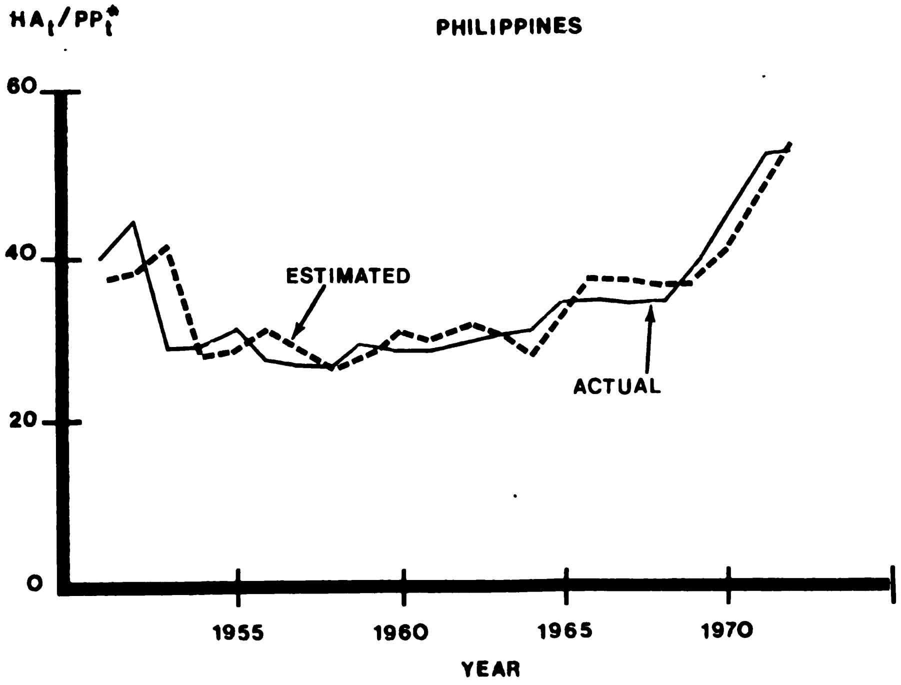


Table 6.3. Short-run Elasticities of Supply (at an export price of 6 cents per lb.)

Country	Elasticity
Argentina	0.4909
Australia	0.3705
Barbados	0.5932
Bolivia-Chile	0.2044
Brazil	0.4880
China-Taiwan	0.2492
Colombia	0.6750
Cuba	0.3416
Dom. Republic	0.2807
Fiji	0.5468
Guatemala	0.6524
Guyana	0.4207
India	0.3190
Indonesia	0.1000#
Iran	0.5444
Jamaica	0.6051
Japan	0.4267
Mauritius	0.4536
Mexico	0.7305
Nicaragua	0.5656
Peru	0.6875
Philippines	0.7390
South Africa	0.1000#
Thailand	0.1650
Trin.-Tobago	0.4323
Venezuela	0.5060
Central America	0.7621
Parag.-Uruguay	0.4405

#denotes minimum imposed

Summary

This chapter outlined the cyclical nature of cane supply due to asset fixity and developed asymmetric land investment and linear yield equations which were estimated for the 28 most important cane producers of the world. Significant asymmetry of response to low as compared with high prices was found. Using 1972 as a base year, at a price of 6 cents per lb. for exports the elasticity of supply ranged from less than 0.10 for South Africa and Indonesia to 0.76 for Central America. At prices above the previous maximum (of 10.68 cents per lb. in most cases), the elasticity of supply was constrained by the estimating procedures to a mazimum of 1.00.

In terms of significance of the relationships, the results compare very favorably with those of Choudhury, who found price to be a significant influence in only two of his nine chosen countries.

CHAPTER VII

THE INTERNATIONAL DEMAND FOR SUGAR

This chapter reports the procedures used in estimating the demand for sugar, both for more than eighty individual countries using time-series data and for seventy-three countries using pooled cross-section and time-series data. The discussion begins with a review of previous studies of a similar nature, passes thence to theory, estimation and results for individual countries' time series, then reports estimation and results for pooled cross-section and time-series data and finishes with a summary and some comments on further research.

Previous Studies

The definitive study of the international demand for sugar was made by Viton and Pignalosa of the F.A.O. in 1961.[1] They fitted consumption as a function of both price and income to international cross sections for the years 1938, 1951 and 1956. They also examined the degree of substitution between sugar and other carbohydrates in the diet and found little evidence of any such substitution. While the F.A.O. has made more recent estimates for individual countries, these have not been published and the F.A.O. projections of 1971[2] utilized income as

[1]Viton, A. and F. Pignalosa. (1961). Trends and Forces of World Sugar Consumption, Commodity Bulletin 32, Rome: United Nations Food and Agriculture Organization.

[2]F.A.O. (1971). Agricultural Commodity Projections, 1970-1980, Rome: United Nations Food and Agriculture Organization.

the only independent variable. A comparison of the results of Viton and Pignalosa with the work here reported will be made later in this chapter.

A multitude of time-series studies exists of the demand by individual countries for sugar, but no attempt was made to gather and classify this information. However, two studies concerning the U.S.A. are of special interest. In a 1969 dissertation, Young[3] utilized a cross section of individual households together with an aggregate time series to estimate that the price elasticity of sugar in the U.S.A. was of the range -0.3 to -0.5 and the income elasticity was approximately zero. In a 1967 article, Hayenga[4] reported that the cross elasticity of demand between sugar and other sweeteners was relatively high for certain uses, but that federal regulation limited substitution.

Theory, Estimation and Results for Time-Series Data

Theory and Estimation

Ideally the demand for sugar (sucrose) might be considered as a subset of the demand for all sweeteners, these including both caloric sweeteners, e.g., sucrose, corn syrup (of various chemical compositions) and honey, and noncaloric sweeteners, e.g., saccharin, cyclamates and aspartame. Such an approach could be particularly important for the U.S.A., where the raw material of corn syrup is relatively cheap and a

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[3]Young, K. H. (1969). Demand for Sugar in the United States, a Synthesis of Time Series and Cross Section Analyses. Unpublished Ph.D. Dissertation, Columbia University.

[4]Hayenga, M. "Sweetener Competition and Sugar Policy," Journal of Farm Economics, 49, (4), (Dec.), pp. 1362-1366.

series of Sugar Acts have maintained a relatively high sugar price. By contrast, substitution of sucrose in Japan and the European countries is toward artificial sweeteners rather than toward corn syrup because of the higher price of corn in these countries (specific data are not available to measure this).

Following the recent high sugar prices in the U.S.A., it is apparent that output of high-dextrose corn syrup is being rapidly expanded. It was estimated in 1973 that sucrose had a 78.0% share of all sweetener sales in the U.S.A., dextrose and corn syrup a 16.3% share, noncaloric sweeteners a 4.4% share and honey, molasses and other syrups a 1.3% share.[5] The expansion of high-dextrose corn syrup output reflects not just relative prices but also technological innovation, since this product was only recently developed.

While to estimate the demand for <u>all</u> sweeteners in a full system of simultaneous equations would have been ideal, the data were not readily available and time did not allow the utilization of this approach. It should therefore be noted that the demand equations here estimated represent <u>upper limits</u> for the rich nations in which the degree of substitution by sweeteners other than sucrose may be expected to increase in the future.

It should also be noted that it is the <u>total</u> demand for sugar which is being estimated, rather than retail demand alone. Much of the

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[5]Walter, B. J. (1973). "Sweetener Economics," Paper presented at the 165th National Meeting of the American Chemical Society, Dallas, Texas, April 8-13, 1973.

consumption of sugar occurs in the richer nations in the form of manufactured foods and drinks; for example, 64% of sugar consumed in the U.S.A. in the first half of 1975 went to "industrial" uses.[6] The derived nature of this demand for sugar (as an input) may in turn partially explain the highly inelastic response of consumption to the price of sugar in such countries.

The demand for sugar in an individual country i at time t may be represented as,

$$(7.1) \quad Q_{it} = f_i\,(Y_{it}, P_{it}, PS_{it}),$$

where Q_{it} = consumption per head,

Y_{it} = real income per head,

P_{it} = real retail price per unit

and PS_{it} = real price of other sweeteners.

Some preliminary analyses for the U.S.A. showed that, using the price of corn syrup for PS_{it}, $(\partial Q_{it}/\partial PS_{it})$ had a negative sign, implying a positive cross elasticity between sugar and corn syrup. Equation (7.1) clearly simplifies substitution to an excessive degree and hence the price of substitutes was dropped from further analyses, leading to Equation (7.2):

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[6] A full classification for the first half of 1975 is as follows: beverages, 23.2%; bakery products, 13.6%; confectionery products, 8.6%; canned, bottled, frozen foods, jams, jellies, preserves, 6.7%; ice cream and dairy products, 5.6%; other foods, 5.4%; nonfood, 0.9%; retail (including institutions and government), 33.2%; unclassified, 2.8%. Source: U.S. Department of Agriculture. (1975). Sugar Market News, 1, (2), (Sept.), p. 15.

(7.2) $Q_{it} = f_i\ (Y_{it}, P_{it})$,

which is a very simple demand function.

The form of f_i should accord with certain a priori expectations about the shape of the price-consumption and income-consumption (Engel) curves. Because the functional form is especially important in the second part of this analysis, as price and income range very widely across countries, it will be discussed in some detail. The price-consumption curve may be expected to be convex to the origin. Ramsey[7] suggests that such a curve may ideally be approximated by a linear and an exponential component, thus,

(7.3) $Q = \lambda(\alpha_0 + \alpha_1\ P) + (1 - \lambda)\ \Theta_0\ e^{\Theta_2 P},\ 0 \leq \lambda \leq 1,$

where P = price of commodity

and Q = quantity demanded.

In Figure 7.1 G(P) is the exponential component, L(P) is the linear component and F(P) is the actual price-consumption curve. In the empirical work on food consumption which he reported, Ramsey estimated the linear and exponential components of (7.3) separately and, on testing the significance of difference between linear and exponential estimates, found none. Consequently the exponential component of (7.3) alone was adopted in this research (although, as will be shown later, this proved unwise in pooled estimation).

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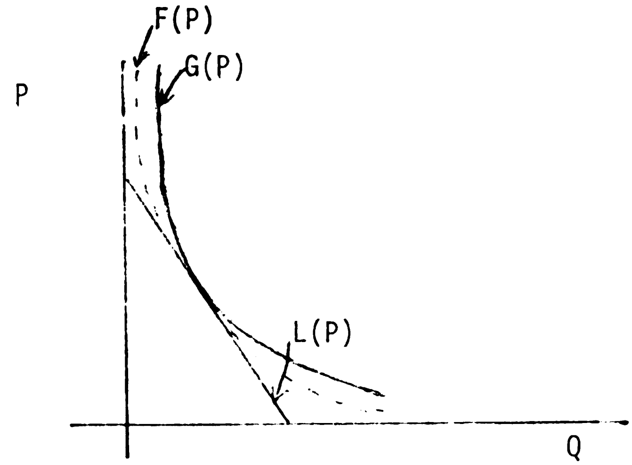
[7]Ramsey, J. B. (1972). "Limiting Functional Forms for Market Demand Curves," Econometrica, 40, (2), pp. 327-341; Ramsey, J. B. (1974). "Limiting Functional Forms for Demand Functions: Tests of Some Specific Hypotheses," Review of Economics and Statistics, 56, (4), (Nov.), pp. 468-477.

Figure 7.1 Shapes of Price-Consumption Curves



Reviewing Engel curves, Aitchison and Brown[8] developed a sigmoidal relationship of the following kind,

(7.4) $Q = e^{\Theta_1 Y^{-1}}$,

where Q = quantity demanded

and Y = income

Equation (7.4) gives a sigmoidal Engel curve as shown in Figure (7.2) and which passes through the origin and has an asymptotic upper bound, all of which are desirable characteristics. Countries with low incomes may be expected to lie around the lower inflection point on this curve while high-income countries may lie near the upper asymptote. Aitchison and Brown noted that, by comparison, semi-logarithmic and double logarithmic functions (see Figure 7.2) did not give sufficient curvature at high incomes and had no inflection point at low incomes.

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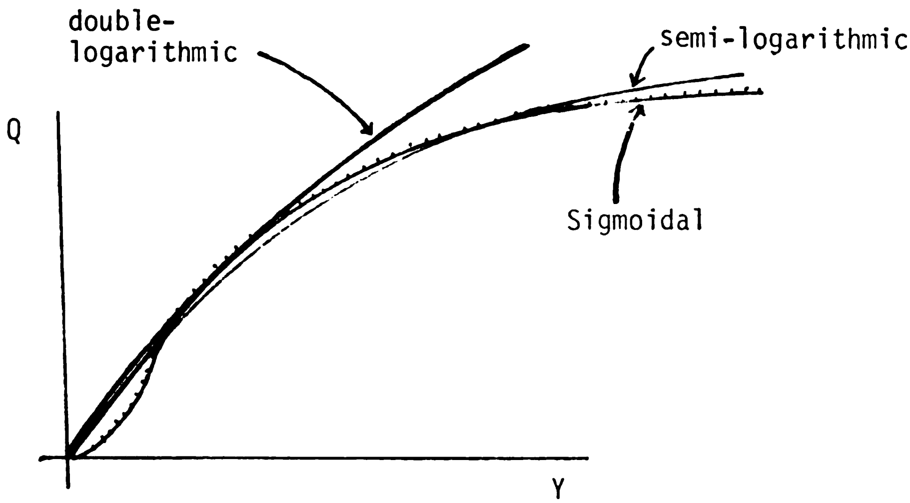
[8]Aitchison, J. and J. A. C. Brown. (1954). "A Synthesis of Engel Curve Theory," Review of Economic Studies, 22, (1), pp. 35-46.

Figure 7.2: Some Engel Curves



Combining Equation (7.4) with the exponential price-consumption component of Equation (7.3) leads to (for country i in year t),

$$(7.5) \quad Q_{it} = e^{[\theta_1 Y_{it}^{-1} + \theta_2 P_{it}]} + U_{it} \, ,$$

where θ_1 and θ_2 are strictly negative, and $U_{it} \sim N(0, \sigma_{it}^2 I_t)$.

To estimate Equation (7.5), it may first be approximated in the logarithms[9] as,

$$(7.6) \quad \log Q_{it} = \delta + \theta_1 Y_{it}^{-1} + \theta_2 P_{it} + \log E_{it} \, ,$$

where δ = a constant.

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[9]The approximation lies in changing an additive to a multiplicative error term. See Ramsey, J. B. (1973). "Classical Model Selection through Specification Error Tests," Frontiers in Econometrics, Chapter 1, ed. P. Zarembka, New York: Academic Press.

Estimation depends on the behavior of E_{it}. For each country, E_{it} was assumed to follow a first-order autoregressive scheme and Orcutt Transformations were utilized to remove the autocorrelation.[10] OLS estimation was then used on the transformed equations. Similar estimating procedures were also followed for the more usual semi-logarithmic and double logarithmic functions (7.7) and (7.8):

$$(7.7) \quad Q_{it} = \alpha_0 + \alpha_1 \log Y_{it} + \alpha_2 \log P_{it} + \log \lambda_{it} ;$$

$$(7.8) \quad \log Q_{it} = \beta_0 + \beta_1 \log Y_{it} + \beta_2 \log P_{it} + \log \omega_{it} .$$

The derived income and price elasticities are $-\theta_1 Y^{-1}$ and $\theta_2 P$ for the "Ramsey" equation, $\alpha_1 Q^{-1}$ and $\alpha_2 Q^{-1}$ for the semi-logarithmic equation, and simply β_1 and β_2 for the double logarithmic equation.

Results of Individual Time Series

Before presenting the results, the sources of data will be noted. Data on gross domestic product, consumer price index and population were taken from the I.M.F.[11] Data on consumption came from the I.S.O. and C.E.F.S.[12] and on retail prices came from statistical yearbooks of individual countries and from the annual I.L.O survey of

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[10]A very standard procedure: see, for example, Kmenta, J. (1971). Ibid., pp. 287-288.

[11]International Monetary Fund (various). International Financial Statistics. Washington, D. C.: International Monetary Fund.

[12]International Sugar Organization (various). Sugar Yearbook. London: International Sugar Organization, 28 Haymarket, W. C. 1; Comité Européen des Fabricants de Sucre (various). Recueil Annuel de Statistiques. Paris: Comité Européen des Fabricants de Sucre, 45 Avenue Montaigne.

retail prices.[13] For the Communist countries, data came from statistical yearbooks. The data related mainly to the period 1950-72, but in some cases (e.g., U.S.A.) to the period 1950-74. Although data exist for years prior to 1950, rationing was widespread prior to this date and so such data were not utilized. For the Communist countries, since rationing by means other than price is the rule, the results should be viewed as exploratory.

Table 7.1 presents the complete set of results for the three kinds of equations. Derived income and price elasticities (η_Y and η_p) are also listed in the table for the "Ramsey" and semi-logarithmic equations, while the price and income coefficients of the double logarithmic equation are themselves also the respective elasticities. Testing with the t-values (in brackets), many of the coefficients were not significantly different from zero at the 5% level. Table 7.2 lists those income and price elasticities which were significantly different from zero for both the "Ramsey" and semi-logarithmic equations. A comparison of the estimates from the two equations reveals substantial differences. Of the 38 income elasticities which were significant with both functional forms, the "Ramsey" equation gave lower values for 32. By contrast, the "Ramsey" equation gave larger (negative) values for the price elasticity in 15 of the 18 significant cases. The "Ramsey" equation therefore attributed more of the variation in consumption to price and less to income than did the semi-logarithmic equation. A full examination of which was the correct specification was

[13] International Labor Office (various). Bulletin of Labor Statistics. Geneva: United Nations International Labor Office.

Table 7.1. Time-Series Results

	Ramsey								Double Logarithmic					Semi-logarithmic						
	Constant	1 (Income)	2 (Price)	$\bar{R}^2$	DW	T	y	p	Constant	1 = y	2 = p	$\bar{R}^2$	DW	Constant	1 (Income)	2 (Price)	$\bar{R}^2$	DW	y	p
Argentina	4.0718	-0.3389	-0.3169	0.344	0.998	19	0.315	-0.080	3.5742	0.3748	-0.0764	0.364	1.693	35.3277	13.9868	-3.1979	0.376	1.624	0.341	-0.078
		(2.367)	(0.761)							(2.425)	(0.597)				(2.430)	(0.670)				
Australia	3.9679	0.0013	7.3414	0.087	1.976	21	-0.065	0.012	3.7424	-0.0840	0.0045	0.084	1.962	39.2909	-4.9974	0.2955	0.090	1.946	-0.088	0.005
		(1.826)	(0.102)							(0.032)	(1.788)				(1.819)	(0.036)				
Austria	3.8971	-0.1187	3.1048	0.635	2.247	19	0.268	-0.163	4.5599	0.3698	0.1443	0.573	1.970	69.9822	13.9445	4.3062	0.579	2.210	0.302	0.092
		(1.765)	(0.396)							(1.280)	(0.225)				(0.738)	(0.172)				
Barbados	---	---	---	---	---	19	---	---	3.3921	-0.1108	-0.6272	0.067	2.000	21.4552	-5.7748	-34.0218	0.055	2.018	-0.107	-0.628
										(1.009)	(1.798)				(0.931)	(1.326)				
Belgium	4.0510	-0.2448	0.4260	0.773	2.184	18	0.215	0.066	3.7595	0.4776	0.0183	0.741	1.925	44.0105	17.6227	1.3496	0.749	1.921	0.421	0.032
		(7.695)	(0.436)							(7.087)	(0.121)				(7.242)	(0.249)				
Bolivia	4.6798	-41.3443	-0.0117	0.916	2.446	16	2.444	-0.204	-0.2293	1.4247	-0.2190	0.919	2.484	50.1969	30.2479	-3.9793	0.926	2.299	1.202	-0.158
		(11.488)	(6.793)							(10.538)	(5.886)				(11.529)	(5.511)				
Brazil	4.4666	-0.4224	-0.3080	0.601	1.762	24	0.205	-0.246	3.2429	0.5560	-0.2760	0.580	1.740	24.0107	20.2002	-9.3429	0.616	1.767	0.484	-0.224
		(4.565)	(3.317)							(4.348)	(3.334)				(4.783)	(3.417)				
Burma	2.0257	-0.0015	46.1098	0.065	1.553	9	0.500	0.692	11.8301	13.998	0.6348	0.000	1.859	30.2859	3.4243	1.7856	0.000	1.899	1.224	0.638
		(1.082)	(1.365)							(0.925)	(1.058)				(0.879)	(1.156)				
Cameroun	1.6043	-0.1018	0.0729	0.765	1.997	8	0.238	0.055	1.6891	0.8055	0.0786	0.771	2.062	4.3205	1.8939	0.1570	0.775	2.024	0.691	0.057
		(4.292)	(0.340)							(4.347)	(0.426)				(4.347)	(0.357)				
Canada	4.0665	-0.0014	-21.9310	0.242	1.876	24	0.040	-0.055*	4.1348	0.1584	-0.0522	0.282	1.987	61.9533	7.7965	-2.4202	0.281	2.003	0.164	-0.051
		(2.487)	(0.926)							(2.764)	(0.879)				(2.783)	(0.334)				
Chile	3.6760	-1.7460	0.0103	0.178	1.525	21	0.096	0.010	2.8913	0.2578	0.0002	0.177	1.464	12.1591	8.8421	0.1523	0.211	1.427	0.221	0.004
		(1.227)	(0.772)							(1.938)	(0.003)				(2.038)	(0.093)				
[China	Con = =8233.5421 + 163.1526 (Year - 1900)								$\bar{R}^2$ = 0.985	t = 20	DW = 0.996]									
			(35.621)																	
China-Taiwan	3.3660	-0.0274	-3.0760	0.730	2.338	18	0.186	-0.258	3.0855	0.5151	-0.2958	0.778	2.464	20.5148	6.9166	-3.8395	0.814	2.338	0.411	-0.228
		(6.403)	(2.657)							(7.222)	(2.754)				(8.068)	(2.973)				
Colombia	3.7573	-0.0079	6.8847	0.610	1.115	19	0.251	0.091	6.6510	0.8521	0.1131	0.657	1.017	95.7955	18.4597	1.7511	0.642	1.022	0.714	0.068
		(21.758)	(0.984)							(4.904)	(1.368)				(4.962)	(0.947)				
Costa Rica	5.0856	-4.7662	-0.0046	0.513	1.629	19	0.142	-0.044	-0.4886	1.2810	-0.0367	0.514	1.567	-128.5153	51.8817	-1.3778	0.559	1.644	1.002	-0.027
		(4.173)	(0.249)							(4.114)	(0.166)				(4.477)	(0.167)				
[Cuba	Con = -544.1665 + 135.6296 POP								$\bar{R}^2$ = 0.759	T = 22	DW = 0.889]									
			(8.214)																	
Czechoslovakia	---	---	---	---	---	16	---	---	1.4678	0.2392	-0.7131	0.769	2.187	-50.4514	-9.6513	-29.1519	0.767	2.214	-0.219	-0.662
										(2.115)	(4.054)									
Denmark	4.0631	0.0090	-8.0851	0.515	1.516	18	-0.052	-0.125	3.3790	-0.0859	-0.1088	0.531	1.553	20.2794	-4.8414	-5.9750	0.531	1.566	-0.090	-0.111
		(1.579)	(1.430)							(1.789)	(1.291)				(1.808)	(1.270)				
Dominican Rep	4.1590	-0.0009	-237.5319	0.901	1.960	21	0.256	-0.436	0.2371	0.0855	-0.6808	0.894	1.734	-70.3170	2.0993	-18.5818	0.892	1.875	0.062	-0.548
		(0.833)	(6.018)							(0.344)	(6.271)				(0.307)	(6.228)				
Ecuador	4.3319	-0.0595	-2.0318	0.922	2.284	9	1.172	-0.039	6.2375	1.0839	-0.0872	0.927	2.214	100.7155	26.3892	-1.5898	0.919	2.225	0.892	-0.054
		(2.418)	(0.104)							(2.226)	(0.183)				(2.154)	(0.132)				
Fiji																				
Finland	3.9351	-0.0128	5.3208	0.620	1.794	19	0.180	0.061	4.7749	0.2064	0.0774	0.654	1.964	37.1463	9.1380	3.2486	0.661	1.988	0.183	0.065
		(5.409)	(1.080)							(33.780)	(1.802)				(5.873)	(1.286)				
France	4.1691	-0.0124	-28.9817	0.835	1.422	18	0.091	-0.330	2.5990	0.2406	-0.3552	0.873	1.824	9.5415	9.2939	-11.1240	0.858	1.791	0.221	-0.264
		(3.584)	(2.119)							(4.417)	(2.388)				(4.415)	(1.935)				
Gabon	2.3528	-0.0576	0.0862	0.415	1.845	11	0.355	-0.079	3.7109	1.1683	0.1550	0.429	1.900	13.9254	4.8486	1.4896	0.476	2.046	0.824	0.253
		(2.796)	(0.204)							(2.898)	(0.159)				(3.287)	(1.048)				
E. Germany	---	---	---	---	---	18	---	---	4.2418	0.2224	---	0.722	0.517							
										(6.711)										
W. Germany	3.9253	0.0019	-36.3259	0.858	1.904	19	-0.019	-0.352	1.4568	- 0.0215	-0.4507	0.872	2.038	-38.6877	-1.0934	-15.6490	0.866	1.944	-0.031	-0.441
		(0.315)	(2.830)							(0.235)	(2.542)				(0.348)	(2.588)				
Ghana	2.2585	0.0001	-136.8569	0.000	1.073	17	-0.068	-0.287	-0.3455	-0.1179	-0.2733	0.000	1.062	-2.3697	0.2557	-2.0089	0.000	0.959	0.026	-0.203
		(0.101)	(0.723)							(0.088)	(0.710)				(0.025)	(0.696)				
Greece																				
Guatemala	2.3838	-0.0013	1524.1473	0.508	2.164	21	0.346	2.426	32.2891	1.9822	2.7859	0.528	2.218	435.4451	36.4692	31.8773	0.647	2.071	1.320	1.154
		(4.356)	(1.9201)							(4.465)	(2.028)				(5.014)	(1.416)				

Table 7.1. Continued

	Ramsey								Double Logarithmic					Semi-logarithmic						
	Constant	β_1 (Income)	β_2 (Price)	$\bar{R}^2$	DW	T	η_y	η_p	Constant	$\gamma_1 + \eta_y$	$\gamma_2 + \eta_p$	$\bar{R}^2$	DW	Constant	δ_1 (Income)	δ_2 (Price)	$\bar{R}^2$	DW	η_y	η_p
Guyana	3.9307	-0.0022	-51.6403	0.422	2.580	18	0.347	-0.077	4.1665	0.2116	-0.0879	0.427	2.618	61.1703	8.5591	-3.2897	0.421	2.629	0.200	-0.077
		(1.879)	(1.686)							(1.827)	(1.711)				(1.874)	(1.623)				
Honduras																				
Hong Kong	3.2179	-1.0696	-0.0060	0.000	2.103	19	0.032	-0.096	3.2346	0.0289	-0.1011	0.000	2.096	25.4383	0.9113	-2.5325	0.000	2.158	0.049	-0.136
		(0.354)	(0.439)							(0.175)	(0.610)				(0.217)	(0.560)				
Hungary																				
Iceland																				
India	2.7976	-0.0002	-52.0537	0.063	1.954	19	0.046	-0.566	1.6766	0.4776	-0.6104	0.066	1.091	4.8721	2.6656	-3.5124	0.086	1.111	0.380	-0.501
		(0.811)	(1.568)							(0.873)	(1.597)				(0.905)	(1.706)				
Indonesia	1.3685	0.0033	4.0495	0.124	1.812	9	-0.060	0.685	0.5473	-1.0210	0.7807	0.772	1.270	0.7592	-5.0451	4.0785	0.719	1.122	-0.639	0.516
		(0.898)	(1.728)							(4.519)	(5.361)				(3.700)	(4.640)				
Iran	3.9806	-0.1005	-2.0922	0.747	2.362	13	0.301	-0.405	2.9467	0.3724	-0.4544	0.735	2.235	21.4366	8.6927	-5.9576	0.781	2.318	0.305	-0.209
		(3.272)	(1.541)							(2.970)	(1.294)				(3.444)	(1.357)				
Iraq	4.1670	-0.1817	-0.3715	0.326	1.144	17	0.144	-0.307	3.3212	0.4760	-0.2882	0.286	1.745	28.0436	13.8632	-7.8376	0.292	1.674	0.422	-0.239
		(2.339)	(1.968)												(2.273)	(1.713)				
Ireland	4.5715	-0.0008	-232.3202	0.840	1.878	18	0.212	-0.140	4.8240	0.3087	-0.1477	0.814	1.698	90.4177	17.9376	-10.2691	0.812	1.662	0.289	-0.149
		(7.554)	(1.683)							(6.795)	(1.363)				(6.596)	(1.583)				
Israel	4.3964	-0.0105	50.6649	0.872	1.155	18	0.207	0.272	8.6029	0.9520	0.3099	0.915	1.004	314.2600	48.0153	20.8698	0.894	1.019	0.745	0.324
		(5.119)	(1.531)							(6.516)	(1.688)				(6.435)	(2.226)				
Italy	3.5076	-6.8799	0.4538	0.443	1.953	18	0.775	0.834	1.6649	0.7450	0.3095	0.373	1.990	34.9655	25.3715	18.9626	0.279	2.084	0.785	0.587
		(1.730)	(1.029)							(1.096)	(0.320)				(1.317)	(0.690)				
Ivory Coast	3.9705	-0.1680	-1.1103	0.631	1.299	10	0.222	-0.591	2.3160	1.0216	-0.7273	0.633	1.510	10.5557	10.5401	-7.0288	0.617	1.208	0.826	-0.551
		(3.407)	(3.030)							(3.354)	(3.118)				(3.346)	(2.912)				
Jamaica	4.4352	-0.0004	-52.0215	0.358	2.723	11	0.093	-0.059	6.4800	0.5722	-0.0800	0.380	2.724	163.0213	25.6463	-3.8855	0.353	2.717	0.539	-0.079
		(1.785)	(0.563)							(1.945)	(0.587)				(1.838)	(0.599)				
Japan	3.7349	-0.0739	-0.3641	0.737	1.344	21	0.014	-0.344	2.8768	0.2586	-0.5335	0.810	1.527	14.8827	7.7181	-7.8953	0.823	1.506	0.254	-0.260
		(2.770)	(4.291)							(3.013)	(4.365)				(4.475)	(3.215)				
Kenya	3.4988	-0.0011	-14.2283	0.381	1.517	17	0.116	-0.212	5.2121	0.7221	-0.2093	0.377	1.580	54.0976	10.0356	-1.9483	0.392	1.536	0.548	-0.106
		(3.440)	(0.395)												(3.511)	(0.272)				
Korea (South)	2.8022	-2.1854	-0.0663	0.693	1.855	19	0.570	-0.389	1.4484	1.3032	-0.7385	0.766	2.001	3.1209	4.8666	-1.6895	0.862	1.290	0.737	-0.256
		(5.238)	(4.336)							(6.391)	(4.876)				(9.899)	(4.627)				
Libya	4.1867	-3.6462	-0.7822	0.909	2.491	7	0.624	-0.297	2.4927	0.4414	-0.3214	0.892	2.359	2.9509	13.3704	-9.4961	0.914	2.418	0.371	-0.263
		(3.114)	(0.926)							(2.975)	(0.976)				(3.376)	(1.080)				
Madagascar	3.9904	-0.4141	1.0583	0.886	2.413	10	1.318	0.549	5.7447	2.7864	0.7390	0.900	2.358	31.4674	18.2518	3.8980	0.881	2.370	2.169	0.463
		(8.000)	(1.486)							(8.531)	(1.758)				(7.649)	(1.269)				
Mauritius	3.8692	0.0000	-54.1910	0.033	2.075	18	0.000	-0.188	2.2292	-0.0560	-0.2187	0.034	2.154	-19.9512	-2.3834	-9.0470	0.034	2.153	-0.056	-0.212
		(0.911)	(1.258)							(0.887)	(1.288)				(0.876)	(1.324)				
Mexico	4.1693	-0.0177	-4.7212	0.961	2.296	22	0.253	-0.078	4.8115	0.5938	-0.1100	0.961	2.014	81.8841	19.6731	-2.4337	0.959	2.374	0.499	-0.062
		(18.973)	(1.583)							(18.948)	(2.274)				(19.029)	(1.524)				
Morocco	3.3538	0.0007	-15.9153	0.524	1.631	19	-0.066	-0.206	1.0856	-0.2851	-0.2305	0.512	1.727	-38.9388	-8.4521	-6.9190	0.498	1.731	-0.291	-0.238
		(1.949)	(3.688)							(1.993)	(3.575)				(1.925)	(3.436)				
Netherlands	4.0709	-0.0015	-16.4688	0.463	1.813	18	0.022	-0.128	3.4548	0.0823	-0.1360	0.472	1.830	27.9349	3.8556	-6.4963	0.473	1.806	0.073	-0.128
		(1.435)	(1.583)							(1.522)	(1.349)				(1.509)	(1.363)				
New Zealand	4.3301	-0.0020	-127.7508	0.658	1.855	18	0.130	-0.159	3.8052	0.2408	-0.1792	0.652	1.979	50.1992	12.9812	-8.7527	0.663	1.920	0.234	-0.157
		(1.751)	(3.464)							(2.051)	(3.353)				(2.235)	(3.311)				
Nicaragua																				
Niger	1.0147	0.0105	-0.5853	0.173	0.909	8	-0.052	-0.375	0.4212	-0.0792	-0.4580	0.174	0.939	1.4016	-0.1981	-0.8940	0.179	0.905	-0.091	-0.411
		(0.268)	(1.860)							(1.863)	(0.209)				(1.878)	(0.269)				
Nigeria	1.0797	-0.0849	-0.4852	0.186	1.000	17	0.204	-0.168	0.5442	0.2203	-0.2905	0.169	1.951	1.7036	0.3209	-0.4517	0.214	1.831	0.177	-0.249
		(1.129)	(1.868)							(0.716)	(1.792)				(0.746)	(1.993)				
Norway	4.0516	-0.0121	-16.4925	0.380	2.331	19	0.079	-0.275	3.0260	0.0519	-0.2001	0.338	2.289	24.5092	4.0631	-6.5663	0.345	2.484	0.087	-0.141
		(0.481)	(2.743)							(0.499)	(2.386)				(1.011)	(2.026)				
Pakistan	4.2379	-0.0070	12.9518	0.564	1.914	16	1.400	0.154	20.2373	3.2941	0.2427	0.576	1.906	66.5681	11.3381	0.2380	0.630	1.664	2.072	0.043
		(4.264)	(0.342)							(4.343)	(0.458)				(4.666)	(0.140)				
Peru	4.0675	-0.0312	-3.7910	0.815	1.815	21	0.366	-0.091	4.6773	0.7034	-0.1244	0.805	1.866	63.1980	18.0153	-2.9971	0.786	1.912	0.568	-0.094
		(7.298)	(0.737)							(7.134)	(0.874)				(6.768)	(0.780)				

Table 7.1. Continued

	Ramsey								Double Logarithmic					Semi-logarithmic						
	Constant	β_1 (Income)	β_2 (Price)	$\bar{R}^2$	DW	T	η_y	η_p	Constant	$\beta_1 = \eta_y$	$\beta_2 = \eta_p$	$\bar{R}^2$	DW	Constant	β_1 (Income)	β_2 (Price)	$\bar{R}^2$	DW	η_y	η_p
Philippines	3.4586	-0.0017 (3.348)	20.6682 (0.454)	0.507	2.074	21	0.213	0.138	7.9143	0.9190 (3.424)	0.1109 (0.442)	0.518	2.127	89.7691	13.7809 (3.726)	0.9662 (0.279)	0.545	2.040	0.718	0.050
Poland						16			3.2289	0.3519 (2.879)	-0.4644 (1.765)	0.947	1.641	14.2768	11.7503 (3.010)	-20.2423 (2.409)	0.960	1.766	0.260	-0.448
Portugal	4.0967	-0.0303 (5.430)	-9.3548 (2.165)	0.906	1.363	19	0.201	-0.430	3.6901	0.7048 (7.097)	-0.3007 (1.550)	0.925	1.434	29.0756	13.6645 (5.140)	-7.4788 (1.440)	0.875	1.207	0.465	-0.254
Saudi Arabia																				
Senegal	1.0228	0.1211 (1.120)	1.2227 (1.220)	0.000	1.023	11	-0.232	0.898	2.4692	-0.9738 (1.001)	0.8063 (1.170)	0.000	0.956	11.5476	-15.7182 (1.169)	13.3916 (1.000)	0.000	0.925	-0.809	0.689
Sierra Leone	2.4917	0.0026 (0.034)	-0.0701 (0.819)	0.000	0.919	8	-0.002	-0.151	2.4796	0.0048 (0.009)	-0.1551 (0.842)	0.000	1.024	11.6981	0.6596 (0.123)	-1.5084 (0.829)	0.000	0.927	0.059	-0.135
Singapore	4.6621	-2.3647 (1.017)	-0.0292 (0.695)	0.000	1.441	12	0.087	-0.171	3.0717	0.3967 (0.865)	-0.1513 (0.566)	0.000	1.410	11.8151	18.8849 (0.619)	-6.7566 (0.380)	0.000	1.588	0.320	-0.114
South Africa	4.3956	-0.0002 (2.827)	-285.9127 (5.730)	0.622	0.858	21	0.041	-0.381	2.3880	0.2071 (2.381)	-0.3829 (5.381)	0.586	0.779	-15.0142	8.6529	-16.0988	0.583	0.776	0.199	-0.370
Spain	4.1114	-0.1840 (9.731)	-2.0827 (3.210)	0.990	1.487	18	0.389	-0.203	3.4704	0.7573 (5.766)	-0.2379 (1.565)	0.977	0.544	30.2951	16.4733 (9.269)	-5.4417 (2.646)	0.991	1.304	0.547	-0.181
Sri Lanka	3.7910	-0.0028 (3.023)	24.6087 (1.140)	0.296	1.569	18	0.374	0.280	10.1802	1.1207 (3.222)	0.3760 (1.322)	0.330	1.614	175.8587	24.6100 (3.403)	7.8044 (1.320)	0.361	1.580	1.325	0.420
Sudan	3.4681	-0.0254 (0.255)	-0.5555 (1.470)	0.012	1.790	15	0.067	-0.654	3.0062	0.1962 (0.335)	-0.7950 (1.478)	0.013	1.719	19.4794	3.1920 (0.424)	-10.0794 (1.459)	0.010	1.648	0.188	-0.595
Sweden	3.7639	0.0145 (1.556)	-2.8420 (0.391)	0.049	2.081	19	-0.091	-0.039	3.4382	-0.0821 (1.355)	-0.0455 (0.380)	0.023	2.032	27.1307	-3.3653 (1.446)	-2.2813 (0.432)	0.037	2.047	-0.084	-0.050
Switzerland	4.2368	-0.0084 (1.380)	-24.4487 (1.773)	0.320	1.926	19	0.068	-0.238	3.0967	0.1353 (1.343)	-0.2357 (1.810)	0.322	1.945	9.9777	6.2539 (1.296)	-11.4108 (1.826)	0.317	1.972	0.125	-0.228
Syria	3.9554	-0.0010 (2.765)	-49.0616 (2.494)	0.442	2.379	16	0.098	-0.326	3.6894	0.5934 (2.826)	-0.4479 (2.570)	0.481	2.511	34.9731	12.1735 (3.258)	-9.1377 (2.946)	0.559	2.534	0.451	-0.339
Tanzania	5.0033	-0.0029 (3.055)	-82.7885 (2.815)	0.526	1.053	12	0.503	-1.200	7.5532	2.0038 (3.126)	-1.1418 (2.833)	0.532	1.162	52.6578	14.8537 (3.024)	-7.5484 (2.444)	0.485	1.051	1.522	-0.774
Thailand	3.7655	-0.0238 (3.228)	-18.4631 (2.288)	0.762	1.866	19	0.667	-0.675	4.1111	1.3326 (3.783)	-0.7743 (2.533)	0.792	1.926	23.7675	8.3410 (3.971)	-4.0755 (2.236)	0.787	1.294	0.734	-0.358
Togo	3.4313	-0.9299 (1.640)	-0.9127 (4.370)	0.826	3.288	5	2.596	-0.739	2.5868	1.6659 (1.931)	-0.5892 (4.360)	0.825	3.306	9.8650	6.6622 (1.810)	-2.4304 (4.215)	0.813	3.299	1.856	-0.677
Trinidad&Tobago	4.3190	-0.0004 (5.472)	20.7445 (0.146)	0.188	1.306	16	0.030	0.060	4.7059	0.5838 (1.814)	0.0655 (0.410)	0.079	0.969	146.0150	20.5104 (1.546)	2.7631 (0.420)	0.026	0.962	0.465	0.063
Tunisia	4.0535	-0.6589 (2.892)	-0.0657 (0.184)	0.403	2.499	12	0.463	-0.062	2.6873	1.1004 (2.772)	-0.1199 (0.353)	0.385	2.425	14.8498	18.0710 (3.631)	-1.9965 (0.469)	0.546	2.399	0.868	-0.096
Turkey	3.5126	-0.0033 (4.274)	-25.1319 (3.801)	0.487	1.174	19	0.114	-0.459	2.9223	0.7457 (13.153)	-0.7247 (11.171)	0.907	1.047	18.2135	10.9063 (15.779)	-10.6839 (13.508)	0.933	1.290	0.512	-0.502
U.S.S.R.						18			7.2745	0.5682 (2.420)	-1.2986 (0.661)	0.700	1.083	154.8314	19.0137 (2.696)	-33.9226 (0.575)	0.726	1.154	0.438	-0.781
U.K.	3.8694	0.0011 (1.661)	3.8819 (0.045)	0.245	1.924	18	-0.157	0.002	3.3262	-0.1221 (1.686)	-0.0039 (0.057)	0.266	1.964	16.3755	-6.7869 (1.731)	-0.3335 (0.089)	0.271	1.967	-0.129	-0.006
U.S.A.	4.0260	-0.0035 (4.892)	-12.2806 (1.341)	0.522	1.880	23	0.030*	-0.028#	4.0258	0.1200 (4.957)	-0.0433 (1.531)	0.553	2.113	55.2296	5.7836 (4.997)	-2.1236 (1.573)	0.558	2.076	0.119	-0.044
Upper Volta	1.8867	-0.1051 (2.350)	-0.7059 (1.451)	0.357	1.000	9	0.702	-0.512	1.8219	0.6014 (2.471)	-0.5801 (1.551)	0.393	1.076	4.4568	1.2977 (2.576)	-1.2053 (1.561)	0.415	1.071	0.543	-0.505
Uruguay	4.3921	-0.0207 (1.588)	-2.9539 (1.016)	0.174	1.839	17	0.251	-0.116	4.8508	0.6110 (1.630)	-0.1027 (1.014)	0.196	1.852	84.1202	23.8201 (1.590)	-4.3978 (1.085)	0.199	1.775	0.580	-0.107
Venezuela	5.2151	-0.0012 (0.145)	-178.0635 (6.175)	0.883	1.880	21	0.025	-1.494	-4.6136	0.0692 (0.269)	-1.7856 (6.325)	0.888	1.914	-204.6838	1.9250 (0.268)	-52.3341 (7.024)	0.907	1.658	0.043	-1.242
Vietnam (South)	2.7872	0.0017 (0.137)	-5.9026 (2.183)	0.151	1.065	17	-0.025	-1.102	1.0775	0.2237 (0.184)	-0.8004 (2.131)	0.138	1.007	17.0203	8.3111 (0.932)	-8.4107 (2.843)	0.299	0.394	0.766	-0.723
Yugoslavia																				
Zambia	2.5499	-0.0000 (0.104)	-67.5888 (0.144)	0.000	0.279	12	0.003	-0.089	3.9775	0.3171 (0.683)	-0.0696 (0.126)	0.000	0.395	31.8390	2.0150 (0.436)	1.0867 (0.197)	0.000	0.248	0.132	0.071

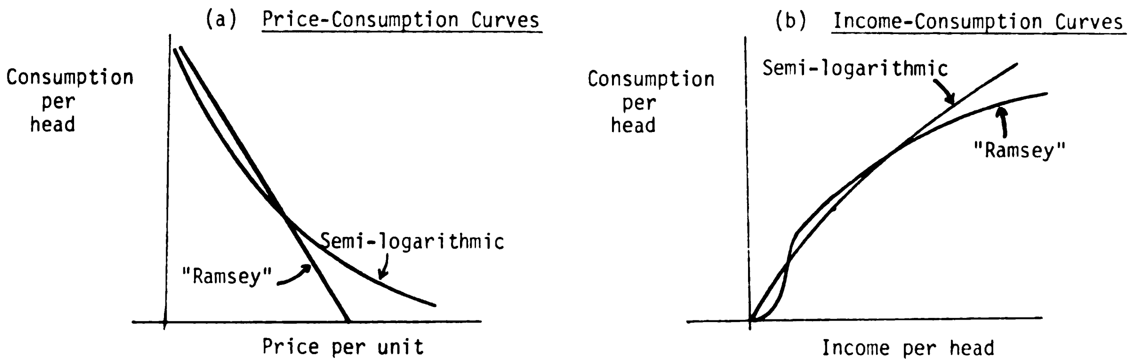
*-0.124 at 1974 price
#-0.054 at 1974 price

Table 7.2. Significant (Income and Price) Elasticities From (Ramsey and Semi-Log) Equations

Country	Income Ramsey	Elasticity Semi-Log	Country	Price Ramsey	Elasticity Semi-Log
Bolivia	2.444	1.202	Venezuela	-1.494	-1.242
Pakistan	1.400	2.072	Tanzania	-1.200	-0.774
Madagascar	1.318	2.169	South Vietnam	-1.102	-0.723
Ecuador	1.172	0.892	Thailand	-0.675	-0.358
Upper Volta	0.702	0.543	Ivory Coast	-0.591	-0.551
Thailand	0.667	0.734	Dom. Republic	-0.436	-0.548
Libya	0.624	0.371	Portugal	-0.430	n.s.
South Korea	0.570	0.737	South Korea	-0.389	-0.256
Tanzania	0.503	1.522	South Africa	-0.381	-0.370
Tunisia	0.463	0.868	W. Germany	-0.352	-0.441
Spain	0.389	0.547	Japan	-0.344	-0.260
Sri Lanka	0.374	1.325	France	-0.330	n.s.
Belgium	0.374	0.226	Syria	-0.326	-0.339
Peru	0.366	0.568	Norway	-0.275	-0.141
Gabon	0.355	0.824	China-Taiwan	-0.258	-0.228
Guatemala	0.346	1.320	Brazil	-0.246	-0.224
Argentina	0.315	0.341	Morocco	-0.206	-0.238
Iran	0.301	0.305	Bolivia	-0.204	-0.158
Mexico	0.253	0.499	Spain	-0.203	-0.181
Cameroun	0.238	0.691	New Zealand	-0.159	-0.157
Ivory Coast	0.222	0.826			
Belgium	0.215	0.421			
Philippines	0.213	0.718			
Ireland	0.212	0.289			
Israel	0.207	0.745			
Brazil	0.205	0.484			
Portugal	0.201	0.465			
China-Taiwan	0.186	0.411			
Finland	0.180	0.183			
Iraq	0.144	0.422			
Costa Rica	0.142	1.002			
Turkey	0.114	0.512			
Syria	0.098	0.451			
France	0.094	0.221			
South Africa	0.041	0.199			
Canada	0.040	·0.164			
U.S.A.	0.030	0.119			
Japan	0.014	0.254			
Trinidad and Tobago	-0.030	n.s.			

outside the scope of the present research, but some comments on the shapes of the price-consumption and income-consumption curves may be instructive at this point. Since the "Ramsey" equation yields higher price elasticities, its price-consumption slope must generally be greater than for the semi-logarithmic equation, as depicted in Figure 7.3a. Similarly, since the "Ramsey" equation gives generally lower income elasticities, its shape would appear to be as in Figure 7.3b, having the lower point of inflection very near the origin.

Figure 7.3



Using the semi-logarithmic results as a standard, the range of price elasticities for 1972 is from -1.242 for Venezuela to -0.141 for Norway. The fact that many price elasticities were not significantly different from zero indicates unreliable data in some cases and a very low price elasticity in others (e.g., Indonesia and the U.S.A. respectively). The income elasticities ranged from a high of 2.169 for

Madagascar to a low of 0.119 for the U.S.A. Many of the European countries and Australia gave negative income elasticities which were, however, not significantly different from zero but do indicate that their consumption is at saturation level and sugar may border on the classification of an "inferior good."

Looking more losely at North America, the results for the U.S.A. and Canada gave significant income elasticities of 0.119 and 0.164 respectively, using the semi-logarithmic equation. However, it is probable that the estimates of 0.030 and 0.040 respectively from the "Ramsey" equation are a truer representation. Similarly, price elasticities for these two "highest income" countries were -0.044 and -0.051 respectively with the semi-logarithmic specification, and -0.028 and -0.055 respectively with the "Ramsey" specification. In neither case was the price elasticity significantly different from zero. The above elasticities are for 1972 prices, but at the higher retail price of 1974, the Ramsey specification would give a higher price elasticity of -0.054 for the U.S.A. and -0.124 for Canada, since the formula for the price elasticity is price dependent, namely, $\eta_p = \theta_2 P$. From 1973 to 1974 there was a 92.78% rise in price and a 2.15 % fall in consumption in the U.S.A., indicating a crude elasticity of -0.023. However, the meteoric rise in price occurred late in 1974 so that full adjustment was not captured by the 1974 data on consumption and the "Ramsey" estimate of -0.054 for price elasticity would appear of the correct magnitude (c.f., semi-logarithmic estimate of -0.044 at all price levels). Finally, the estimates of Young[14] of -0.3 to -0.5 for price elasticity for the U.S.A. appear unreasonably large. Further

[14] Ibid.

comments and comparisons follow the pooled demand estimation which is next reported.

Theory, Estimation and Results for Pooled Cross-Section and Time-Series Data

The advantage of pooling the individual countries' time-series data lies in the increased degrees of freedom thus obtained. In estimating individual countries' relationships from time-series it was found that three major problems arose from the data, namely: (i) countries with relatively low incomes have only short series of data which are also often unreliable; (ii) at high levels of consumption the variation in consumption is very low, hence elasticities are inefficiently estimated; and (iii) many countries have maintained relatively stable retail prices for long periods thus leading to inefficient estimates of their price elasticities. Pooling the data may help increase the efficiency of estimation. On the other hand, the elasticities derived from a pooled analysis may be expected to differ from those of simple time series. It is sometimes suggested that cross-section results be considered long run in nature and time series short run. This argument considers the pattern of tastes to change as a country's income rises so that, in the long run, elasticities may be higher than those estimated from a times series (of fifteen to twenty years). The cross-section analysis of Viton and Pignalosa,[15] for example, may be considered to give such long-run elasticities. In a pooled study, the derived elasticities will lie somewhere between the short- and long-run extremes, probably being nearer the long-run kind since there may be less variation in the time-series than in the cross-section data. If the "taste" variable could be identified, its

[15] Ibid.

inclusion at a given level for each country would lead to pooled estimates exactly equivalent to time-series estimates for the individual countries.

In this research, pooled estimates were made in which each country's "taste" was assumed to differ, this difference being accommodated by the inclusion of (N-1) dummy variables, where N is the number of countries. Writing the model in its simplest form,

$$(7.9) \quad Q_{it} = f\,(Y_{it}, P_{it}, W_i), \qquad t = 1, 2, \ldots, T; \quad i = 1, 2, \ldots, N$$

where i = country i

t = year

and W_i = dummy variable for this country.

In the "Ramsey" functional form the equation becomes,

$$(7.10) \quad \log Q_{it} = \sum_{j=1}^{N-1} W_j + \delta + \theta_1 Y_{it}^{-1} + \theta_2 P_{it} + \log E_{it} ,$$

which differs from Equation (7.6) only in the inclusion of the dummy variables. The behavior of E_{it} is assumed to be as follows:

(i) $E(E_{it}{}^2) = \sigma_i{}^2$, i.e., heteroscedasticity in cross section;

(ii) $E(E_{it}, E_{jt}) = 0$, i.e., cross-sectional independence;

(iii) $E_{it} = \rho_i E_{i,t-1} + U_{it}$, i.e., autoregression in time series;

(iv) $U_{it} \sim N(0, \sigma_{ui}{}^2)$;

(v) $E_{io} \sim N(0, \dfrac{\sigma_{ui}}{1-\rho_i{}^2})$;

(vi) $E(E_{i,t-1}, U_{jt}) = 0$, for all i, j.

From the above it may be deduced that Generalized Least Squares (GLS) is the appropriate procedure for estimation, the matrix of disturbances being corrected for autocorrelation and each country having its own correction for heteroscedasticity. GLS was accomplished in two stages, in the first of which each country's data were transformed to remove autocorrelation. and OLS was conducted. The residuals were then used to correct for heteroscedasticity and OLS was again conducted to give the final estimates which should be unbiased and asymptotically efficient.[16] Similar procedures were also used in estimating the semi-logarithmic and double logarithmic functions.

Using exactly the same approach, but dropping the dummy variables, a set of "longer-run" pooled estimates was also obtained for each of the three functional forms. It should be noted that, unlike the situation for the individual countries where domestic currencies and deflators were used, in the pooled estimation all prices and incomes were converted to constant (1974) U.S. dollars, using the U.S. consumer price index as a deflator and end-of-period exchange rates given by the I.M.F.

Results of Pooled Estimation

Seventy-three countries were included in the pooled estimation, the range in consumption being from less than 2 to more than 50 kilograms per head per year, in price from less than 6 cents per kilo to more than $1.00 per kilo and in income from more than $6,000 per head to less than $70 per head.[17] The mean values of the sample were 27.8 kilograms per head per year, 37.9 cents per kilo and $373 per head of income per

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[16] For a full derivation and discussion , see Kmenta, J. (1971). Ibid., pp. 508-517.

[17] See the 1972 values on the right-hand side of Table 7.3.

year. Data were for the years 1950 to 1972 and, in some cases, to 1974. The 73 countries were selected on the basis of available data, particularly the availability of an exchange rate.

Equations (7.11), (7.12) and (7.13) present the results of the GLS estimation for the Ramsey, double logarithmic and semi-logarithmic forms respectively. Note that the coefficients of the dummy variables are not included with the equations, but are listed in Table 7.3.

$$(7.11)\qquad \log Q_{it} = \sum_{j=1}^{N-1} W_j + 11.9322 - \underset{(19.819)}{0.1299}\, Y_{it}^{-1} - \underset{(21.228)}{0.7348}\, P_{it} + e_{it}$$

$\bar{R}^2 = 0.999$

$NT = 1196$

$$(7.12)\qquad \log Q_{it} = \sum_{j=1}^{N-1} W_j + 10.6456 + \underset{(24.510)}{0.2812} \log Y_{it} - \underset{(22.106)}{0.3083} \log P_{it} + e_{it}$$

$\bar{R}^2 = 0.998$

$NT = 1196$

$$(7.13)\qquad Q_{it} = \sum_{j=1}^{N-1} W_j + 8.6892 + \underset{(23.830)}{6.4861} \log Y_{it} - \underset{(19.573)}{5.4827} \log P_{it} + e_{it}$$

$\bar{R}^2 = 0.986$

$NT = 1196$

The double-logarithmic Equation (7.12) is the simplest to interpret, giving constant price elasticity of -0.308 and income elasticity of 0.281. The corresponding income and price elasticities for each of the 73 countries for the Ramsey and semi-logarithmic equations are listed in Table 7.3. Beginning with the Ramsey results, income elasticity ranged from a low of 0.020 for the U.S.A. to a high of 1.428 for Burma.

Table 7.3. Pooled Estimates

Country	Dummy Variable	S.E.	η_y (1972)	η_p (1972)	Dummy Variable	S.E.	Dummy Variable	S.E.	η_y (1972)	η_p (1972)	kg./hd. (1972)	$ Inc./hd. (1972)	¢/kg. price (1972)
	Ramsey				Double Log		Semi-logarithmic				Raw Value 1974 Dollars		
Argentina	3.3317	(0.0323)	0.100	-0.224	2.6197	(0.0368)	12.0236	(1.4499)	0.147	-0.125	44.0	1297	30.5
Australia	3.9325	(0.0200)	0.031	-0.254	2.6121	(0.0462)	21.4561	(1.9384)	0.114	-0.097	56.6	4201	34.5
Austria	3.2577	(0.0390)	0.040	-0.281	2.5434	(0.0416)	8.7827	(1.8048)	0.140	-0.118	46.3	3230	38.2
Belgium	5.3844	(0.0421)	0.030	-0.433	4.1461	(0.0476	22.1389	(1.7634)	0.161	-0.136	40.3	4317	58.9
Bolivia	3.7281	(0.0530)	0.459	-0.212	2.8150	(0.0530)	9.0105	(1.2085)	0.257	-0.218	25.2	283	28.9
Brazil	1.7533	(0.0295)	0.226	-0.163	1.3959	(0.0294)	-0.0812	(1.2924)	0.156	-0.131	41.7	574	22.2
Burma	-2.6038	(0.1745)	1.428	-0.236	-2.5344	(0.1595)	-7.0789	(0.8864)	1.853	-1.566	3.5	91	32.1
Cameroun	0.4240	(0.0271)	0.548	-0.309	0.0756	(0.0252)	-3.3107	(0.4978)	1.802	-1.522	3.6	237	42.1
Canada	2.0027	(0.0257)	0.023	-0.295	1.2364	(0.0394)	3.3859	(1.3887)	0.137	-0.116	47.4	5691	40.2
Chile	1.9486	(0.0595)	0.119	-0.416	0.7051	(0.0904)	-11.9319	(2.4888)	0.162	-0.137	40.0	1088	56.6
China-Taiwan	1.5313	(0.0338)	0.229	-0.237	1.0322	(0.0368)	3.2965	(0.4066)	0.386	-0.326	16.8	568	32.2
Colombia	1.1766	(0.0365)	0.232	-0.175	0.3828	(0.0539)	-8.8109	(1.2215)	0.251	-0.213	25.8	561	23.8
Costa Rica	0.4045	(0.0426)	0.174	-0.156	0.3333	(0.0377)	-17.9074	(2.0856)	0.125	-0.106	51.7	748	21.2
Denmark	3.8884	(0.0201)	0.026	-0.332	2.6426	(0.0423)	17.2713	(2.0080)	0.120	-0.102	53.9	5045	45.2
Dom. Republic	3.4323	(0.0503)	0.261	-0.191	2.9803	(0.0420)	1.0286	(2.1472)	0.191	-0.162	33.9	497	26.0
Ecuador	2.6229	(0.0576)	0.347	-0.106	2.5356	(0.0354)	4.6257	(1.1815)	0.219	-0.185	29.6	374	14.4
Finland	4.0794	(0.0416)	0.039	-0.392	2.9366	(0.0541)	23.6141	(1.5163)	0.130	-0.110	49.8	3320	53.3
France	4.5041	(0.0290)	0.029	-0.283	2.9490	(0.0547)	11.7681	(1.4910)	0.190	-0.161	34.1	4464	38.5
Gabon	0.1592	(0.0744)	1.326	-0.406	-0.8725	(0.0897)	-1.6007	(0.6750)	0.110	-0.093	58.8	98	55.2
W. Germany	5.0610	(0.0331)	0.026	-0.347	2.7438	(0.0812)	2.5761	(1.9907)	0.184	-0.155	35.3	4953	47.2
Ghana	-0.4350	(0.1068)	0.454	-0.298	-0.5294	(0.0963)	-6.2728	(0.8982)	0.655	-0.554	9.9	286	40.5
Guatemala	0.2825	(0.0525)	0.282	-0.148	0.2101	(0.0455)	-8.2583	(1.0629)	0.235	-0.199	27.6	461	20.1
Guyana	5.0419	(0.0184)	0.306	-0.214	3.6226	(0.0436)	30.9733	(0.8788)	0.151	-0.128	42.8	425	29.1
Hong Kong	1.2694	(0.0755)	0.111	-0.410	0.6660	(0.0817)	-19.3947	(2.4360)	0.349	-0.295	18.6	1170	55.8
India	-0.6201	(0.0611)	1.048	-0.218	-0.3970	(0.0437)	-0.6215	(0.2499)	0.927	-0.783	7.0	124	29.7
Indonesia	-2.5712	(0.2219)	1.226	-0.240	-2.2105	(0.1830)	-19.4991	(1.9179)	0.821	-0.694	7.9	106	32.7
Iran	3.2109	(0.0375)	0.198	-0.279	2.6024	(0.0362)	10.7890	(0.9620)	0.227	-0.192	28.5	656	38.0
Iraq	1.3209	(0.0432)	0.213	-0.293	1.0257	(0.0427)	-5.8935	(1.5824)	0.201	-0.170	32.3	609	40.0
Ireland	3.4381	(0.0252)	0.064	-0.237	3.0055	(0.0214)	20.6028	(1.9214)	0.094	-0.079	69.1	2025	32.3
Israel	1.4275	(0.0432)	0.057	-0.176	1.3576	(0.0300)	-21.0171	(3.0188)	0.100	-0.085	64.7	2276	24.0
Italy	2.6430	(0.0550)	0.051	-0.389	2.4520	(0.0319)	4.4970	(1.1699)	0.205	-0.173	31.7	2553	52.9
Ivory Coast	0.3503	(0.0458)	0.280	-0.239	0.1779	(0.0429)	-1.2777	(0.3928)	0.527	-0.446	12.3	464	32.6
Jamaica	1.2876	(0.0246)	0.143	-0.176	0.9754	(0.0277)	-2.5967	(1.4899)	0.131	-0.111	49.5	909	23.9
Japan	0.2600	(0.0465)	0.039	-0.433	0.3825	(0.0267)	-4.2449	(0.7053)	0.213	-0.180	30.4	3311	59.0
Kenya	0.5786	(0.0388)	0.666	-0.225	0.2603	(0.0403)	-1.8531	(0.5783)	0.373	-0.315	17.4	195	30.6
Korea (South)	-3.8100	(0.2336)	0.368	-0.398	-4.1453	(0.2321)	-11.1212	(1.2708)	0.983	-0.831	6.6	353	54.2

Table 7.3. continued

Country	Dummy Variable	S.E.	η_y (1972)	η_p (1972)	Dummy Variable	S.E.	Dummy Variable	S.E.	η_y (1972)	η_p (1972)	kg./hd. (1972)	$ Inc./hd. (1972)	¢/kg. price (1972)
	Ramsey				Double Log		Semi-logarithmic				Raw Value 1974 Dollars		
Libya	3.3989	(0.0818)	0.047	-0.132	3.1535	(0.0497)	0.1596	(2.1216)	0.180	-0.152	36.1	2756	17.9
Madagascar	0.6895	(0.0547)	0.769	-0.229	0.3361	(0.0507)	4.1281	(0.2901)	0.811	-0.685	8.0	169	31.1
Mauritius	0.6486	(0.0224)	0.363	-0.067	0.5370	(0.0192)	-0.7871	(0.7259)	0.152	-0.128	42.7	358	9.1
Mexico	2.1522	(0.0301)	0.141	-0.159	1.8457	(0.0259)	0.2972	(1.3357)	0.165	-0.139	39.4	922	21.7
Morocco	1.5421	(0.0222)	0.414	-0.281	1.3364	(0.0188)	6.4894	(0.6432)	0.224	-0.189	29.0	314	38.3
Netherlands	2.8039	(010285)	0.032	-0.339	2.3495	(0.0260)	14.4564	(1.7686)	0.127	-0.108	50.9	4034	46.1
New Zealand	3.1768	(0.0167)	0.037	-0.207	2.2283	(0.0326)	16.0993	(1.2934)	0.117	-0.099	55.6	3484	28.2
Niger	0.0000	-	1.073	-0.285	0.0000	-	0.0000	-	2.495	-2.108	2.6	121	38.8
Nigeria	-0.3887	(0.0652)	0.684	-0.373	-0.8994	(0.0562)	-8.4514	(0.7615)	2.703	-2.284	2.4	190	50.8
Norway	4.8680	(0.0502)	0.030	-0.348	3.1109	(0.0821)	12.8215	(2.6603)	0.139	-0.118	46.6	4369	47.3
Pakistan & Bangladesh	-1.0124	(0.1057)	0.726	-0.313	-1.9348	(0.1314)	1.1668	(0.3736)	0.119	-0.100	54.7	179	42.6
Peru	2.3691	(0.0198)	0.212	-0.126	1.6456	(0.0306)	2.5983	(0.9056)	0.205	-0.173	31.7	614	17.2
Philippines	0.0410	(0.0699)	0.496	-0.161	0.0878	(0.0562)	-7.7163	(0.9887)	0.338	-0.286	19.2	262	21.9
Portugal	1.1236	(0.0493)	0.110	-0.226	1.0174	(0.0381)	-3.9727	(1.0140)	0.221	-0.186	29.4	1179	30.8
Senegal	-0.0229	(0.0743)	0.442	-0.304	-0.1354	(0.0702)	-10.3403	(1.3187)	0.334	-0.283	19.4	294	41.4
Sierra Leone	0.3168	(0.0397)	0.999	-0.189	0.2201	(0.0327)	-1.8209	(0.4826)	0.579	-0.489	11.2	130	25.7
Singapore	-0.5199	(0.1193)	0.091	-0.203	-0.6730	(0.1158)	-104.2593	(9.3839)	0.110	-0.093	59.0	1424	27.6
South Africa	1.7051	(0.0131)	0.127	-0.207	1.4164	(0.0137)	6.3766	(0.8186)	0.149	-0.126	43.5	1023	28.2
Spain	1.4160	(0.0689)	0.081	-0.241	1.5375	(0.0425)	-3.6412	(1.3190)	0.215	-0.182	30.1	1598	32.8
Sri Lanka	1.4934	(0.0306)	0.710	-0.205	1.0727	(0.0337)	1.3976	(0.8305)	0.349	-0.295	18.6	183	27.9
Sudan	1.1055	(0.0540)	0.656	-0.529	0.6823	(0.0548)	1.3969	(0.7811)	0.386	-0.326	16.8	198	72.0
Sweden	4.2949	(0.0348)	0.021	-0.387	2.3791	(0.0785)	5.2972	(2.7064)	0.141	-0.119	46.0	6101	52.7
Switzerland	2.6718	(0.0356)	0.023	-0.318	1.8816	(0.0448)	0.8888	(2.1794)	0.130	-0.110	50.0	5482	43.3
Syria	0.5440	(0.0446)	0.365	-0.170	0.4293	(0.0398)	-4.9066	(0.9289)	0.240	-0.203	27.0	356	23.2
Tanzania	0.2762	(0.0548)	1.007	-0.238	-0.1632	(0.0572)	0.9096	(0.3519)	0.662	-0.559	9.8	129	32.4
Thailand	1.7831	(0.1552)	0.512	-0.192	-2.2779	(0.1603)	-2.1035	(0.5520)	0.569	-0.481	11.4	254	26.1
Togo	1.4077	(0.0673)	0.688	-0.315	0.0193	(0.0846)	-0.5261	(0.7037)	1.802	-1.523	3.6	189	42.8
Trinidad & Tobago	0.3260	(0.0219)	0.115	-0.177	0.1607	(0.0237)	-8.4973	(1.0801)	0.162	-0.137	40.0	1132	24.1
Tunisia	0.5257	(0.0773)	0.269	-0.234	0.2831	(0.0732)	-6.3266	(1.1610)	0.312	-0.264	20.8	483	31.9
Turkey	2.3461	(0.0618)	0.249	-0.242	1.4745	(0.0706)	2.4244	(1.0237)	0.305	-0.257	21.3	521	32.9
U.K.	4.6277	(0.0366)	0.042	-0.204	2.9083	(0.0731)	22.8597	(2.3887)	0.124	-0.105	52.4	3075	27.7
U.S.A.	3.3648	(0.0263)	0.020	-0.265	2.3323	(0.0410)	21.7044	(0.9914)	0.129	-0.109	50.1	6514	36.1
Upper Volta	1.7887	(0.0782)	1.733	-0.269	0.3675	(0.0472)	9.6526	(0.5942)	2.495	-2.108	2.6	75	36.6
Uruguay	1.6267	(0.0397)	0.231	-0.224	1.2791	(0.0389)	-3.4721	(1.8022)	0.158	-0.133	41.1	563	30.5
Venezuela	1.5952	(0.0803)	0.085	-0.198	1.1552	(0.0753)	-26.3260	(3.4176)	0.154	-0.130	42.1	1529	26.9
Vietnam (South)	-2.9022	(0.1740)	1.031	-0.257	-2.5328	(0.1535)	-15.4273	(1.4142)	0.559	-0.473	11.6	126	35.0
Zambia	-0.9559	(0.0728)	0.286	-0.267	-0.9721	(0.0706)	-11.3372	(0.9743)	0.424	-0.358	15.3	455	36.3

In general these income elasticities accord well with the time-series estimates previously noted. The price elasticities for the Ramsey equation ranged from -0.067 for Mauritius to -0.529 in the Sudan. These elasticities show a much narrower range than those from time series, a point which will be examined shortly. For the semi-logarithmic Equation (7.13), income elasticity ranged from 0.094 for Ireland to 2.703 for Nigeria and price elasticities ranged from -0.079 for Ireland to -1.566 for Burma. The income elasticities from this equation are large at high incomes (e.g., the U.S.A.) by comparison with the time-series results, while the price elasticities are relatively consistent with the results from time series.

A comparison between the pooled and time-series results may be made by observing the results for those countries for which both price and income coefficients were significant in time series. This is done in Table 7.4. In general, the table shows a "reasonable" correspondence between the pooled and time-series estimates. In 7 of the 11 cases, the Ramsey income elasticity (η_y), was larger in the pool than in time series, while in only one of the 11 was the semi-logarithmic value larger, implying that the Ramsey pooled estimate of income elasticity was a closer approximation to time series. Turning to price elasticity (η_p), in 7 of the 11 cases the pooled estimate was larger with the Ramsey equation and in 5 of the 11 with the semi-logarithmic equation. However, the semi-logarithmic pooled price elasticity may be the more accurate because the Ramsey pooled price elasticity is independent of the level of consumption and depends only on price. This leads to a priori unacceptable estimates. For example, since the price in Thailand is lower than that in the U.S.A., the price elasticity in the U.S.A. is

Table 7.4. Comparison of Time Series and Pooled Estimates

Country	Ramsey				Semi-Logarithmic			
	Time Series		Pooled		Time Series		Pooled	
	η_y	η_p	η_y	η_p	η_y	η_p	η_y	η_p
Bolivia	2.444	-0.204	0.459	-0.212	1.202	-0.158	0.257	-0.218
Brazil	0.205	-0.246	0.226	-0.163	0.484	-0.224	0.156	-0.131
China-Taiwan	0.186	-0.258	0.229	-0.237	0.411	-0.228	0.386	-0.326
Ivory Coast	0.222	-0.591	0.280	-0.239	0.826	-0.551	0.527	-0.446
Japan	0.014	-0.344	0.039	-0.433	0.254	-0.260	0.213	-0.180
Korea (South)	0.570	-0.389	0.368	-0.398	0.737	-0.256	0.983	-0.831
South Africa	0.041	-0.381	0.127	-0.207	0.199	-0.370	0.149	-0.126
Spain	0.389	-0.203	0.081	-0.241	0.547	-0.181	0.215	-0.182
Syria	0.098	-0.326	0.365	-0.170	0.451	-0.339	0.240	-0.203
Thailand	0.667	-0.675	0.512	-0.192	0.734	-0.358	0.569	-0.481
Turkey	0.114	-0.459	0.249	-0.242	0.512	-0.502	0.305	-0.257

estimated to be higher than that for Thailand. In summary, the income elasticity from the Ramsey equation and the price elasticity from the semi-logarithmic equation best approximate the time-series estimates.

In the pooled estimation each country had its own intercept through the use of dummy variables, as listed in Table 7.3. The coefficients of the dummy variables may be considered as measures of all excluded influences, once price and income effects are removed. These influences might be called "taste" for sugar and countries with similar "tastes" should have similar magnitudes for the coefficients of their dummy variables. Table 7.5 lists this "taste" variable from the Ramsey equation in rank order, the values ranging from +5.3844 for Belgium to -3.8100 for South Korea. Should one wish to test for significance of difference in taste between countries, the standard errors in Table 7.3 may be used. In general a difference in taste of one unit is significant since the standard errors are small. An approximate grouping of countries for "taste for sugar" beginning at the highest level would be: (i) W. Europe, Canada, U.S.A., Australia, New Zealand; (ii) South and Central America; (iii) N. Africa and Middle East; (iv) Sub-Saharan Africa (excl. South Africa); (v) South and Southeast Asia (excl. Taiwan and Hong Kong). The "taste" variable may be interpreted as indicating, for example, that at the same price and income level consumption of sugar per head in Western Europe would be considerably higher than in Southeast Asia. Since the variable is logarithmic, a simpler interpretation (in terms of kilograms per head for example), is not readily forthcoming.

As well as estimating the pooled relationships including individual-country dummies, equations were estimated with these variables

Table 7.5. Rank Order of Taste for Sugar

Country	Rank	Intercept Value	Country	Rank	Intercept Value
Belgium	1	5.3844	Israel	38	1.4275
W. Germany	2	5.0619	Spain	39	1.4160
Guyana	3	5.0419	Togo	40	1.4077
Norway	4	4.8680	Iraq	41	1.3209
U.K.	5	4.6277	Jamaica	42	1.2876
France	6	4.5041	Hong Kong	43	1.2694
Sweden	7	4.2949	Colombia	44	1.1766
Finland	8	4.0794	Portugal	45	1.1236
Australia	9	3.9325	Sudan	46	1.1055
Denmark	10	3.8880	Madagascar	47	0.6895
Bolivia	11	3.7281	Mauritius	48	0.6486
Ireland	12	3.4381	Kenya	49	0.5786
Dom. Rep.	13	3.4323	Syria	50	0.5440
Libya	14	3.3989	Tunisia	51	0.5257
U.S.A.	15	3.3648	Cameroun	52	0.4240
Argentina	16	3.3317	Costa Rica	53	0.4045
Austria	17	3.2577	Ivory Coast	54	0.3503
Iran	18	3.2109	Trinidad & Tobago	55	0.3260
New Zealand	19	3.1768	Sierra Leone	56	0.3168
Netherlands	20	2.8039	Guatemala	57	0.2825
Switzerland	21	2.6718	Tanzania	58	0.2762
Italy	22	2.6430	Japan	59	0.2600
Ecuador	23	2.6229	Gabon	60	0.1592
Peru	24	2.3691	Philippines	61	0.0410
Turkey	25	2.3461	Niger	62	0.0000
Mexico	26	2.1522	Senegal	63	-0.0229
Canada	27	2.0027	Nigeria	64	-0.3887
Chile	28	1.9486	Ghana	65	-0.4350
Upper Volta	29	1.7887	Singapore	66	-0.5199
Thailand	30	1.7831	India	67	-0.6201
Brazil	31	1.7533	Zambia	68	-0.9559
South Africa	32	1.7051	Pakistan	69	-1.0124
Uruguay	33	1.6267	Indonesia	70	-2.5712
Venezuela	34	1.5952	Burma	71	-2.6038
Morocco	35	1.5421	S. Vietnam	72	-2.9022
China-Taiwan	36	1.5313	S. Korea	73	-3.8100
Sri Lanka	37	1.4934			

excluded. The equations were corrected for autocorrelation but not for heteroscedasticity, since the latter correction led to a "blowing-up" of the estimates. Equations (7.14), (7.15) and (7.16) list the Ramsey, double-logarithmic and semi-logarithmic estimates respectively.

$$(7.14) \quad \log Q_{it} = 1.7254 - \underset{(14.411)}{0.1730}\ Y_{it}^{-1} - \underset{(17.907)}{3.1774}\ P_{it} + e_{it}$$

$\bar{R}^2 = 0.258$

$NT = 1196$

$$(7.15) \quad \log Q_{it} = 1.0169 + \underset{(36.446)}{0.7224} \log Y_{it} - \underset{(45.544)}{1.8341} \log P_{it} + e_{it}$$

$\bar{R}^2 = 0.726$

$NT = 1196$

$$(7.16) \quad Q_{it} = 8.5478 + \underset{(51.697)}{12.8248} \log Y_{it} - \underset{(41.450)}{20.8910} \log P_{it}$$

$\bar{R}^2 = 0.773$

$NT = 1196$

The equations give both much higher income and much higher price elasticities than the earlier equations which had dummy variables. The derived elasticities bear little resemblance to the individual time-series estimates or to the purely cross-sectional estimates of Viton and Pignalosa.[18] The conclusion is that "taste" differences may not be omitted from consideration without severely biasing the results.

Summary and Comments

In this chapter the elasticity of demand for sugar was estimated for a large number of countries, both from time series and from pooled time-series/cross-section data. Alternative functional forms were

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[18] Ibid.

discussed and, for individual time series, the "Ramsey" form was favored over semi- and double-logarithmic alternatives. In pooled estimation, no single form was superior, but the inclusion of a dummy variable to cover "taste" variation was found to be important. An unique taste scale was devised which demonstrated that, at the same price and income, Western countries consume more sugar per head than South American, African and Asian countries (in that general order). Income elasticity was found to range from 0.02 for the U.S.A. to more than 1.40 for the poorest countries. Price elasticity ranged from approximately -0.04 for the U.S.A. to -1.50 in the poorest countries. Except in the poorest countries, sugar may be said to be both price and income inelastic.

By way of comment, three areas for further investigation are apparent. Firstly, the cross elasticity between sucrose and other sweeteners was not estimated and a separate study of this substitution for the U.S.A. would be valuable, updating the work of Hayenga.[19] Secondly, further work on functional forms for demand equations would be of value since no single form proved completely satisfactory for pooled estimation. Estimating both linear and exponential price components of the Ramsey equation[20] could be fruitful in this respect and a full set of specification error tests might assist in choosing the most appropriate functional form. Finally, the identification of a taste variable presents the interesting possibility of defining more clearly what comprises taste and how it varies in both space and time.

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[19] Hayenga. (1967). Op. cit.

[20] Rather than just the exponential.

CHAPTER VIII

RESULTS FROM THE MODEL UNDER ALTERNATIVE POLICIES

Introduction

This chapter presents the results from simulating the world sugar economy under a variety of policies. The model was solved in two distinct modes which may be termed "recursive" and "equilibrium." The objectives of the recursive solutions were to validate the model, by demonstrating its ability to track historic market behavior, particularly the price-fluctuations of 1973-75, and to obtain some indication about price variability under alternative policies. The objective of the equilibrium solutions was to appraise the long-run distribution of losses and gains to be expected under an array of alternative policies. Further discussion of the policy and welfare implications of the findings will be addressed in Chapter IX. Before presenting the "recursive" results, a recapitulation of the relationships used in the model and a few further assumptions necessary to the solution of the model will be given--these occupy the remainder of this introductory section.

Considering first, demand, semi-logarithmic functions were used throughout for the 75 regions. Whenever individual equations from the time-series of Chapter VII were deemed reliable, these were used. Otherwise a general equation from the pooled time-series/ cross-section analysis was used. Each constant term was normalized so that <u>actual</u> consumption in 1972 was accurately predicted, or, where possible, equations in domestic currencies were converted to a 1974 dollar basis using estimated consumption in 1972 as the base.[1] Because the demand equations related to retail prices for refined sugar and the supply equations to wholesale prices of raw sugar, it was necessary to add a retail/wholesale margin and a refining margin in the model. A refining margin of 3 cents per lb. was assumed for all countries. Retail/wholesale margins were observed for 1972 and are listed in Table 8.1. Also in Table 8.1 the assumptions on growth of population and income may be found.

Turning to supply,[2] of the 67 equations which were used 28 were asymmetric (cane producers), 14 were log-linear (beet producers), 18 were simple functions of time, 4 were assumed totally price inelastic and 3 were derived from interpolation with a table of values previously calculated (U.S. cane areas). Elaborating slightly on treatment of U.S. supply, the four beet regions of Chapter III were combined into two for which the ports of San Francisco and New York were utilized. The equations were, with terms other than those shown at 1974 levels:

New York (Areas I & II):

$$\log QS = 5.1892 + 0.9056 \log PS_{t-1} - 0.7934 \log PIN_t + 0.0481\ T$$

San Francisco (Areas III & IV):

$$\log QS = 5.5120 + 2.7135 \log PS_{t-1} - 1.5719 \log PIN_t + 0.0397\ T$$

where:

QS = thousand metric tons of raw sugar,

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[1]For the Communist countries the following incomes per capita were used for purposes of normalization: U.S.S.R. and Eastern Europe $1000 per head; East Germany $1500 per head; China $300 per head. For Cuba no assumption was necessary since income elasticity of demand was assumed zero.

[2]For a list of countries and functional forms see Table 2.1 of Chapter II.

Table 8.1 Price Margins and Income/Population Growth

Country	Retail/Whol. Margin in 1974 ¢/kg.	% Annual Growth of GDP	% Annual Growth of Population	Country	Retail/Whol. Margin in 1974 ¢/kg.	% Annual Growth of GDP	% Annual Growth of Population	Country	Retail/Whol. Margin in 1974 ¢/kg.	% Annual Growth of GDP	% Annual Growth of Population
Argentina	2.3	4.2	1.5	Iceland	7.7	4.8	1.3	Spain	2.8	6.7	1.1
Australia	3.9	5.4	1.6	India	0.3	3.2	2.1	Sri Lanka	1.8	3.5	1.9
Austria	4.2	6.4	0.6	Indonesia	3.5	7.1	2.3	Sweden	16.9	3.3	0.4
Barbados	0.0	-	0.8	Iran	1.8	12.2	3.0	Switzerland	11.0	5.0	1.3
Belgium	12.0	5.7	0.4	Ireland	2.1	4.2	0.9	Thailand	1.8	6.4	3.2
Bolivia & Chile	7.1	6.8	2.4	Italy	2.7	4.3	0.8	Trinidad & Tobago	1.3	6.8	1.2
Brazil	2.5	10.2	2.9	Jamaica	0.8	4.7	1.9	Turkey	2.6	7.1	2.5
Canada	8.8	5.3	1.2	Japan	12.7	9.6	1.3	U.S.S.R.	10.0	7.1	1.0
China	10.0	4.5	1.7	Korea	1.7	11.1	2.0	U.K.	2.1	2.8	0.3
China-Taiwan	3.4	11.0	2.1	Mauritius	2.6	5.3	1.3	U.S.A.	4.2	3.5	0.9
Colombia	2.5	6.4	3.2	Mexico	1.6	6.5	3.5	U.S.A.-P. Rico	4.2	6.9	2.4
Cuba	3.0	2.5	1.6	Netherlands	9.0	5.1	1.0	Venezuela	3.9	5.4	2.8
Czechoslovakia	10.0	4.6	0.6	New Zealand	3.1	4.1	1.8	Eastern Europe	10.0	6.8	0.8
Denmark	6.8	5.1	0.6	Nicaragua	3.0	6.8	1.5	Central America	3.9	6.8	2.8
Dom. Rep.	2.6	10.4	3.0	Norway	9.9	4.5	0.7	Near East	3.0	8.6	3.2
Fiji	0.0	-	1.9	Pakistan & Ban.	2.5	3.6	3.6	Far East	3.0	5.8	2.3
Finland	12.2	6.6	0.4	Parag. & Urug.	3.0	6.8	2.5	North Africa	2.1	5.0	2.7
France	2.7	6.1	0.4	Peru	1.0	5.6	3.2	West Africa	3.0	6.0	2.7
East Germany	10.0	4.7	0.0	Philippines	1.6	6.4	3.0	N.E. Africa	2.7	5.3	2.2
West Germany	7.4	5.0	0.7	Poland	10.0	6.4	0.9	East Africa	2.4	5.5	2.7
Greece	6.2	6.5	1.5	Portugal	3.9	6.5	- 0.4	S. Central Africa	6.5	4.5	3.3
Guatemala	2.1	6.0	2.8	Saudi-Arabia	4.9	10.0	2.9	S. W. Central Africa	8.3	3.3	2.8
Guyana	2.3	6.8	1.8	Singapore	2.6	6.8	1.7				
Hong Kong	12.5	7.0	1.7	South Africa	2.1	4.7	2.8				

Sources: International Sugar Organization (various). Sugar Yearbook. London: I.S.O., Haymarket, W.C.I.
United Nations (1974). U.N. Demographic Yearbook. New York: United Nations.
U.S. Agency for International Development (1974). **Gross National Product: Growth Rates and Trend Data. Washington** D.C.:U.S.A.I.D.
United Nations (1975) **Yearbook of National Accounts Statistics, 1973. New York:**United Nations.

PS = wholesale price of raw sugar in 1974 cents per lb.,

PIN = an index of input prices (1972 = 100),

T = year (1966 = 66),

t = a year subscript.

The mainland cane regions, Louisiana, Florida and Texas, were combined into a single region located at the port of New Orleans. Because the computational burden in making projections as in Chapter IV would have been large, the 1985 projections listed there were recalculated for 1974 to give the following estimates:

Table 8.2. U.S. Domestic Cane Supply in Thousand Metric Tons Raw Value at 1974 Prices

Price ¢/lb.	Region					Total
	Texas[1]	Florida	Louisiana	Hawaii	Puerto Rico	
3	-	11	178	98	-	287
4	-	18	249	226	-	493
5	-	25	316	362	-	703
6	-	36	381	491	-	908
7	-	51	439	608	-	1,098
8	18	84	494	715	132	1,443
9	36	251	543	812	164	1,806
10	54	496	589	898	169	2,206
11	64	671	630	972	162	2,499
12	73	818	674	1,045	205	2,815
13	82	970	710	1,114	333	3,109
14	91	1,091	746	1,175	276	3,379
15	91	1,244	780	1,231	414	3,760
16	91	1,349	816	1,281	652	4,189
17	91	1,449	847	1,328	820	4,535
18	91	1,562	876	1,369	955	4,853

[1]Assumed and not estimated.

Continuing the list of assumptions and approximations, the model was initialized with all input prices and the prices of competing crops at 1974 levels. Quota agreements by the U.S.A., U.K. and Cuba were included at their 1973 levels, unless otherwise stated.[3] The asymmetric supply functions were initialized for 1972 on the basis of 1970 and 1971 export prices. Finally, the model was solved to an accuracy of 0.2 cents per lb., or approximately a 2 percent level of error, the endogenously determined variables being price, production and consumption in each region and trade flows between each pair of regions.

Annual Recursive Solution

Because the computational burden proved greater than expected, simulation of the market was restricted to the period 1972-75. The results are therefore of an interim rather than final nature; a fuller set of results awaits the development of a more efficient algorithm. A summary of the results for the major regions and a comparison with actual quantities and prices is given in Table 8.3. In the table two kinds of solution are shown, one called "basic" and the other "taxed." Discussion begins with the "basic" solution, which assumes that exporting countries allow their domestic prices to rise to the international equilibrium level when supply declines relative to demand.

Simulated world supply, (on the right hand of the table), in 1972 is 75,308 thousand tons and rises in 1973 to 77,859 thousand tons. Actual supplies in these two years were similar to these estimates. In 1974, however, simulated supply falls drastically to

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[3]An exception was the elimination of Australia's quota to the U.K., which was not included as it expired in 1974.

Table 8.3. Model and Actual Quantities and Prices, 1972-75

Year	U.S.A.			EEC			U.S.S.R.			Brazil			Cuba	Australia	World
	Supply	Demand	Price	Supply	Demand	Price	Supply	Demand	Price	Supply	Demand	Price	Supply	Supply	Supply
BASIC															
1972	5,772	10,654	10.65	8,885	10,293	13.52	9,538	10,902	7.42	5,659	4,160	6.17	6,285	2,801	75,308
1973	5,773	10,654	10.65	9,622	11,007	9.14	9,430	10,996	6.97	6,008	4,283	5.44	6,241	2,851	77,859
1974	5,109	10,814	14.15	6,621	10,648	14.07	9,292	10,253	12.85	6,117	4,070	12.45	6,197	2,883	71,215
1975	8,556	11,133	8.90	9,439	11,323	9.75	9,957	10,825	7.93	6,251	4,652	6.77	6,154	2,898	79,728
TAXED															
1972							SAME AS BASIC SOLUTION								
1973															
1974	5,109	10,737	16.22	6,619	10,435	15.53	9,299	10,639	14.83	6,117	4,465	9.77	6,197	2,883	71,221
ACTUAL															
1972	5,724	10,619	9.09	9,936	10,475	n.a.	9,674	10,750	n.a.	6,151	4,125	7.43[1]	4,688	2,869	75,771
1973	5,729	10,632	10.29	10,177	11,116	n.a.	9,600	11,200	n.a.	6,937	4,266	9.61[1]	5,383	2,582	78,101
1974	5,399	10,325	29.50	9,237	11,698	n.a.	8,526	11,250	n.a.	6,931	4,577	29.99[1]	5,926	2,938	77,055[2]
1975															81,860[2]

[1]World spot price in Caribbean

[2]Parallel to F. O. Licht estimate.

71,215 thousand tons while actual supply fell much less sharply to 77,055 thousand tons. For 1975 simulated supply is slightly lower than currently estimated supply. Although the 1974 solution gives a lower supply than actually existed, free-market (see Brazil) and U.S. prices do not rise as much in 1974 in the model as in reality. U.S. price in 1974 was actually 29.50 cents per pound, while the model gives 14.15 cents per pound. Free-market price was 29.99 cents per pound and the model gives 12.45 cents per pound. The discrepancy may be partly attributed to the behavior of exporting countries in 1974 (and other such years). When prices rose, instead of allowing domestic prices to rise the exporting countries limited exports thus increasing the burden of adjustment in the importing countries. To test this behavioral hypothesis, regression equations were estimated for 59 countries in which real retail price was made a function of the free-market price of sugar (in real dollars) in the current and preceding years. Thirty-eight of the countries were importers of sugar and, of these, 24 significantly (5 percent level) raised prices in response to world prices. Only 4 of the 21 exporting countries significantly raised prices under similar circumstances and 2 countries showed significant negative responses. The estimates concern the years 1950-1972, but the conclusion, that exporting countries reduce exports rather than raise domestic prices, is confirmed by a study of price-behavior in 1974 by Compagnie Financière Sucres et Denrées.[4]

In the "taxed" results given in Table 8.3, a restriction was placed on the raising of domestic prices in exporting countries.

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[4]Compagnie Financière Sucres et Denrées (1974). "The Rise of Sugar Prices: Its Effect on Consumption." Paris: CFSD.

Although the intention was to restrict prices in these countries to a rise of 10 percent for 1974, this proved computationally very difficult. Instead, prices were restricted to a rise of approximately 90 percent, as compared with approximately 130 percent in the "basic" solution. The solutions are called "taxed" because the effect of limiting the rise of domestic prices is exactly equivalent to imposing a tax on exports and computationally such a procedure was used. The results for 1972 and 1973 were exactly the same as for the basic solution, no tax being necessary on exports. For 1974, the restriction of exports leads to price behavior slightly more similar to reality than in the "basic" solutions. U.S. price was pushed up an additional 2.06 cents and EEC price an additional 1.46 cents, to reach 16.22 and 15.53 cents per pound respectively. Further experiments are required to determine whether more severe export-restriction could account for the average 29.5 cents per pound price in the U.S.A. in 1974, but it seems likely that an additional influence, possibly speculation, is needed to account for such very high prices.

The results of using the model in its recursive mode are incomplete and of an interim rather than final nature. They are included here more as a demonstration of the future use of the model than as a completed piece of research. The very tentative implication of the work thus far is that the minor decline in world supply and the actions of exporters to stabilize their domestic prices by restricting exports in 1974 were the most important influence leading to that year's very high price. The end of the U.S. Sugar Act and uncertainty over EEC policy were probably not important influences. Although the model was not used to project conditions in 1976, a large response to

1974 prices by the cane producers may be expected, leading to an extended period of relatively low prices.

Long-Run Equilibria Under Alternative Policies

Thirteen different combinations of policies were run, ranging from a set in which current policies were included, to one with completely free trade. The solutions are "long-run" in the sense that all lags are worked out. The experiments are listed in Table 8.4, where information on some important prices and quantities is also given. The six policy-variables require a short explanation. A plus (+) in the table denotes a policy in operation and a minus (-) the abandonment of a policy. The "U.S. Sugar Act" policy included quotas of 4,882,000 tons, a 0.625 cent per pound tariff and the banning of nonquota imports. The "E.E.C. Levy" policy denied entry to the EEC of raw sugar at less than the threshold price of 14.6172 cents per pound and countervailing charges ensured compliance with the policy. The "Cuban Quotas" policy directed 2,745,000 tons of Cuban exports to Communist countries. The "Commonwealth Quotas" policy directed 1,383,000 tons to be delivered from Commonwealth countries (excluding Australia) to the U.K. The "Other Tariffs" policy simply imposed all other specific and ad valorem tariffs known to exist. Finally, the "Export Tax" policy imposed a tax on exports from all cane producing countries equal to the amounts shown, as a representation of the possible effect of a cartel of exporters.

Before proceeding to a discussion of the individual results in Table 8.4, which are the key findings of this research, some general comments will be made. It may firstly be noted that under all of the

Table 8.4 Policy Experiments and Long-Run Equilibria

Experiment Number	Policy: U.S. Sugar Act	Policy: EEC Levy	Policy: Cuban Quotas	Policy: Common-wealth Quotas	Policy: Other Tariffs	Policy: Export Tax	Prices: Free-Market New York	Prices: U.S. Domestic New York	Prices: EEC (France)	Prices: Cuban Domestic	U.S.A.: Imports	U.S.A.: Domestic Production	E.E.C.: Imports	E.E.C.: Domestic Production	World: Production and Consumption
I	+	+	+	+	+	-	7.76	11.89	12.79	6.72	4882	5987	1383	9303	78535
II	-	-	-	-	-	-	10.85	10.72	11.36	9.81	5674	5216	2808	8112	77575
III	-	+	+	+	+	-	10.23	10.33	12.56	9.19	6380	4544	1383	9305	77818
IV	+	-	+	+	+	-	9.17	11.82	9.87	8.13	4882	5991	3918	7140	77627
V	-	-	+	+	+	-	11.24	11.13	10.31	10.20	5718	5148	3587	7451	77393
VI	-	+	-	+	+	-	9.78	9.53	12.83	8.74	6902	4013	1383	9295	77820
VII	10% VTAR	+	+	+	+	-	9.86	11.01	12.74	8.82	5954	4951	1383	9296	78301
VIII	-	-	-	+	+	-	10.40	10.22	10.78	9.36	6263	4644	3275	7663	77134
IX	+	+	+	-	+	-	7.43	11.86	13.83	6.39	4882	5990	366	10196	78830
X a	+	+	+	+	+	2¢/lb.	9.07	11.91	12.84	6.03	4882	5991	1383	9305	78752
b	+	+	+	+	+	6¢/lb.	10.13	11.88	12.61	3.09	4882	5990	1383	9292	77391
c	0.625¢/lb. FTAR	+	+	-	+	10¢/lb.	13.77	14.48	13.78	2.73	3443	7375	322	10223	76245
d	0.625¢/lb. FTAR	+	+	-	+	20¢/lb.	16.24	16.24	14.59	1.36	1443	9322	- 204	10717	75281
1973	+	+	+	+	+	-	11.68	11.42			4831	5731	313	10177	78095
1974	0.625¢/lb. FTAR	+	+	-	+	-	31.03	29.50			5188	5398	1036	9237	77055#

Notes: VTAR denotes ad valorem tariff
FTAR denotes specific tariff

EEC Threshold Price is 14.6172¢/lb.
Prices are c.i.f. in 1974 cents/lb.

Quantities are in thousand metric tons of raw sugar
#Projected I.S.O. figure parallel to F. . Licht estimate

different policies the volume of world production is relatively constant. This results not only from the low magnitudes of changes in price which are induced by the alternative policies, but also from the ease with which beet production may be substituted for cane production. Even under a huge export tax of 20 cents per pound (Xd), the volume of world production is not greatly curtailed but its geographical distribution merely changed.

Secondly, it is worth noting that prices are considerably lower than those existing in 1974, even under the imposition of a large export tax by cane exporters. The results suggest that a return to lower average prices is very likely for future years.

Turning to specific questions of the effects of alternative policies, the first comparison to be made is between the most likely set of policies (I) and completely free trade (II). Surprisingly, world production would decline by 960,000 tons under free trade. The underlying cause is the increased free-market price, from 7.76 to 10.85 cents per pound, and the associated increase in sugar prices in exporting countries. Since the price elasticity of demand is higher in the exporting nations as a group than in the importing nations, high prices reduce consumption by more in the exporting countries than they increase consumption in the importing countries. The net effect in equilibrium between production and consumption is a small decline in world production (and consumption). The effect of free trade on U.S. and EEC prices and production is less than might have been expected. In both regions some domestic production is replaced by imports and the domestic price falls to meet the free-market price (which has risen). Imports to the U.S.A. increase by 792,000 tons or 16 percent and to the EEC by 1,505,000 tons or 103 percent. For a full listing of national prices, production and consumption under these and the six most interesting other policies, the reader is directed to Appendix C.

The second comparison to be made is between the most likely set of policies (I) and a set in which the U.S. Sugar Act is ended (III). World production and consumption decline slightly by 717,000 tons. U.S. and free-market prices become synonymous, but the free-market price rises much more (+2.47 cents) than the U.S. domestic price falls (-1.56 cents). The hypothesis of Sanchez[5] that the U.S. Sugar Act raised free-market prices is rejected by this experiment--the converse is true. Because the U.S. domestic price falls more than it would under free trade, imports rise correspondingly more. As compared with the benchmark I, imports rise 1,498,000 tons or 31 percent and domestic production declines 1,443,000 tons or 24 percent.

The third comparison is between the benchmark (I) and the unilateral end of its protective levy by the EEC (IV). Just as with the abolition of U.S. protection in III, the free-market price is raised (by 1.41 cents), but in this case the EEC price (as measured in France) falls (by 2.92 cents) even more, indicating that the U.S.A. influences world price more than does the EEC. The consequent decline in EEC production is quite large, being 2,163,000 tons or 23 percent, while imports expand correspondingly by 2,535,000 tons or 183 percent. World production remains remarkably constant under this as under each of the other policies.

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[5]Sanchez, N. (1972). "The Economics of Sugar Quotas," Unpublished Ph.D. dissertation, University of Southern California.

The fourth comparison is between the benchmark (I) and the simultaneous abolition of trade-barriers by the U.S.A. and EEC (V). The major effect is to raise the free-market price even more than under free trade. U.S. prices are slightly higher than under free trade, but EEC prices fall and there is a corresponding decline in EEC production.[6] The implication of experiment V, as compared with III and IV, is that orchestrated reduction of trade-barriers by the U.S.A. and EEC would lead to smaller problems of domestic adjustment than the unilateral reduction of trade barriers by either region alone.

The fifth comparison is between the unilateral ending of the U.S. Sugar Act (III) and the simultaneous ending of the U.S. Sugar Act and Cuba's Quota Agreements (VI). Cuban sugar may now enter the U.S.A. in larger amounts and the free-market price, (as measured at New York) and the U.S. domestic price are both lower under VI than under III. U.S. domestic production suffers its severest decline, by 1,974,000 tons (33 percent) as compared with the benchmark (I). U.S. imports rise similarly by 2,020,000 tons (41 percent) as compared with I.

The sixth comparison is between III, the policy set with no U.S. Sugar Act, and VII, a policy set in which the U.S. imposes a 10 percent ad valorem tariff on sugar. The effect is very slight. There is a small decline in free-market price, a small rise in U.S. domestic price and a correspondingly small replacement of imports by domestic production in the U.S.A.

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[6]While New York U.S. prices rise from II to V, U.S. production does not rise due to slightly lower prices in the other U.S. regions.

The seventh comparison is between free trade (II) and the continuation alone of the Commonwealth quotas and other countries' tariffs (VIII). All prices fall in this set relative to free-trade and consequently U.S. and EEC domestic production also fall, but the magnitude is small.

The eighth comparison is between the benchmark (I) and the ending of the Commonwealth Sugar Agreement (IX). Free-market price declines slightly, but the EEC price rises somewhat and the latter region becomes almost self-sufficient in sugar, importing a mere 366,000 tons. The importance attached by the U.K. to continuing the Commonwealth Sugar Agreement in the interest of Commonwealth exporters is seemingly justified by this experiment.

The final comparisons are between the most likely policy set (I) and sets with similar policies except for the addition of an export tax of varying magnitude by the cane exporting countries (X a, b, c, d). Export taxes of 2, 6, 10 and 20 cents per pound were considered. At taxes of 10 and 20 cents the U.S. Sugar Act and Commonwealth Sugar Agreements were no longer functional (c and d). Taxes of 2 or 6 cents per pound would merely be impositions on importers from the free-market such as Canada and Japan, somewhat similar therefore to the weak International Sugar Agreements of the past. The free-market price would not rise to the level of the U.S. or EEC prices, thus avoiding disruptions in those markets. However, an export tax of 10 cents per pound, if also levied on the U.S.A. and EEC, would raise prices in these two regions and encourage domestic production. A tax of 20 cents per pound would result in the EEC becoming a net exporter and the U.S.A. importing a mere 1,443,000 tons (a reduction of 70 percent). The relatively elastic supply of domestic sugar in the U.S.A. and EEC and the inelastic supply of the cane exporters result together in the easy substitution of domestic for imported sugar and only a small reduction in output worldwide when exporters conspire to raise prices. Under a 10 cent tax several traditional exporters of cane cease to export, for example Argentina, Brazil, Colombia, Guatemala, Mexico, Nicaragua, Peru, South Africa, Thailand, Venezuela and Central America. Under a 20 cent tax Australia, Barbados, China-Taiwan, Dominican Republic, Fiji, Guyana, Jamaica, Philippines and Trinidad and Tobago are added to the list of nonexporters. By contrast, the U.S.S.R. and Eastern Europe greatly expand output when the cane producers tax their exports.[7]

The results in terms of price, supply and demand are now complete, but it is interesting to convert the protection given by the U.S. Sugar Act and by the EEC's variable levy into the tariff-equivalencies necessary to achieve the same price under the alternative polices. This is done in Table 8.5. Comparison with free-trade gives tariff equivalencies in the 10-20 percent range for the two regions. However, approximately a 20 percent tariff is required to achieve equivalent protection in the U.S.A. should the U.S. Act continue to be defunct and the EEC would need approximately a 30 percent tariff to equal its levy should that cease. No U.S. Sugar Act and no EEC levy together imply somewhat lower tariff-equivalencies due to the higher free-market price which results as compared with unilateral action.

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[7]Refer to Appendix C.

Table 8.5. Percent Tariff-Equivalencies of U.S. and EEC Policies

Region \ Policy	Free Trade	No U.S. Act	No EEC Levy	No U.S. Act or EEC Levy
EEC				
Belgium	12.4	---	31.5	26.5
Denmark	13.4	---	26.4	19.0
France	12.5	---	29.5	24.1
W. Germany	14.7	---	27.0	20.6
Ireland	13.3	---	30.2	24.7
Italy	16.0	---	32.8	23.4
Netherlands	15.0	---	31.3	24.4
U.K.	11.9	---	28.5	22.5
U.S.A.				
Hawaii	6.9	20.0	---	8.6
Puerto Rico	16.0	25.1	---	17.2
Mainland Cane	19.5	28.4	---	18.2
Mainland Beet (1)[1]	10.9	15.2	---	6.9
Mainland Beet (2)[1]	13.7	16.0	---	7.3

[1]Area (2) comprises the West and Northwest (beet areas III and IV). Area (1) comprises all other regions (beet areas I and II).

Before proceeding to welfare comparisons, it is interesting to note the saving in worldwide transportation costs which occurs under free trade (II) as compared with a fully protected market (I). The costs are 819 and 1,059 million dollars, respectively, the saving from free-trade being therefore 240 million dollars or 23 percent. The actual direction of trade is not of major interest to this study, but trade-flows under policies I (full distortions) and II (free trade) are listed in Appendix D. The largest single change implied by free trade is, not unexpectedly, the redirection of Cuban sugar to fill almost all of the U.S. import requirements.

Welfare Implications of Long-Run Equilibria

In Table 8.6[†] comparisons are made, in terms of producers' and consumers' surplus and government revenue, between the benchmark solution I, (full distortions), and the four most important alternatives: Free Trade (II), no U.S. Act (III), no EEC protection (IV), and a 10 cent export tax by cane exporters (X c). All calculations are relative to the benchmark or most likely solution, I. In order to simplify the calculations, the supply and demand functions were assumed linear over the appropriate ranges and the small changes in tariff-revenue which accrue to importers under III, IV and Xc were assumed negligible relative to I. The calculations are summarized in Table 8.7.

Table 8.7. Summary of Gains in Thousands of Dollars

Policy / Region	Free Trade II	No U.S. Protect. III	No EEC Protect. IV	No U.S. or EEC Protect. V	10 Cent Tax Xc
U.S.A.	+ 66,406	+ 33,125	0	- 26,004	-245,142
EEC	+ 70,059	0	+184,331	+140,848	- 32,873
LDC's	+328,557	+ 71,951	+123,022	+147,277	-482,635
DC's	+ 1,402	- 90,572	+ 49,089	- 40,468	-440,934
Cuba	+392,285	+313,664	+179,238	+441,811	+551,795
Exporters of Cane	+638,622	+171,703	+405,622	+432,133	-454,574
Total	+329,959	- 20,053	+172,111	+107,380	-923,569
Free-Market Price[1]	10.85	10.23	9.17	11.24	13.77

[1]Cents per pound f.o.b. New York.

[†]See pp. 226-27.

Table 8.6. Gains in Welfare Under Alternative Policies

Country	Free Trade II				No US Act III				No EEC C.A.P. IV				No U.S. or EEC Protection V				10 Cent Export Tax Xc			
	C.S.	G.R.	P.S.	NET	C.S.	G.R.	P.S.	NET	C.S.	G.R.	P.S.	NET	C.S.	G.R.	P.S.	NET	C.S.	G.R.	P.S.	NET
Argentina*	-50339	-5952	73114	16823	-28255	-5952	27589	-6618	-30188	0	44127	13939	-38333	-5952	56268	11983	68031	-5952	-81931	-19852
Australia	-36048	-26513	147949	85388	0	-26513	12137	-14376	-22666	0	92798	70132	-19028	-26513	77881	32340	88614	148753	-272748	-35381
Austria	-23973	0	24169	196	-7428	0	7398	-30	-11705	0	11721	16	-17154	0	17201	47	39684	0	40449	80133
Barbados*	-874	-9526	9780	-620	-568	-154	6310	5588	-387	-9731	4242	-5876	-898	-9526	10052	-372	-2941	2069	-23072	-23944
Bolivia & Chile*	-23722	-3194	10740	-16176	-11622	-464	5837	-6249	-17554	0	8302	-9252	-23349	-464	10718	-13095	-75249	-1322	40699	-35872
Brazil*	-249084	-54317	339960	36559	-105690	-46146	142200	-9636	-125269	0	168764	43495	-188757	-46146	256444	21541	340884	-46146	-392279	-97541
Canada (West)	-9861	-14048	0	-23909	-15584	0	0	-15584	-12082	0	0	-12082	-21662	0	0	-21662	-39610	0	0	-39610
Canada (East)	-20437	-22984	3703	-39718	-33974	0	6160	-27814	-23232	0	4206	-19026	-47408	0	8614	-38794	-92896	0	16926	-75970
Sri Lanka*	-6187	-5533	180	-11540	-3885	0	112	-3733	-8506	0	248	-8258	-8484	0	247	-8237	-21271	0	639	-20632
China*	-105657	0	141806	36149	2842	0	-3208	-366	-76354	0	85487	9133	-60713	0	70480	9767	-211434	0	318516	107082
China-Taiwan*	-15230	-6184	37164	15750	-2745	-6184	6699	-2230	-9800	0	23956	14156	-9121	-6184	22273	6968	41749	48931	-82952	7728
Colombia*	-35124	-5336	49016	8562	-27415	-5336	38030	5279	-18267	0	25276	7009	-36397	-5336	51095	9362	35990	-5336	-41457	-10803
Cuba*	-31017	0	423302	392285	-24814	0	338478	313664	-14177	0	193415	179238	-34874	0	476685	441811	40640	1007061	-495906	551795
Czechoslovakia	-50977	0	54905	3928	-14859	0	15772	913	-24471	0	26108	1637	-29838	0	31880	2042	72999	0	79263	152262
Denmark	9044	0	-8342	702	0	0	0	0	15351	0	-13384	1967	12200	0	-10835	1365	5899	0	6287	12186
Dominican Rep.*	-9577	-51867	60331	-1113	-6618	-51867	42499	-15986	-4893	0	30719	25826	-10704	-51867	68771	6200	21216	16476	-72527	-34835
Belgium	11724	0	-23203	-11479	0	0	0	0	25421	0	-49014	-23593	25381	0	-49176	-23795	-4655	0	9662	5007
France	70813	0	-69131	1682	0	0	0	0	145370	0	-129014	16356	124106	0	-112582	11524	-48524	0	57071	8547
W. Germany	81053	0	-87945	-6892	0	0	0	0	145526	0	-139165	6361	108362	0	-113753	-5391	-55748	0	67791	12043
Netherlands	23015	0	-14181	8834	0	0	0	0	44377	0	-24215	20162	35808	0	-20478	15330	-11596	0	8729	-2867
Italy	80335	0	-59661	20674	0	0	0	0	137804	0	-97236	40568	105726	0	-76612	29114	-32958	0	30473	-2485
Fiji*	-1255	-16089	20289	2945	-322	-3169	5171	1680	-720	-12920	11633	-2007	-782	-16089	12626	-4245	2950	-3964	-33988	-35002
Finland	16030	0	-5160	10870	-4183	0	1331	-2852	-9071	0	2903	-6168	-11278	0	3616	-7662	-25135	0	8158	-16977
E. Germany	-50007	-2625	49604	-3028	-16025	0	15099	-926	-27861	0	26800	-1061	-37356	0	36480	-876	76223	0	78347	154570
Greece	6108	-7584	-3785	-5261	-4096	0	2583	-1513	-6930	0	4390	-2540	-11064	0	7100	-3964	-23963	0	15708	-8255
Guatemala*	-10297	-4329	15295	669	-7201	-4329	10721	-809	-5091	0	7433	2342	-10058	-4329	14925	537	8817	-4329	-10386	-5898
Guyana*	1938	-21257	18649	-670	-1499	-2242	14286	10545	-1022	-19016	9764	-10274	-1938	-21257	18624	-4571	3478	9828	-17343	-4037
Hong Kong*	-4959	0	0	-4959	-688	0	0	-688	-2831	0	0	-2831	-3119	0	0	-3119	-8636	0	0	-8636
Iceland	-656	0	0	-656	-249	0	0	-249	-317	0	0	-317	-497	0	0	-497	-1087	0	0	-1087
India*	-86669	-26357	76434	-36592	-57648	-5643	49877	-13414	-112839	-2275	101390	-13724	-119940	-26357	108459	-37838	-135360	-26357	123632	-38085
Indonesia*	13154	-37823	-5935	-30604	-13746	0	6308	-7438	-41156	0	20225	-20901	-39538	0	19554	-19984	-110105	0	66126	-43979
Iran	39228	0	-35793	3435	-5035	0	5035	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	7126	0	-5843	1283	0	0	0	0	13984	0	-11384	2600	24288	0	-9887	14401	-6604	0	5492	-1112
Jamaica*	-6408	-24657	34992	3927	-4994	0	26826	21832	-3228	-24657	16537	-11348	6962	-24657	38358	20663	9477	2901	-32562	-20184
Japan	275150	-312845	-68928	-106623	-22092	0	6486	-15606	-107580	0	33072	-74508	-97572	0	29675	-67897	-280728	0	95680	-185048
Korea*	6374	-26889	0	-20515	-4307	0	0	-4307	-16819	0	0	-16819	-16236	0	0	-16236	-52655	0	0	-52655
Mauritius*	-1648	-38289	31542	-8431	-403	-3169	7978	4006	-1434	-35120	23804	-12750	-1012	-38289	19045	-20256	5157	103466	-89737	18886
Mexico*	-129840	-44678	197289	22771	-97251	-44678	146936	5007	-69168	0	105610	36442	-131851	-44678	200166	23637	167052	-44678	-207035	-84661
New Zealand	-8404	0	0	-8404	-3060	0	0	-3060	-4990	0	0	-4990	-6509	0	0	-6509	-20104	0	0	-20104
Nicaragua*	5872	-5411	12870	13331	-3752	-541	7999	-1163	-2822	0	5760	2938	-5153	-5411	11103	539	7086	-5411	-10101	-8426

Table 8.6. Continued

Country	Free Trade II C.S.	Free Trade II G.R.	Free Trade II P.S.	Free Trade II NET	No US Act III C.S.	No US Act III G.R.	No US Act III P.S.	No US Act III NET
Norway	-9243	-2951	0	-12194	-3519	0	0	-3519
Pakistan & Bangladesh*	100538	-46809	-51505	2224	-10741	0	6561	-4180
Peru*	-6559	-28600	11898	-23261	3896	-28600	-6927	-31631
Philippines*	-41776	-101105	243159	100278	-10536	-101105	29871	-81770
Poland	-118505	0	172188	53683	-47907	0	66763	18856
Portugal	5093	-20419	-212	-15538	-6614	0	281	-6333
Saudi-Arabia	-11091	0	0	-11091	-4639	0	0	-4639
Singapore*	32861	-37963	0	-5102	-302	0	0	-302
South Africa	-46554	-15322	72738	10862	-8179	-7498	14056	-1621
Spain	-58638	-559	44465	-14732	-26636	0	19986	-6650
Sweden	-27724	0	18295	-9429	-10871	0	7093	-3778
Switzerland	-9407	-12072	2165	-19314	-8456	0	1949	-6507
Thailand*	-22611	-1314	21258	-2667	-4469	-1314	4039	-1744
Trinidad & Tabago*	-3010	-12797	16427	620	-2138	-696	11493	8659
Turkey	-25597	0	26539	942	-315	0	315	0
U.S.S.R. (West)	-390882	0	753181	362299	-113189	0	206936	93747
U.S.S.R. (East)	-394216	0	0	-394216	-106115	0	0	-106115
U.K.	86649	0	-31394	55255	0	0	0	0
U.S. - Hawaii	548	0	-14545	-13997	1392	0	-35223	-33831
U.S. - San Francisco	32704	0	-20944	11760	103637	0	-59036	44601
U.S. - New Orleans	83869	0	-66341	17528	113599	0	-84592	29007
U.S. - New York	155798	-67268	-31637	56893	104746	-67268	-41858	-4380
Puerto Rico	385	0	-6163	-5778	6840	0	-9112	-2272
Venezuela	-32363	-2164	38155	3628	-24173	-2164	28442	2105
E. Europe	-27315	0	21134	-6181	-82521	0	64285	-18236
Central America*	31503	-24250	-43676	-36423	40510	-22239	-54252	-35981
Paraguay & Uruguay*	1201	-2888	-904	-2591	-4020	-464	3067	-1417
Near East*	-17825	-37014	2001	-52838	-14877	0	1667	-13210
Far East*	487	-64705	44	-64174	-17659	0	1603	-16056
N. Africa*	196559	-113563	-106293	-23297	-75930	0	45675	-30255
W. Africa*	3995	-27734	-474	-24213	-16685	0	2232	-14453
N.E. Africa*	200676	-49337	-114611	36728	-21724	0	16173	-5551
E. Africa*	1910	-5630	-1412	-5132	-8033	0	6015	-2018
S.C. Africa*	-35064	-1932	46731	9855	-7709	-1932	14695	5054
S.W.C. Africa*	-56	0	58	2	0	0	0	0
Total				329959				-20553
LDC's				328557				70019

Country	No EEC C.A.P. IV C.S.	No EEC C.A.P. IV G.R.	No EEC C.A.P. IV P.S.	No EEC C.A.P. IV NET	No U.S. or EEC Protection V C.S.	No U.S. or EEC Protection V G.R.	No U.S. or EEC Protection V P.S.	No U.S. or EEC Protection V NET	10 Cent Export Tax Xc C.S.	10 Cent Export Tax Xc G.R.	10 Cent Export Tax Xc P.S.	10 Cent Export Tax Xc NET
Norway	-6637	0	0	-6637	-8334	0	0	-8334	-26978	0	0	-26978
Pakistan & Bangladesh*	-22449	0	14004	-8445	-22645	0	14116	-8529	-58133	0	38665	-19468
Peru*	740	0	-1339	-599	-4528	-28600	8805	-24323	62511	-28600	-86136	-52225
Philippines*	-26559	0	76226	49667	-23876	-101105	68744	-56237	126776	-48415	-234598	-156237
Poland	-66586	0	93969	27383	-80034	0	113925	33891	-182440	0	273972	91532
Portugal	-8243	0	349	-7894	-13012	0	558	-12454	-26819	0	1171	-25648
Saudi-Arabia	-6483	0	0	-6483	-7891	0	0	-7891	-16464	0	0	-16464
Singapore*	-3702	0	0	-3702	-3152	0	0	-3152	-11319	0	0	-11319
South Africa	-27083	-7825	45155	10247	-26312	-15322	43099	1465	155560	-15322	-199150	-58912
Spain	-31339	0	23701	-7638	-49370	0	37337	-12033	-117965	0	90938	-27027
Sweden	-16417	0	10752	-5665	-18954	0	12445	-6509	-42604	0	28366	-14238
Switzerland	-12808	0	2962	-9846	-16927	0	3932	-12995	-34704	0	8222	-26482
Thailand*	-14894	0	12667	-2227	-14897	-1314	12664	-3547	4532	-1314	-4321	-1103
Trinidad & Tabago*	-1475	-12101	7755	-5821	-3239	-12797	17681	1645	4507	3517	-16337	-8313
Turkey	0	0	0	0	-6753	0	6824	71	-61267	0	66529	5262
U.S.S.R. (West)	-201079	0	374871	173792	-256865	0	484669	227804	-587441	0	1168756	581315
U.S.S.R. (East)	-210935	0	0	-210935	-267535	0	0	-267535	-577575	0	0	-577575
U.K.	181591	0	-61681	119910	149993	0	-51693	98300	-109259	0	45067	-64192
U.S. - Hawaii	0	0	0	0	664	0	-17414	-16750	-1125	0	32082	30957
U.S. - San Francisco	0	0	0	0	50855	0	-31510	19345	-92272	0	74857	-17415
U.S. - New Orleans	0	0	0	0	78971	0	-63241	15730	-36324	0	36813	489
U.S. - New York	0	0	0	0	96348	-67269	-19891	9189	-342615	0	80257	-262358
Puerto Rico	0	0	0	0	5054	0	-6564	-1510	-5296	0	8481	3185
Venezuela	-15988	0	18575	2587	-34631	-2164	40589	3794	16738	-2164	-17870	-3296
E. Europe	-127245	0	99465	-27780	-151334	0	118803	-32531	-343801	0	274860	-68941
Central America*	0	0	0	0	24650	-24250	-34278	-33878	62302	-24250	-77449	-39397
Paraguay & Uruguay*	-6822	0	5328	-1494	-8882	-464	7023	-2323	-17369	0	15283	-2086
Near East*	-28605	0	3278	-25327	-39651	0	4495	-35156	-86592	0	10084	-76508
Far East*	-56870	0	5320	-51550	-45965	0	4310	-41655	-140517	0	13923	-126594
N. Africa*	-85468	0	51356	-34112	-127598	0	78959	-48639	-278394	0	180598	-97796
W. Africa*	-16455	0	2208	-14247	-24016	0	3415	-20601	-56532	0	9881	-46651
N.E. Africa*	-40524	0	30848	-9676	-38445	0	29184	-9261	-99095	0	80888	-18207
E. Africa*	-13995	-637	10579	-4053	-14120	-637	10686	-4071	-36592	-637	28857	-8372
S.C. Africa*	-15287	0	29417	14130	-15632	-1932	30113	12549	-40771	0	80836	40065
S.W.C. Africa*	0	0	0	0	0	0	0	0	-4746	0	5873	1127
Total				17211				107380				-923569
LDC's				123022				147277				-482635
												-454574

Note: * - LDC

Considering firstly free trade, II, the net gain would be $329,959,000 of which $328,557,000 would go to less developed countries. The largest single beneficiary would be Cuba, the largest exporter, which would gain $392,285,000. Since Cuba would gain more than the overall gain to less developed countries, it follows that on the average other such countries would lose under this policy. This is not surprising if transfers to LDC's under the U.S. Act and Commonwealth Sugar Agreement are considered. Under these policies the premia given to exporters are estimated to be worth $377,367,000 and $125,831,000, respectively, a total of $503,198,000, most of which goes to LDC's. In consequence, Cuba's gain is offset by the losses of many other countries which were protected by the U.S.A. and U.K.

Looking at the net situation in the developed countries of the West, the EEC would gain $70,059,000, most of which would accrue to the U.K. ($55,255,000) and Italy ($20,674,000). Producers in the EEC would lose $299,700,000 and consumers would gain $369,759,000. The U.S.A. as a whole would gain $66,406,000 resulting from a gain to consumers of $273,304,000, a loss to producers of $139,630,000 and a loss of tariff-revenue of $67,268,000.

Considering, secondly, unilateral action by the U.S. in ending its Sugar Act (experiment III), there would be an overall world loss of $20,553,000. In this experiment Cuban sugar was allowed access to the U.S.A. and hence Cuba had a large gain of $313,664,000 which was offset by the $377,367,000 which was the premium previously paid by the U.S.A. to quota-holding countries. For example, Australia, Brazil, Dominican Republic and the Philippines lose under this policy due to the end of U.S. quotas. Importers from the free market, such as Canada and Japan, also lose due to the higher world price. Turning to the U.S.A., the net gain from an end of the Sugar Act is estimated to be $33,125,000, resulting from gains to consumers of $330,214,000 and losses to government of $67,268,000 and to producers of $229,821,000. The EEC is unaffected by this particular change in policy.

The third welfare comparison concerns experiment IV, the unilateral end of protection by the EEC. There is an estimated international gain of $172,111,000, divided $123,022,000 to the LDC's and $49,089,000 to the developed countries. As before, the gainer of greatest magnitude is Cuba, gaining an estimated $179,238,000. Because of the increase in world free-market price, exporters of sugar gain and importers lose. However, because there is no longer any Commonwealth premium since all countries receive the same price from the EEC (although the experiment maintained 1,383,000 tons of Commonwealth imports to the U.K.), Commonwealth countries such as Barbados, Guyana, Jamaica, Mauritius and Trinidad and Tobago suffer small losses. The EEC as a whole gains $184,331,000, chiefly due to the consumer gain of $709,424,000, while the producers' loss is $525,093,000. The gains would particularly accrue to the importers in the EEC, that is, to the U.K. ($119,910,000), Italy ($40,568,000) and Ireland ($2,600,000). The U.S.A. is unaffected by this change in EEC policy.

The fourth set of welfare measurements was made with respect to experiment V in which both U.S. and EEC protection ceases. The international gain of $107,380,000 is less than under unilateral EEC action because there was previously an international gain from the U.S. Sugar Act. However, gains to LDC's of $147,277,000 exceed those under unilateral action by the EEC or U.S.A., mainly because the free-market price is raised more by this bilateral action. Cuba is again the chief beneficiary, to the extent of $441,811,000. So large a gain by Cuba implies that other LDC's lose under this policy. The EEC as a whole gains an estimated $140,848,000 under this policy and the U.S.A a mere $26,004,000.

The final welfare measurements of this kind were made for policy Xc, a 10 cent per lb. export tax being imposed by all cane-sugar exporters. It has already been noted that many exporters would simply become producers for their domestic markets under this policy and, as a group, they are estimated to lose $454,574,000 under this policy. As under other policies, however, Cuba is a large gainer, this time to the extent of $551,795,000. Other substantial gainers are China ($107,082,000) and the large beet producers of Eastern Europe, namely East Germany ($154,470,000), Czechoslovakia ($152,262) and Poland ($91,532,000). The total world loss would be a huge $923,569,000, this loss resulting both from the cessation of exports by certain countries such as the Philippines, (loss of $156,237,000), and from the higher free-market price to be paid by all importers. Under this policy LDC's as a group would lose $482,635,000 and DC's $440,934,000. The U.S.A. would lose $245,142,000 due to the high cost of 3,443,000 tons of imports, but the EEC would lose only $32,873,000 due to its low dependence on imported sugar, (only 322,000 tons).

A Summary of Chapter VIII

The results of this chapter are the product of combining many of the relationships which were developed in the previous chapters. The model was first solved in a recursive mode for the years 1972-75, but the results were of an interim rather than final nature due to unresolved computational problems. However, restriction of exports by cane-producing nations in 1974, in order to satisfy their domestic markets, was shown to be a possible influence on price in that year. 1974 represented the zenith of a price-cycle and steadily falling prices for 1975 and 1976 may be expected as a new cycle develops. Further solutions in the recursive mode await the development of a more efficient algorithm.

The solution of the model in a long-run equilibrium mode showed that the developed countries, which are importers or protect their domestic sugar industries, have less to fear from freer trade than might have been expected. The absence of U.S. protection raised free-market price by 2.47 cents and lowered U.S. price by 1.56 cents. The absence of EEC protection, by contrast, raised free-market price by 1.41 cents and lowered EEC domestic price by 2.92 cents. The change in domestic production under these two movements to freer trade, considered separately, would be 24 percent (U.S.) and 23 percent (EEC) less domestic production. Should both the U.S.A. and EEC switch together to free trade, the effects would be even less, since free-market price is raised even further, the U.S. decline in production being 14 percent and the EEC decline 20 percent.

World production was remarkably constant under all policies, since beet production may easily substitute for cane production. This was particularly the case when the cane exporters were hypothesized to impose a uniform export tax which resulted, (at least at a level of 10 cents or more) in a deterioration in their earnings except in the case of Cuba.

From a welfare viewpoint, Cuba would gain under almost any policy-set relative to the set existing in 1973. Under free trade almost every country improves its welfare, except the traditional importers from the free market. Free trade by the U.S. alone would have little global effect except to redistribute gains to Cuba which previously accrued to other quota holders. The end of EEC protection would bring large benefits to domestic consumers and foreign producers.

At the aggregate "world level" of abstraction, free trade leads to a $330 million dollar gain, a large but hardly remarkable amount. A 10 cent export tax by cane exporters would lead to a world loss of $924 million, much of which would be borne by the exporters themselves. Strong cartels would therefore seem a very dim possibility.

CHAPTER IX

POLICY IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

This chapter attempts to draw together the implications of the results, not only of Chapter VIII but of the whole work, for the policies of the U.S.A., EEC, less-developed countries and cane sugar exporters. Value judgments concerning different groups in society are implicit in alternative policies, but such judgments have as far as possible been kept to a minimum. The chapter concludes with suggestions for further research.

U.S. Sugar Policy

The U.S. Sugar Acts, which ran continuously from 1934 to 1975, spoke of a "fair division of benefits" from protection. However, the division clearly favored producers at the expense of consumers. The former were protected from low prices through quotas on imports, but the latter were not protected from high prices should there be a coincidence of reduced domestic and international production (as there was in 1974). It was a coalition of consumers and industrial users that brought about the downfall of the Act in 1974--they had nothing to lose.

The equilibrium solutions of this research suggested that without protection, mainland cane production would contract 34 percent, Hawaiian cane production 12 percent, Puerto Rican cane production 8 percent and mainland beet production 23 percent. The major adjustments would be in California and the North-West with respect to beet and in Florida with respect to cane. Only in Florida might the fixity of assets and the lack of suitable alternative products pose a problem for producers' incomes.

The end of U.S. protection was estimated to hurt overseas suppliers to this country, who previously held quotas, to the extent of $153 million. However, most of this loss was the result of assuming that Cuban sugar could enter freely. If Cuban sugar remained excluded, the losses of these countries (mainly the Philippines, Dominican Republic, Brazil, Mexico and Australia) would be minimal. The "aid" aspect of the Sugar Program is therefore not very important.

From a static-equilibrium viewpoint, such as that of D. Gale Johnson, the case against any form of protection is clear cut. Protection is a priori inefficient. Johnson estimated in 1974 that the Sugar Act cost consumers and taxpayers approximately $616 million to transfer $100 million to domestic producers and $198 million to overseas suppliers. His estimates implied a "deadweight loss" of $318 from protection. The estimates in this report, on a slightly different basis, are of a total cost to consumers of $330 million to transfer $230 million to domestic producers and $67 million to government, a "deadweight loss" of a mere $33 million. This implies that Johnson probably overstated the cost of resource misallocation under the Sugar Act. Whether the Act is in "the public interest" or not therefore hinges not so much upon the misallocation of resources as upon the desirability of transferring income from consumers to producers in this manner. The answer lies in the political arena and outside the context of this report.

If protection is deemed in the public interest, a deficiency payment is likely to lead to a smaller "deadweight loss" than a tariff (or quota).[1] To give protection equivalent to that of the Sugar Act would require a subsidy of at least 1.56 cents per pound. This subsidy would be paid on all domestic production, giving a minimum total cost of $206 million. To offset this there would be the gain to consumers relative to the Sugar Act of at least $330 million. The problem with a deficiency payment would be that it is based upon the willingness of the populace to be taxed an additional $206 million in order to subsidize sugar producers and maintain a low price of sugar. An implicit tax, through a tariff or quota, may be politically more acceptable although economically less efficient.

Thus far only static-equilibrium considerations have been reviewed in relation to protection. In a more dynamic context, there may be losses of producers' and consumers' welfare due to price fluctuations. A Sugar Program which led to a more constant price might appeal to both producers and consumers. If it is assumed that domestic producers should be protected from low prices and consumers from high prices, an array of alternative policies may be reviewed with respect to these objectives. The policies include tariffs, quotas, variable levies and deficiency payments, either separately or in some combination.

Before 1934, tariffs were used by the U.S. to protect producers, but they were rejected in favor of quotas in the Jones-Costigan Act because they did not give sufficient protection from low prices.

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[1]See Chapter II for a discussion.

The combination of quotas, tariffs and deficiency payments in successive Sugar Acts was eminently successful in avoiding low prices for producers. Of these policies, however, only the deficiency (conditional) payments may have had any (extremely marginal) influence in reducing consumer prices. To protect consumers, policies of a different nature are required. Some possibilities are: 1) buffer stocks built up when the price of sugar is low and released under high prices; 2) a direct subsidy to consumers on sugar when the price is high; and 3) the pooling of a regulated domestic and a fluctuating international price so that consumers pay the pooled, average price.

Buffer stocks, the first alternative, are not very attractive for sugar because storage is expensive, although they would achieve the desired smoothing of price. For buffer stocks to work, the U.S. market would have to be separated from the free market by a quota system so that the release of sugar could have an impact in the U.S. alone. Since the price elasticity for sugar in the U.S. is of the order of -0.03, a 1 percent change in quantity could induce a change in price of 33 percent, hence the stocks would not have to be very large in relation to total consumption. Considering, secondly, a direct subsidy of consumer prices, it is not likely to be acceptable in the U.S.A., although it has been used in other countries for staple products, e.g., bread and milk in the U.K. Thirdly, the pooling of domestic and international prices has been used in the U.S.A. in relation to oil, but is the kind of regulation which is politically not very acceptable (and would further induce the free-market price to rise).

The above discussion on price variability and policies has not included free trade by the U.S. as an alternative. Protection under the U.S. Sugar Act was estimated to reduce free-market price by 2.47 cents per pound. Should protection be reinstituted, the proponents will undoubtedly claim that the new protection saved the U.S. from the ensuing, low, free-market prices. They forget that U.S. protection actually contributes to that low price. There is, therefore, reason to believe that the free market with the U.S. included would be less prone to low prices. However, free trade by the U.S. would not limit price rises.

To conclude the discussion of U.S. policy, should a policy of no protection be continued(as in 1975)the major effect will be a redistribution of income from producers to consumers. Should the estimated 24 percent reduction in domestic production be politically unacceptable, a tariff could be imposed or quotas reinstated but a deficiency payment to producers would be more efficient. The level of protection required would vary from year to year, but would average approximately 20 percent tariff-equivalence. Should it be desirable to avoid price rises of the kind that occurred in 1974, a program of buffer stocks could be instituted or domestic prices could be regulated and the wholesale price of sugar be made the pooled average of domestic and international prices.

EEC Policy

Unilateral action in ceasing protection by the EEC would reduce domestic prices an estimated 23 percent but also reduce domestic production by 23 percent. The burden of adjustment would fall most heavily on France, where production would contract an estimated 30 percent (c.f. 26 percent in Netherlands, 20 percent in Italy, 15 percent in U.K., 12 percent in West Germany and 8 percent in Belgium). The end of protection would give consumers a huge gain of $709 million, while producers would lose $525 million, giving a net gain to the EEC of $184 million. With so large a net gain, compensation to displaced producers could be arranged--there are many such precedents in relation to milk production under the Common Agricultural Policy.

In 1966-67, 45.6 percent of sugar beet in France was grown in lots of 100 hectares or more per farm[2] and a similar, though less extreme, pattern existed in the other countries. If protection of sugar producers is based upon the social necessity of transferring income to the impoverished rural sector, such a policy is sadly misjudged since beet production is concentrated on the larger, more wealthy farms.

The Common Sugar Policy differs from that for most other agricultural products in two ways. Firstly, production is to some extent controlled by the complex system of quotas.[3] Secondly, surpluses are not stored, but they are jettisoned onto the free market and the producers receive only the return from that market. Hence the misallocation of resources under the Sugar Policy is likely to be less than that for other products.

Turning to the more dynamic aspects of the market, the EEC avoided so meteoric a rise in price as occurred in the U.S.A. in 1974 by

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[2] EEC Statistical Office (undated). Enquete sur la Structure des Exploitations Agricoles, 1967/67. Luxembourg: EEC Statistical Office.

[3] See Chapter V.

taxing exports from the community and subsidizing imports from the Commonwealth producers and from the free market. This action was somewhat equivalent to the pooling of domestic and international prices suggested as a way of combatting price rises earlier in this chapter. However, such a policy reduces the total export supply and leads to greater peaks in price on the residual free market.

Future EEC policy seems aimed at internal self-sufficiency, with imports from Commonwealth countries being balanced by exports. Such a policy implies even greater protection than the (approximately) 30 percent tariff-equivalence at present. The Sugar Policy is very successful in terms of raising the price to producers and has been adjusted in years such as 1974 to protect consumers from very high prices. These gains must be weighted against the cost to consumers of $709 million and the "deadweight loss" of $184 million. The conclusion must be that resource misallocation under the EEC policy by far exceeds that under the U.S. Sugar Act, although the volumes of sugar consumed in the two regions are similar.

Less-Developed Countries and Exporters of Cane Sugar

Under all policies of free trade, the total gains of all LDCs are less than the gains accruing to Cuba alone. Freer trade would, therefore, lead to a loss of welfare (as measured here) for the majority of LDCs. However, LDC exporters (not including Cuba) would gain approximately $146 million under free trade, despite the loss of revenues from preferential markets. Conversely, LDC importers would lose approximately $120 million under free trade, due to the higher free-market price.

The world's exporters of cane sugar comprise the LDC exporters plus Australia, South Africa and Venezuela.[4] Their joint gain from free trade would be $639 million or from the end of EEC protection would be $406 million. As before, Cuba is the main beneficiary. The end of U.S. protection is beneficial to this group as a whole, but the gains to Cuba exceed the gains to other countries as a group. Should the cane exporters consider forming a cartel, their effectiveness is likely to be very low. The elastic international supply of beet sugar ensures that the restriction, at least at the level equivalent to a 10 cent per pound export tax, hurts the exporters (except Cuba) as much as the importers. A minor restriction of exports, such as that accomplished under the International Sugar Agreements, might, however, raise the free-market price while not affecting the U.S. and EEC prices (assuming the latter to have protective policies). There is, therefore, little likelihood of a strong cartel developing--the motivation of widespread gains in income is lacking.

International Sugar Agreements

International Sugar Agreements have in the past brought together both exporters and importers of sugar with the objectives of smoothing price fluctuations and avoiding disastrously low prices (such as the average 1.86 cents per pound on the free market in 1968). The small degree to which price may be raised by export restriction has already been discussed.

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[4]Not considered a LDC here because of oil revenues.

The question then arises as to whether an international sugar agreement to remove, rather than impose, barriers to trade might be possible. The U.S.A. and EEC would both gain from freer trade, as would the exporters as a group. The losers would be, as D. Gale Johnson has pointed out, the traditional importers from the free market, notably Canada, Japan and a group of Asian and African countries. The protection of their domestic producers by the U.S.A. and EEC has caused other countries, which are both producers and importers of sugar, to raise similar barriers to avoid the entry of low-priced sugar from the free market. There could well be many mutual gains from the orchestrated removal of such barriers to trade, implying an adjusted pattern of production in which comparative advantage would be the paramount influence.

One function which the International Sugar Organization now fulfills, in addition to administering International Sugar Agreements, is the collection and dissemination of sugar statistics. Since imperfect knowledge concerning the actions of other producers is a major source of the instability in the sugar market, the I.S.O. could usefully increase its services both by improving the quality of its data and by extending the coverage to include investments being undertaken in the sugar industry throughout the world.

Further Research

The suggestions for further research will be listed:

1. One objective of this research, to simulate the dynamics of the world sugar economy, was only partially fulfilled. The development of a more efficient algorithm for solving the model is essential in this respect.

2. Supply was most adequately modeled for the U.S.A. Further work on European beet sugar supply and the international supply of cane sugar is needed. Further work of a theoretical and empirical nature on cane investment decisions would help in accepting or rejecting the asymmetric model developed in Chapter VI.

3. In analyzing demand, the relationships between alternative sweeteners were ignored. A study of substitution between sucrose, corn syrup, saccharin, etc. in the Western countries would be very useful.

4. A larger number of alternative policies could be evaluated with the model. This would be particularly interesting with respect to U.S. policy in 1976 and the development of International Sugar Agreements.

APPENDICES

APPENDIX A

A NOTE ON DIRECT VERSUS INDIRECT ESTIMATION OF AGRICULTURAL SUPPLY

APPENDIX A

A NOTE ON DIRECT VERSUS INDIRECT ESTIMATION OF AGRICULTURAL SUPPLY

It is a common practice in estimating agricultural supply to separately estimate the derived demand for the predominant input, (e.g., land area, number of animals), and the output per unit of that input (e.g., tons per acre, pounds of carcase weight per animal). The purpose of this note is to clarify the pros and cons of such separate or "indirect" estimation of supply as contrasted with the "direct" estimation of the equation in which quantity supplied is the dependent variable. The procedure to be followed will be to state each of the arguments in favor of indirect estimation which have been found in the literature and to critically examine their validity. Henceforth it will be assumed that the supply of a crop is being estimated, although the argument is equally valid for animal products.

Perhaps the most influential study of farmers' responses has been that of Nerlove in the 1950s.[1] However, Nerlove was careful to point out that he had only estimated the derived demand for land and not quantity of product supplied. His justification was that the area which was planted was a better guide to farmers' intended responses than was the quantity of product, since the latter was subject to variation due to weather, pests and diseases. If one were interested only in the derived demand for land, there could be no questioning of Nerlove's approach.

[1]Nerlove, M. (1958). The Dynamics of Supply: Estimation of Farmers' Response to Price. (Baltimore: Johns Hopkins Press.)

However, if the elasticity of land as an input is taken as the elasticity of supply, this implies that farmers do not respond to economic variables in determining yield per unit of land, which is highly questionable. As an estimate of the elasticity of supply, the elasticity of land is likely to be both biased and inefficient.

Several authors, among them Hee,[2] recognized that yield per unit of land was a response to economic variables within the farmer's control and established the tradition of separately estimating the derived demand for land and the yield per unit of land. Quoting Hee,

> Acreage response and yield response are two separate and distinct functions; a considerable quantity of information in regard to farmers' behavior may be lost when only a single supply function is considered.[3]

The second part of the statement is not in dispute, but the first part is questionable. Hee and other researchers made yield a function of a different set of variables from that used to estimate the demand for land. Yet, intuitively, in deciding on the area to plant the farmer must surely have some expectation concerning yield, hence yield and area cannot be completely independent. Yield is not so much a response to different variables, as to the same variables in a later time period at which time their values may have changed. That is, expectations about prices may have changed from the time of planting to the time at which other variable inputs are applied.

The following, more formal, presentation may help to clarify the arguments. Suppose there are two inputs, land and fertilizer. Assuming

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[2]Hee, O. (1958). "The Effect of Price on Acreage and Yield of Potatoes," Agricultural Economics Research, 10, (4), (Oct.), pp. 131-141.

a production function to exist, it may be written

(1) $Q = f_Q\ (L, F)$,

where Q = output,

L = land

and F = fertilizer.

Profit may be defined as

(2) $\Pi = P_Q \cdot Q - P_L \cdot L - P_F \cdot F$,

where Π = profit,

P_Q = product price,

P_L = price of land

and P_F = price of fertilizer.

Taking the first derivatives and setting them equal to zero, the marginal conditions for profit maximization may be written,

(3) $P_L = f_{1L} \cdot P_Q$, and

(4) $P_F = f_{1F} \cdot P_Q$,

where $f_{1L} = \frac{\partial Q}{\partial L}$

and $f_{1F} = \frac{\partial Q}{\partial F}$.

Utilizing the implicit-function theorem,[4] the existence of the following reduced form equations may be established

[4]For a discussion of implicit functions, see, for example, Thomas, G. B. (1968). Calculus and Analytic Geometry, Reading, Mass.: Addison Wesley, p. 79.

(5) $L = g_L (P_Q, P_L, P_F)$,

(6) $F = gF (P_Q, P_L, P_F)$, and

(7) $Q = g_Q (P_Q, P_L, P_F)$.

Equation (5) is the derived demand for land, (6) is the derived demand for fertilizer and (7) is the supply function. The analogous yield equation is

(8) $Y = g_Y (P_Q, P_L, P_F, L)$,

where Y = yield=(Q/L).

Should decisions on land and fertilizer be taken at different times, Equations(5) and (8) may be rewritten as respectively,

(5)' $L = g_L (P_Q*, P_L*, P_F*)$, and

(8)' $Y = g_Y (P_Q\#, P_L\#, P_F\#, L)$,

where * = an expectation

and # = a different expectation.

This formal presentation has the following implications:

(i) the derived demand for land and the yield per unit of land are functions of the same set of variables, except that yield is additionally a function of land area and that the values of the variables may be different due to a change in expectations during the gestation of the product;

(ii) the longer the delay between planting and the application of other variable inputs, the more probable it is that expectations about prices will have changed so that indirect estimation of supply becomes the more promising approach; e.g., for perennial crops indirect estimation would be preferable to direct estimation or for crops whose prices are subject to extreme variability.

Comparing these implications with the procedure of Hee, the crop in question was an annual, the potato, and different variables were included in the land and yield equations.

The formal presentation is useful in condemning another approach sometimes found in the literature,[5] the use of two-stage least squares (2SLS) on Equations (5) and (8). The two equations may be collapsed into Equation (7), the supply function, and ordinary least squares (OLS) on (7) is bound to be at least as efficient as 2SLS on (5) and (8). The use of 2SLS implies that decisions on yield and area are simultaneous, which in turn implies that estimation of (7) is the correct procedure.

The most common self-deception in the indirect approach to estimating agricultural supply appears to have arisen from an overly pragmatic approach to research.[6] Without a well specified model, the researcher estimates the supply Equation (7) and finds coefficients which are not significantly different from zero. He attributes the lack of significance to "too many variables" and then estimates the demand for land as a function of one subset of the variables and the yield per unit land as a function of a different subset of the variables. More happy, perhaps, with the "significance" of the newly estimated coefficients, the researcher "estimates" total supply by multiplying the yield and area responses together. The chief deception lies in supposing that the supply thus estimated is more significantly related to the

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[5]For example, Ilag, L. M. (1970). An Econometric Analysis of the Impact of the United States Sugar Program on the Philippine Sugar Industry. Unpublished Ph.D. Dissertation, Purdue University.

[6]See, for example, Oury, B. (1966). A Model for Wheat and Feedgrains in France. Amsterdam: North Holland Publishing Co.

variables than was that directly estimated. Were the researcher able to compute the standard errors of the "compound" coefficients in his new supply function, they would bear values at least as great as in the directly estimated function. Also, by omitting relevant variables in the land and yield equations, the researcher's indirect results are biased.

Finally, there is a situation in which indirect estimation is clearly superior. When the demand for land is exogenously determined, such as by governmental control, the land equation becomes a function of governmental decisions and the yield equation a function of the array of prices facing the farmer. Note, however, that when the governmental program is the restriction of output rather than land, the farmer's behavior may be cost minimization for the given output but the variables and argument are exactly as before when profit maximization was assumed.

The argument of this note may be summarized as follows. To base estimates of agricultural supply on the derived demand for the most important input alone will lead to biased and inefficient estimates. In general, the separate estimation of the derived demand for the most important input and the output per unit of that input (i.e., indirect estimation), will at best be as efficient as directly estimating supply. Should variables be omitted from either of the equations in the indirect approach, bias will result. In two cases the indirect approach is preferable to the direct. The first involves the supply of products (e.g., perennials), whose gestation is sufficiently long for price expectations to differ at the time of initiating production from those at the time of applying certain variable inputs. The second involves the exogeneity of the major input from the farmer's viewpoint due to governmental or other controls.

APPENDIX B

A COBWEB MODEL FOR SUGAR

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A COBWEB MODEL FOR SUGAR[1]

It has been observed that there is a six to nine year cycle in the price of sugar in the world "free market." The purpose of this note is to demonstrate that such a phenomenon is consistent with two conditions, (i) a demand curve which is shifting steadily to the right over time and (ii) a supply curve which is asymmetric with respect to price and for which quantity supplied is a function of both previous high price and previous (rather than current) prices. The exposition is in two stages, a graphical and an algebraic. The discussion borrows liberally from Waugh,[2] who in turn has borrowed from the writings of Ezekiel, Leontief and Nerlove, among others.

Graphical Presentation

Although the "free market" has many sellers and buyers, assume that the aggregate behavior may be approximated as if there were only one supplier. Also assume that the sugar is all derived from sugar cane, (whereas in actuality only two-thirds is from that source). Figure 1 depicts the supply and demand system, which is envisaged, for an eight year period. abcd is the elastic, long-run supply curve

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[1]This note was written in response to a question raised by Professor J. C. H. Fei of Yale University.

[2]Waugh, F. V. (1964). "Cobweb Models," J. Farm. Econ 46, (4), (Nov.), pp. 732-750.

Figure B.1. Price and Quantity

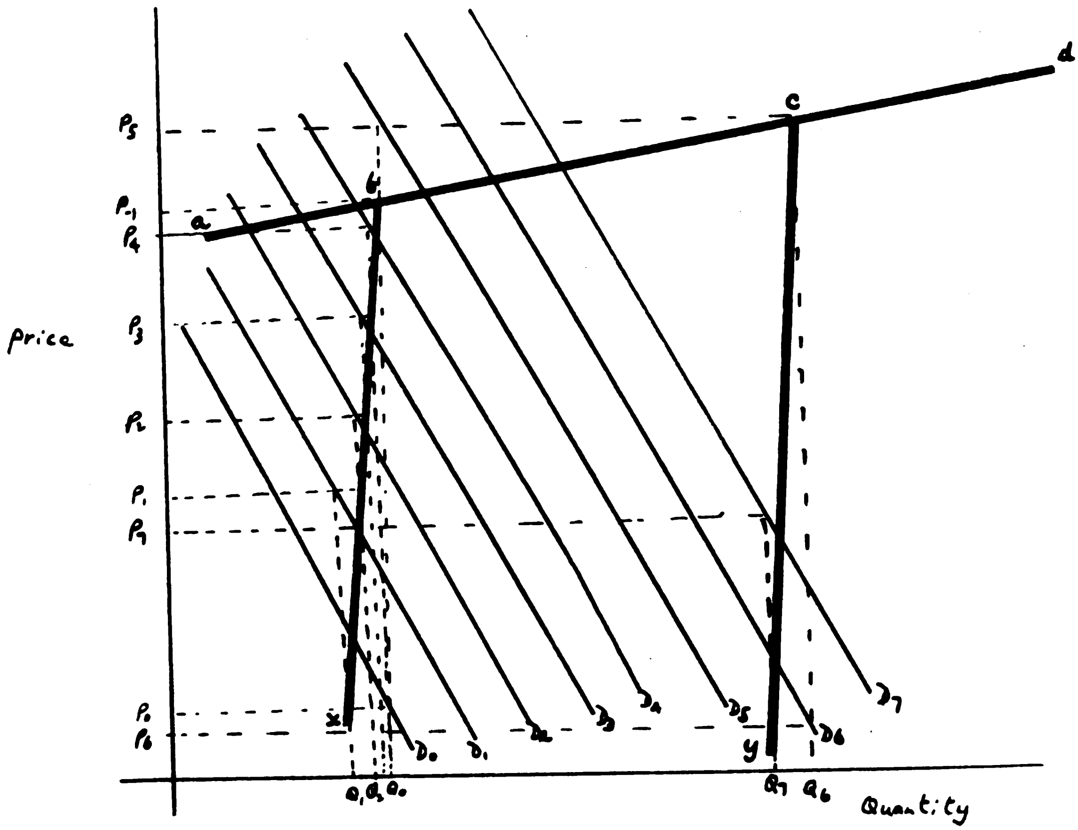
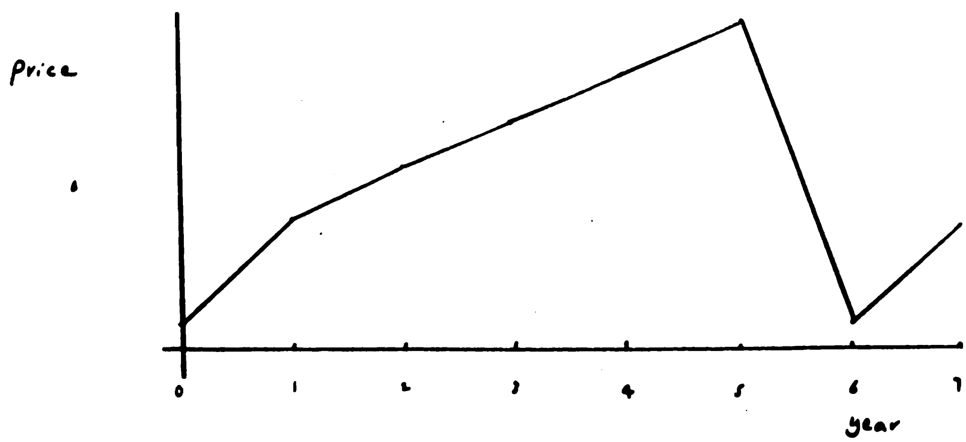


Figure B.2. Price and Year



and xb and yc are the inelastic, short-run supply curves. A series of demand curves D_0 . . . D_7 is shown, the subscripts denoting the applicable years. Assume that there has been a recent expansion in capacity to point b, which has driven price down to P_0. Along the short-run curve there is a single year's delay in production response and hence supply in year 1 is Q_1, resulting in price P_1 which clears the market. In the next year Q_2 is supplied which results in price P_2. The normal action continues until year 5 in which price P_5 exceeds the previous high price and there is in consequence a movement along the long-run supply curve from b to c in the next year. The large quantity Q_6 depresses the price to P_6 and a new cycle is initiated.

Figure 2 plots the price from Figure 1 over time. Price rises steadily from P_0 to P_5, falls heavily to P_6 and then begins climbing once again. The length of the cycle depends on the slopes of the short- and long-run supply functions, on the slope of the demand function and on the rapidity with which population and income shift demand to the right.

The market behavior of Figures 1 and 2 assumed that there was a lag of a single year between price and supply for both the short and long runs. Short-run response is an adjustment within current capacity, hence is accomplished in a one year period. This response is highly inelastic because producers resist any restriction on utilization of their investments. Long-run response is an adjustment of capacity, involving investment in extra cane and often in extra factory equipment. This investment lag might be expected to be at least two years in duration and during this delay price will climb to a greater level than shown in Figures 1 and 2, since demand will shift two "steps" to the right rather than one. Figure 3 demonstrates the action in a market which is typified by such annual short-run adjustments and two-year long-run adjustments. Figure 4 plots price from Figure 3 over time and shows that a two-year investment delay leads to much larger cycles in price.

Algebraic Presentation

An algebraic presentation will now be given, beginning with a simple cobweb model which is then adapted to the conditions of a shifting demand and an asymmetric supply. The standard cobweb model has price as a function of current quantity,

(1) $Pt = - aQt$

and quantity supplied next year as a function of current price,

(2) $Q_{t+1} = w_1 b_1 \; P_t,$

where Q = quantity supplied

P = price

w_1, b_1 and a = parameters

and t = a year subscript.

By successive substitution from Equation (1) and (2) one may obtain

$$Q_{t+1} = w_1 b_1 a Q_t \text{ , and}$$

$$Q_{t+2} = w_1 b_1 P_{t+1} = -w_1 b_1 a Q_{t+1} = (w_1 b_1 a)^2 \; Qt, \text{ and } \cdot \cdot \cdot \cdot \cdot$$

(3) $Q_{t+2k} = (w_1 b_1 a)^{2k} Q_t$

Figure B.3. Price and Quantity

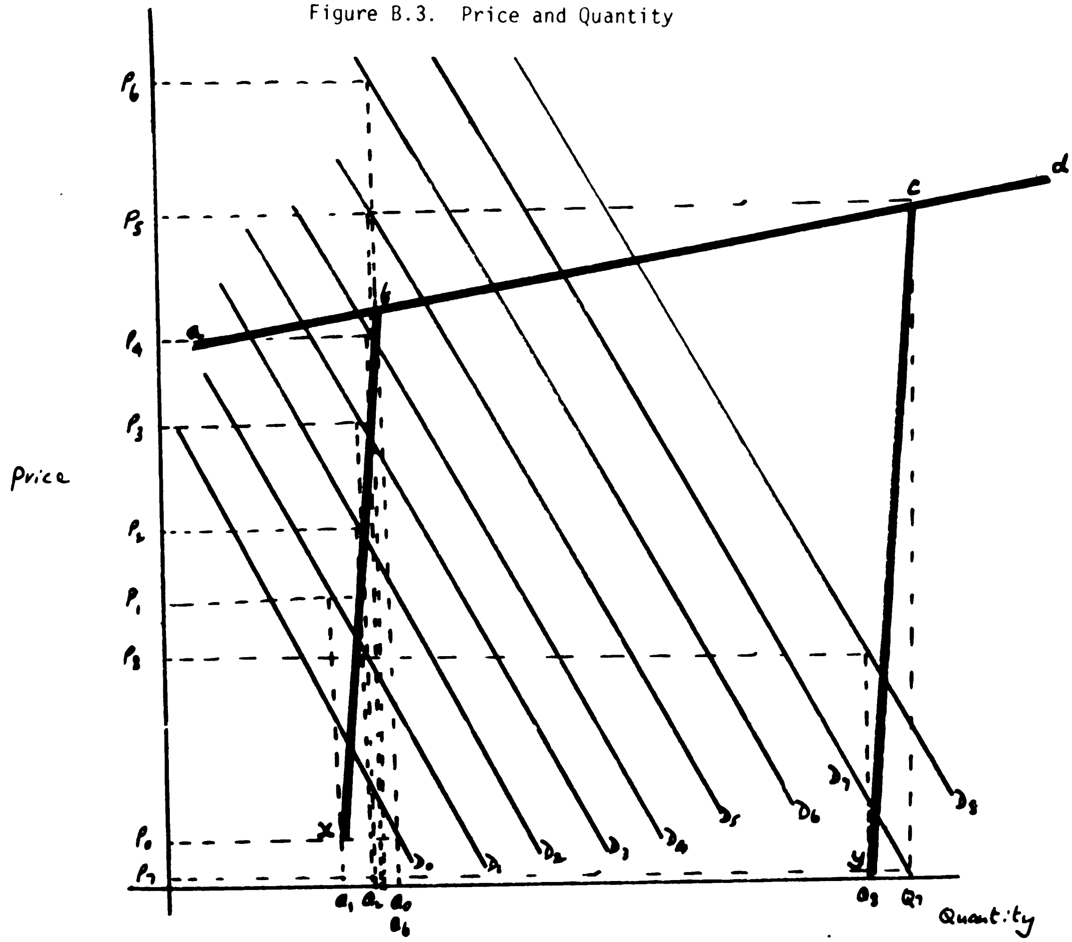
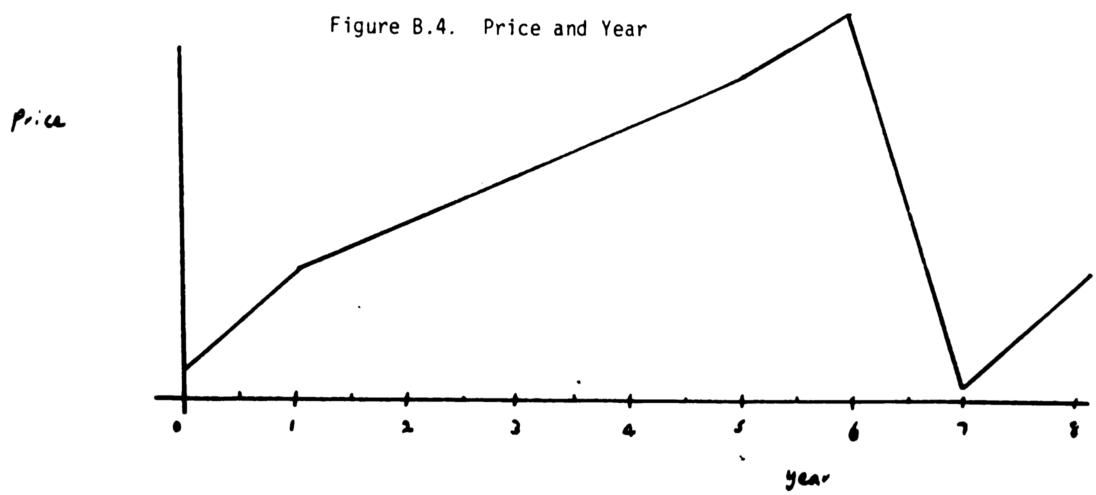


Figure B.4. Price and Year



Waugh shows that $(w_1b_1a)^2\ Q_t<1$ implies convergence of the system whereas $(w_1b_1a)^2\ Q_t>1$ implies system divergence.

The demand function will now be complicated by the inclusion of income and population. It may be stated as

(4) $P_t = a_1Q_t + a_2Y_t + a_3N_t,$

where Y_t = income

and N_t = population.

The supply function will be complicated in two stages, in the first of which quantity supplied is made a distributed lag of previous prices and in the second of which the property of asymmetry is introduced. Firstly, then, let short-run supply become a function of a geometrically distributed lag of prices,[3]

(5) $Q^{SR}_{t+1} = w_1b_1P_t + (w_1b_1)^2P_{t-1} + (w_1b_1)^3P_{t-2} + \ldots,$

where Q^{SR} = short-run quantity supplied

and w_1 = a parameter.

A Koyck transformation on Equation (5) leads to

(6) $Q^{SR}_{t+1} = w_1b_1Q^{SR}_t + w_1b_1P_t.$

Secondly, let long-run supply be defined as a function of a second distributed lag of prices, beginning one year further back,

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[3]The geometric lag was chosen for simplicity: other lags could have been used.

(7) $$Q^{LR}_{t+1} = w_2b_2P_{t-1} + (w_2b_2)^2P_{t-2} + (w_2b_2)^3P_{t-3} + \ldots,$$

where Q^{LR} = long-run quantity supplied,

and w_2 = a parameter.

A Koyck transformation on Equation (7) leads to

(8) $$Q^{LR}_{t+1} = w_2b_2Q^{LR}_{t-1} + w_2b_2P_{t-1} .$$

In the graphical exposition, the long-run supply function was activated whenever price in the current year exceeded the previous maximum price. Because there is assumed to be a two year delay in long-run response, the long-run supply function only operates in year t when price in year t-2 was higher than the previous maximum in that year. Equations (6) and (8) may be combined with this "trigger" mechanism by making

w_1 = 1, when $P_t \leq P^0_{t-2}$, 0 otherwise, and

w_2 = 1, when $P_t > P^0_{t-2}$, 0 otherwise,

where P^0_{t-2} = the highest price which has existed up to and including that at time t-2.

The combination of the two equations then becomes,

(9) $$Q_t = w_1b_1Q_{t-1} + w_2b_2Q_{t-2} + w_1b_1P_{t-1} + w_2b_2P_{t-2},$$

in which short-run and long-run superscripts are no longer necessary.

The system of equations so far consist of a demand function (4) and an asymmetric supply function (9). To complete the algebraic equivalence with the graphical presentation, income and population may be allowed to grow in the following manner,

$$(10) \quad Y_{t+1} = (1+g_y)Y_t \text{ , and}$$

$$(11) \quad N_{t+1} = (1+g_n)N_t \text{ ,}$$

where g_y and g_n are the respective growth rates for income and population.

The complete model of the free market in sugar row comprises Equations (4), (9), (10) and (11). Equations (4) and (9) may be combined to give

$$(12) \quad Q_t = w_1b_1 \, (1+a_1) \, Q_{t-1} + w_2b_2 \, (1+a_1) \, Q_{t-2}$$
$$+ w_1b_1 \, (a_2Y_{t-1} + a_3N_{t-1}) + w_2b_2 \, (a_2Y_{t-2} + a_3N_{t-2}).$$

Equation (12), given (10) and (11), may be solved for any desired year to give the recursively determined supply. The generalization of (12) is cumbersome and will not be elaborated. Because population and income continually shift the demand function, the system is always in disequilibrium and one cannot define it as divergent or convergent. However, were population and income to be held constant, the condition for convergence would collapse to

$$(13) \quad (w_1b_1)^2 \, (1+a_1)^2 + (w_2b_2)^2 \, (1+a_1)^2 < 1 \text{ ,}$$

for which the first term on the LHS is zero in the long run and the second term on the LHS is zero in the short run. Since $b_2 > b_1$, by definition, the long-run function, when operating, will lead to greater divergence than the short-run function.

A cobweb model for sugar has now been specified, its most important feature being the asymmetric supply function (9). However, multicollinearity and problems of autocorrelation would make that equation very difficult to estimate. Instead of estimating (9) one may define another equation which possesses the same asymmetry for the short and long run but, by utilizing variables in ratio form, avoids multicollinearity. The function is analogous to Duesenberry's "ratchet" consumption function as adapted by Griliches et al.[4]

Let $X_t = Q_t / P_{t-2}$

and $Z_t = P_{t-2} / P^0_{t-2}$.

The model posits

(14) $X^*_t = \alpha + \beta Z_t$, and

(15) $X_t - X_{t-1} = \gamma(X^*_t - X_{t-1})$,

where γ = an adjustment coefficient

and $*$ = a desired value.

Combining Equations (14) and (15) leads to

(16) $X_t = \alpha\gamma + \beta\gamma Z_t + (1-\gamma)X_{t-1}$.

Equation (16) gives asymmetric responses. Its estimation will depend upon the nature of the error term associated with it. Given a "well-behaved" error, OLS would be appropriate.

One may question the use of the same adjustment coefficient, γ, for both the short and long run components. Since the sugar cycle is

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[4]Griliches, Z. et al. (1962). "Notes on Estimated Aggregate Quarterly Consumption Functions," Econometrica, 30, (3), pp. 491-500.

of six to nine years duration, it has occurred only three times in the post-war time series and it is not feasible to estimate different adjustment processes for the short and long runs.

Summary and Implications

This note has shown how an asymmetric supply and smoothly shifting demand may produce price cycles of several years' duration. An algebraic formalization led to four equations concerned with supply, demand and the growth of income and population. The system never attains equilibrium, but the conditions under which convergence occurs, given a static income and population, were derived. An empirical approach to modeling the asymmetric supply was described.

The world sugar economy consists of many suppliers and demanders rather than the extreme case of a single supplier and a single demander of this note. Further, the sugar entering the market is derived both from the annual, sugar beet, and the perennial, sugar cane. The price cycles of this note are therefore an extreme case and in reality the cycles, as may be observed, are much more complex. Underlying the cycles which have been described is the assumption that imperfect knowledge leads to "irrational" investment behavior and the imperfections may be the result of politically-induced price distortions in the major exporting nations. The continued existence of hog cycles, after many years of economic analysis of their cause, demonstrates that knowledge among producers within a single country is far from perfect. At the international level knowledge about the action of others is even less, as is the case with sugar.

APPENDIX C

FULL RESULTS OF THE EIGHT MOST IMPORTANT POLICY EXPERIMENTS

N.B. All prices in (1974) cents per lb. and all quantities in thousands of metric tons in this and following appendices.

Table C.1. Results of Policies I and II

	Benchmark I			Free Trade II		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Argentina	1,059	7.0740	1,493	1,037	9.2150	1,604
Australia	712	7.7975	2,909	708	10.1011	2,919
Austria	373	8.0705	370	360	11.0341	370
Barbados	12	6.9965	136	12	9.8058	153
Bol/Chile	558	9.0052	284	551	10.9418	218
Brazil	4,721	7.2470	6,242	4,408	9.7224	6,218
Canada W.	360	10.4448	0	358	11.6905	0
Canada E.	719	9.9997	130	716	11.2914	130
Sri Lanka	244	10.5894	7	237	11.7562	7
China	2,629	8.7023	3,150	2,064	10.7442	3,150
Taiwan	306	8.3699	736	286	10.6991	710
Colombia	649	7.0601	856	605	9.9006	893
Cuba	457	6.7231	6,240	455	9.8051	6,220
Czechosl.	696	7.5681	734	665	10.9610	734
Denmark	275	12.5021	275	279	11.0209	236
Dom. Rep.	158	6.9007	1,021	148	9.7400	912
Belgium	378	12.5925	768	383	11.1991	741
France	2,235	12.7892	2,426	2,269	11.3633	1,971
W. Germany	2,299	12.3383	2,679	2,346	10.7547	2,361
Netherlands	592	12.8651	413	655	11.1919	356
Italy	1,831	13.5965	1,463	1,875	11.6306	1,289
Fiji	24	7.7363	379	24	10.0141	410
Finland	252	7.6561	80	244	10.5822	80
E. Germany	758	7.5607	695	725	10.6162	778
Greece	232	12.9531	145	235	11.7691	145
Guatemala	160	6.8523	221	148	9.8749	237
Guyana	35	7.0310	332	34	9.5787	332
Hong Kong	89	8.9529	0	85	11.5241	0
Iceland	10	8.4752	0	9	11.4518	0
India	4,039	11.0344	3,360	3,895	12.0253	3,637
Indonesia	965	12.6382	423	1,000	12.0308	403
Iran	961	13.3109	961	1,002	11.4991	830
Ireland	209	13.0729	173	213	11.5410	173

Table C.1. Continued

COUNTRY	Benchmark I DEMAND	PRICE	SUPPLY	Free Trade III DEMAND	PRICE	SUPPLY
Jamaica	102	6,9115	492	98	9.7900	611
Japan	3,342	15.5291	970	3,526	11.8957	751
Korea	398	12.2273	0	400	11.5045	0
Mauritius	333	8.2056	620	31	10.5058	623
Mexico	2,047	7.0329	3,059	2,008	9.937	3,103
New Zealand	174	7.7851	0	167	10.0078	0
Nicaragua	84	6.9586	163	81	10.1486	202
Norway	197	8.7353	0	191	10.8853	0
Pak/Bangla.	712	17.0327	427	954	11.5613	427
Peru	459	9.1101	830	453	9.7611	828
Philippines	763	8.5754	2,160	719	11.1327	2,152
Poland	1,658	7.2122	2,236	1,585	10.5252	2,477
Portugal	261	12.3116	11	266	11.4365	11
Saudi Arabia	157	8.5810	0	149	11.8478	0
Singapore	123	23.4180	0	129	11.6348	0
S. Africa	1,092	7.8738	1,885	1,063	9.8336	1,482
Spain	1,143	8.9063	858	1,120	11.2570	858
Sweden	401	7.6861	260	385	11.8778	260
Switzerland	339	10.2646	77	330	11.5402	77
Thailand	475	9.7249	431	438	12.0854	385
Trin/Tobago	49	6.9549	248	47	9.7989	275
Turkey	910	10.6064	910	855	11.3213	921
USSR W.	5,833	7.3874	10,426	5,586	10.4128	11,575
USSR E.	5,715	8.6816	0	5,482	11.8753	0
U.K.	2,865	12.8185	1,105	2,898	11.4545	982
U.S.A. Hawaii	34	10.8107	944	35	10.1085	914
West	2.829	11.9999	1,920	2,832	11.4759	1,705
South	1,837	12.6177	1,657	1,849	10.5552	1,260
East	6,033	11.8943	1,281	6,053	10.7233	1,170
P. Rico	134	11.5446	185	136	9.9563	165
Venezuela	509	6.8877	578	478	9.8563	587
E. Europe	2,368	10.6636	1,826	2,351	11.1886	1,826
C. America	603	11.8442	913	620	9.5093	782

Table C.1. Continued

	Benchmark I			Free Trade II		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Parag/Urug.	193	9.5621	148	198	9.2849	147
Near East	921	11.0257	103	913	11.9069	103
Far East	1,327	12.1381	119	1,319	12.1548	119
N. Africa	1,407	17.5210	819	1,622	11.6340	819
W. Africa	506	11.3285	61	536	10.9763	61
N.E. Africa	374	31.0393	271	575	11.8557	271
E. Africa	433	11.1098	319	429	11.3106	319
S. C. Africa	485	7.9887	915	454	10.3083	915
S.W.C. Africa	172	9.7188	172	164	9.9734	172
TOTAL	78,535		78,535	77,575		77,575

Table C.2. Results of Policies III and IV

	No U.S. Sugar Act III			No Protection By E.E.C. IV		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Argentina	1040	7.8906	1570	1045	8.3750	1583
Australia	712	7.9874	2889	710	9.2435	2910
Austria	368	9.0195	370	366	9.5074	370
Barbados	12	8.9774	152	12	8.3467	148
Bol/Chile	552	9.9542	274	548	10.4425	239
Brazil	4577	8.2782	6268	4552	8.4724	6251
Canada W.	357	12.4139	0	357	11.9714	0
Canada E.	714	12.1490	130	716	11.4674	130
Sri Lanka	240	11.3175	7	235	12.1971	7
China	2951	8.6561	3150	2998	9.9333	3150
Taiwan	296	8.7822	736	296	9.8443	736
Colombia	614	9.0293	895	609	8.3764	885
Cuba	456	9.1887	6214	457	8.1302	6230
Czechosl.	686	8.5428	734	680	9.1815	734
Denmark	275	12.6072	277	279	9.9883	208
Dom. Rep.	148	8.8499	956	165	8.2708	1011
Belgium	378	12.5888	768	385	9.5779	707
France	2240	12.5612	2430	2288	9.8741	1588
W. Germany	2299	12.3334	2675	2354	9.7152	2134
Netherlands	597	12.7357	408	721	9.8013	304
Italy	1826	13.4384	1465	1892	10.2386	1164
Fiji	24	8.3212	405	24	9.0424	410
Finland	250	8.4105	80	247	9.3020	80
E. Germany	746	8.5290	723	738	9.2491	744
Greece	230	13.7556	145	228	14.3169	145
Guatemala	151	8.9395	233	149	8.3375	232
Guyana	34	8.9741	335	34	8.3551	335
Hong Kong	92	9.2978	0	89	10.3796	0
Iceland	10	9.6025	0	10	9.9127	0
India	3941	11.6896	3546	3855	12.3310	3732
Indonesia	932	13.2952	448	897	14.6434	491
Iran	961	13.3103	961	961	13.3206	961
Ireland	209	13.1197	173	215	10.0430	173

Table C.2. Continued

COUNTRY	No U.S. Sugar Act III DEMAND	PRICE	SUPPLY	No Protection by E.E.C. IV DEMAND	PRICE	SUPPLY
Jamaica	98	9.1545	592	100	8.3471	552
Japan	3333	15.8293	989	3293	16.9998	1069
Korea	397	12.7175	0	390	14.1611	0
Mauritius	33	8.7600	620	32	10.2070	459
Mexico	2034	9.1937	3110	2029	8.5720	3166
New Zeal.	168	8.5920	0	170	9.0972	0
Nicaragua	81	8.9969	192	83	8.4646	184
Norway	195	9.5476	0	193	10.2753	0
Pak/Bangla.	686	17.7297	427	656	18.5203	427
Peru	463	8.7276	813	452	9.0366	822
Philipp.	752	9.2059	2138	738	10.1806	2147
Poland	1625	8.5352	2341	1614	9.0578	2382
Portugal	256	13.4700	11	257	13.7524	11
Saudi Ar.	156	9.9214	0	154	10.4660	0
Singapore	122	23.5294	0	122	24.7888	0
S. Africa	1036	8.2143	1860	1060	9.0155	1702
Spain	1144	9.9629	858	1126	10.1593	858
Sweden	394	8.9235	260	391	9.5619	260
Switzerland	328	11.4130	77	327	12.0092	77
Thailand	458	10.1593	413	448	11.1888	354
Trin/Tobago	47	8.9755	267	48	8.3344	262
Turkey	909	10.0221	909	909	10.0288	909
USSR W.	5757	8.1933	10764	5692	8.9702	11058
USSR E.	5578	9.5339	0	5588	10.3743	0
U.K.	2862	12.9568	1105	2922	9.9723	860
U.S.A. Hawa.	35	9.0064	827	35	10.5634	938
West	2842	10.3423	1311	2830	11.9222	1926
South	1855	9.8271	1093	1839	12.5878	1671
East	6057	10.3271	1142	6035	11.8243	1278
P.Ric.	134	9.2292	171	133	11.4955	176

Table C.2. Continued

COUNTRY	No. U.S. Sugar Act III DEMAND	PRICE	SUPPLY	No Protection by E.E.C. IV DEMAND	PRICE	SUPPLY
Venezuela	480	9.1006	587	496	8.3280	591.
E. Europe	2319	12.2605	1826	2303	13.1344	1826
C. America	641	8.8900	751	603	11.8442	913
Parag/Urug.	194	10.5021	148	194	11.1572	155
Near East	915	11.7600	103	903	12.4695	103
Far East	1293	12.7491	119	1215	14.1661	119
N. Africa	1316	20.0507	819	1318	20.3653	819
W. Africa	405	12.9882	61	402	12.9707	61
N.E. Africa	354	33.7464	271	338	36.2026	271
E. Africa	418	11.9651	319	409	12.6141	319
S.C. Africa	473	8.7172	915	465	9.4470	915
S.W.C. Africa	172	9.7188	172	172	9.7188	172
TOTAL	77818		77818	77626		77626

Table C.3. Results of Policies V and VI

	No U.S. Sugar Act or C.A.P. V			No U.S. Sugar Act and No Cuban Quotas VI		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Argentina	1042	8.7292	1589	1045	8.3750	1583
Australia	709	9.0123	2907	710	9.2435	2910
Austria	363	10.1792	370	366	9.5074	370
Barbados	12	10.1302	154	12	8.3467	148
Bol/Chile	552	10.9118	225	548	10.4425	239
Brazil	4476	9.1089	6253	4552	8.4724	6251
Canada W.	355	13.1984	0	357	11.9714	0
Canada E.	711	13.0052	130	716	11.4674	130
Sri Lanka	235	12.1928	7	235	12.1971	7
China	3158	9.7172	3150	2998	9.9333	3150
Taiwan	297	9.7398	738	296	9.8443	736
Colombia	604	9.6953	903	609	8.3764	885
Cuba	455	10.2011	6226	457	8.1302	6230
Czechosl.	677	9.5382	734	680	9.1815	734
Denmark	278	10.5043	217	279	9.9883	208
Dom. Rep.	139	10.1484	899	165	8.2708	1011
Belgium	388	9.9544	720	385	9.5779	707
France	2297	10.3060	1686	2288	9.8741	1588
W. Germany	2363	10.2301	2215	2354	9.7152	2134
Netherlands	694	10.3410	322	721	9.8013	304
Italy	1883	11.0147	1228	1892	10.2386	1164
Fiji	24	9.1557	410	24	9.0424	410
Finland	248	9.7055	80	247	9.3020	80
E. Germany	732	8.8321	761	738	9.2491	744
Greece	223	15.1591	146	228	14.3169	145
Guatemala	148	9.7957	238	149	8.3375	232
Guyana	34	9.5793	330	34	8.3551	335
Hong Kong	89	10.5339	0	89	10.3796	0
Iceland	10	10.7298	0	10	9.9127	0
India	3828	12.4175	3752	3855	12.3310	3732
Indonesia	874	14.5876	486	897	14.6434	491
Iran	961	13.3104	961	961	13.3206	961
Ireland	216	10.4807	173	215	10.0430	173

Table C.3. Continued

	No U.S. Sugar Act or C.A.P. V			No U.S. Sugar Act and No Cuban Quotas VI		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Jamaica	98	10.0380	620	100	8.3471	552
Japan	3335	16.8545	1060	3293	16.9998	1069
Korea	389	14.0941	0	390	14.1611	0
Mauritius	32	9.5967	621	32	10.2070	459
Mexico	2007	9.9827	3096	2029	8.5720	3166
New Zealand	169	9.4741	0	170	9.0972	0
Nicaragua	81	9.7412	199	83	8.4646	184
Norway	192	10.6739	0	193	10.2753	0
Pak/Bangladesh	657	18.5322	427	656	18.5203	427
Peru	455	9.5585	830	452	9.0366	822
Philippines	751	10.0051	2202	738	10.1806	2147
Poland	1606	99.4353	2412	1614	9.0578	2382
Portugal	251	14.6126	11	257	13.7524	11
Saudi Arabia	152	10.8829	0	154	10.4660	0
Singapore	122	24.5853	0	122	24.7888	0
S. Africa	1103	8.9608	1712	1060	9.0155	1702
Spain	1125	10.9602	858	1126	10.1593	858
Sweden	390	9.8572	260	391	9.5619	260
Switzerland	323	12.5808	77	327	12.0092	77
Thailand	451	11.1828	356	448	11.1888	354
Trin/Tobago	46	10.0160	275	48	8.3344	262
Turkey	895	10.3458	914	909	10.0288	909
USSR W.	5657	9.4153	11255	5692	8.9703	11058
USSR E.	5558	10.8345	0	5588	10.3743	0
U.K.	2913	10.4643	885	2922	9.9723	860
H.S.A. Hawa.	35	9.9507	892	35	10.5634	938
West	2836	11.1855	1590	2830	11.9222	1926
South	1842	10.6709	1290	1839	12.5878	1671
East	6016	11.1298	1209	6035	11.8243	1278
P. Rico	136	9.8528	166	133	11.4955	176

Table C.3. Continued

COUNTRY	No U.S. Sugar Act or C.A.P. V			No U.S. Sugar Act and No Cuban Quotas VI		
	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Venezuela	484	10.0495	586	496	8.3280	591
E. Europe	2283	13.6148	1826	2303	13.1344	1826
C. America	625	10.0245	796	603	11.8442	913
Parag/Urug.	193	11.6443	158	194	11.1572	155
Near East	894	13.0054	103	903	12.4695	103
Far East	1209	13.7811	119	1215	14.1661	119
N. Africa	1239	21.8941	819	1318	20.3653	819
W. Africa	351	13.8678	61	402	12.9707	61
N.E. Africa	340	35.9241	271	338	36.2026	271
E. Africa	409	12.5293	319	409	12.6141	319
S.C. Africa	464	9.4815	915	465	9.4470	915
S.W.C. Africa	172	9.7188	172	172	9.7188	172
TOTAL	77393		77393	77626		77626

Table C.4. Results of Policies Xc and Xd

COUNTRY	Benchmark Plus 10 Cent Export-Tax Xc DEMAND	PRICE	SUPPLY	Benchmark Plus 20 Cent Export-Tax Xd DEMAND	PRICE	SUPPLY
Argentina	1070	4.1751	1070	1099	4.3955	1099
Australia	729	2.2226	1525	741	.9281	741
Austria	353	13.0293	370	348	14.4841	370
Barbados	13	2.5943	67	13	.4977	13
Bol/Chile	530	15.2738	305	522	17.4247	350
Brazil	5366	4.1815	5366	5365	4.1868	5365
Canada W.	355	15.4706	0	352	17.5911	0
Canada E.	708	15.9054	130	705	17.6280	130
Sri Lanka	221	14.7304	7	213	17.7823	7
China	1552	13.2889	3150	1215	15.0793	3150
Taiwan	382	2.8729	632	421	1.7921	421
Colombia	713	4.6646	713	714	4.6451	714
Cuba	467	2.7330	5035	473	1.3560	3218
Czechosl.	655	12.4664	734	645	14.1216	734
Denmark	273	13.4967	308	271	14.6822	323
Dom. Rep.	326	2.9323	635	449	1.7992	449
Belgium	374	13.7141	794	376	14.5369	801
France	2214	13.7782	2807	2198	14.5928	2996
W. Germany	2269	13.4452	2877	2247	14.3703	3002
Netherlands	564	13.7743	458	573	14.7595	495
Italy	1800	14.5128	1553	1804	15.1525	1636
Fiji	25	2.3834	178	26	.1970	26
Finland	240	12.2814	80	238	14.0802	80
E. Germany	712	12.2615	817	698	14.1893	853
Greece	215	17.8165	146	211	19.3723	147
Guatemala	176	4.4789	176	176	4.4789	176
Guyana	36	2.5865	177	42	.6576	42
Hong Kong	83	13.4554	0	79	15.9297	0
Iceland	9	13.4063	0	9	15.1247	0
India	3798	12.6013	3798	3798	12.6013	3798
Indonesia	774	18.3788	622	686	20.6314	686
Iran	961	13.3185	961	961	13.3194	961
Ireland	207	14.5130	173	205	14.8578	173

Table C.4. Continued

	Benchmark Plus 10 Cent Export-Tax Xc			Benchmark Plus 20 Cent Export-Tax Xd		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Jamaica	107	2.8370	233	122	1.5140	122
Japan	3194	19.9425	1257	3142	21.8486	1377
Korea	371	18.4229	0	363	20.9048	0
Mauritius	41	1.9674	685	63	.1265	63
Mexico	2176	3.4451	2176	2176	3.4342	2176
New Zeal.	160	13.2131	0	157	16.8784	0
Nicaragua	95	3.4069	95	94	3.4514	94
Norway	186	13.3156	0	183	15.1506	0
Pak/Bangla.	571	21.1400	427	498	23.5622	427
Peru	518	3.3175	518	548	3.6628	548
Philipp.	1159	2.5915	1398	1194	2.3597	1194
Poland	1556	12.3602	2592	1535	13.8205	2672
Portugal	241	17.1390	11	235	18.9196	1
Saudi Ar.	145	13.4943	0	138	15.1472	0
Singapore	121	27.6264	0	120	30.4040	0
S. Africa	1737	2.8771	1737	1711	2.9912	1711
Spain	1082	13.7139	858	1062	15.2854	858
Sweden	376	12.6349	260	376	14.4104	260
Switzerland	310	15.1083	77	312	16.8346	77
Thailand	484	9.2966	484	484	9.2955	484
Tin/Tobago	54	3.0236	129	60	1.4047	60
Turkey	790	13.2759	935	747	14.8415	945
USSR W.	5481	12.0977	12083	5384	13.9381	12631
USSR E.	5411	13.3902	0	5384	15.2550	0
U.K.	2840	14.5553	1248	2836	14.7818	1286
U.S.A. Hawa.	34	12.2681	1052	34	14.1520	1192
West	2819	13.4820	2662	2801	15.1531	3779
South	1836	13.5611	1883	1822	15.4299	2201
East	5995	14.4780	1536	5975	16.2398	1711
P.Ric.	132	13.3527	239	130	15.1037	436

Table C.4. Continued

	Benchmark Plus 10 Cent Export-Tax Xc			Benchmark Plus 20 Cent Export-Tax Xd		
COUNTRY	DEMAND	PRICE	SUPPLY	DEMAND	PRICE	SUPPLY
Venezuela	526	5.4206	526	528	5.2866	528
E. Europe	2199	17.4914	1826	2219	19.3885	1826
C. America	666	7.3973	666	666	7.3894	666
Parag/Urug.	188	13.6762	188	188	13.6764	188
Near East	847	15.4664	103	842	17.3010	183
Far East	1074	17.3452	119	922	20.7206	119
N. Africa	1117	27.5233	819	1067	30.3567	819
W. Africa	191	18.6760	61	125	20.0908	61
N.W. Africa	289	44.5782	271	271	48.6692	271
E. Africa	374	15.2131	319	344	17.6662	319
S.C. Africa	436	11.9960	915	411	14.4814	915
S.W.C. Africa	106	13.2675	172	100	14.1337	172
TOTAL	76244		76244	75281		72536

APPENDIX D

THE TRADE FLOWS UNDER POLICIES I AND II AND THE TARIFFS AND QUOTAS UNDER POLICY I

Table D.1. Trade Flows Under Policy I

TRADE FLOWS UNDER BENCHMARK SOLUTION

Source	Destination	Quantity Shipped
Argentina	Argentina	1059.27
Argentina	Bol. Chile	131.38
Argentina	New Zealand	174.65
Argentina	Par. Uruguay	51.67
Australia	Australia	712.47
Australia	Indonesia	542.70
Australia	Japan	81.33
Australia	Singapore	123.00
Australia	Far East	1106.59
Austria	Austria	362.29
Austria	Greece	7.71
Barbados	Barbados	12.85
Barbados	Portugal	19.12
Bol. Chile	Bol. Chile	278.33
Brazil	Brazil	4721.32
Brazil	India	350.23
Brazil	Spain	128.12
Brazil	W. Africa	445.40
Canada M	Canada E	130.00
Sri Lanka	Sri Lanka	7.00
China	China	2329.44
China	Japan	541.63
China	Korea	278.93
Taiwan	Taiwan	326.50
Taiwan	Hong Kong	89.97
Taiwan	Japan	260.29
Colombia	Bol. Chile	137.70
Colombia	Colombia	649.48
Cuba	Bol. Chile	6.67
Cuba	Canada E	589.08
Cuba	Cuba	457.19
Cuba	Greece	79.11
Cuba	Iceland	10.17
Cuba	Japan	1218.76
Cuba	Portugal	19.54
Cuba	Near East	624.63

TRADE FLOWS UNDER BENCHMARK SOLUTION

Source	Destination	Quantity Shipped
Cuba	North Africa	489.95
Czechoslavakia	Czechoslavakia	546.64
Czechoslavakia	Switzerland	187.36
Denmark	Denmark	275.34
Dom. Rep.	Dom. Rep.	158.60
Dom. Rep.	Portugal	93.96
Dom. Rep.	Spain	98.00
Belgium	Belgium	378.55
Belgium	Netherlands	13.17
Belgium	U.K.	376.74
France	France	2235.68
France	Italy	154.39
France	Ireland	36.23
W. Germany	W. Germany	2299.01
W. Germany	Netherlands	166.12
W. Germany	Italy	213.88
Netherlands	Netherlands	413.41
Italy	Italy	1463.10
Fiji	Fiji	24.73
Fiji	Japan	189.36
Finland	Finland	80.00
E. Germany	E. Germany	508.57
E. Germany	Norway	186.74
Greece	Greece	145.57
Guatemala	Bol. Chile	4.92
Guatemala	Guatemala	160.72
Guyana	Guyana	35.27
Guyana	Spain	59.23
India	India	3262.51
Indonesia	Indonesia	423.15
Iran	Iran	961.55
Ireland	Ireland	173.00
Jamaica	Jamaica	102.84
Jamaica	Portugal	118.17
Japan	Japan	970.39
Mauritius	Sri Lanka	160.01

Table D.1. Continued

TRADE FLOWS UNDER BENCHMARK SOLUTION

Source	Destination	Quantity Shipped
Mauritius	Mauritius	33.39
Mexico	Canada W	352.74
Mecico	Japan	80.79
Mexico	Mexico	2047.55
Nicaragua	Canada W	7.35
Nicaragua	Nicaragua	85.88
Pak. Bangladesh	Pak. Bangladesh	427.00
Peru	Peru	460.00
Philippines	Philippines	763.43
Philippines	Thailand	61.68
Philippines	Far East	27.20
Poland	Austria	11.23
Poland	Poland	1633.56
Poland	Saudi Arabia	157.89
Poland	Sweden	141.73
Poland	Switzerland	74.80
Poland	Europe	217.50
Portugal	Portugal	11.00
S. Africa	India	324.99
S. Africa	Pak. Bangladesh	285.33
S. Africa	S. Africa	1092.09
Spain	Spain	858.00
Sweden	Sweden	260.00
Switzerland	Switzerland	77.00
Thailand	Thailand	414.26
Trin/Tob.	Trin/Tob.	49.43
Trin/Tob.	N. Africa	56.75
Turkey	Turkey	910.25

TRADE FLOWS UNDER BENCHMARK SOLUTION

Source	Destination	Quantity Shipped
USSR RI	Finland	172.61
USSR RI	Norway	10.99
USSR RI	USSR RI	4333.37
USSR RI	USSR VL	5715.73
USSR RI	Near East	194.01
U.K.	U.K.	1105.77
Hawaii	USA HAW	35.00
Hawaii	USA SFR	909.09
San Francisco	USA SFR	1920.38
New Orleans	USA NOR	1657.04
New York	USA NOP	129.54
New York	USA NY	1151.76
Puerto Rico	USA NOR	51.41
Puerto Rico	Puerto Rico	134.10
Venezuela	Venezuela	589.60
Venezuela	N. Africa	41.34
E. Europe	E. Europe	1826.00
C. America	C. America	603.98
Par/Uruguay	Par/Uruguay	142.11
Near East	Near East	103.00
Far East	Far East	119.00
N. Africa	N. Africa	819.00
W. Africa	W. Africa	61.00
N.E. Africe	N.E. Africa	271.00
E. Africa	E. Africa	312.00
S.C. Africa	Sri Lanka	77 30
S.C. Africa	India	101.80
S.C. Africa	N.E. Africa	103.45
S.C. Africa	E. Africa	121.88
S.C. Africa	S.C. Africa	485.56
S.W.C. Africa	S.W.C. Africa	172.00

All Prod. All Mkts 69525.01

Table D.2. Trade Flows Under Policy II

TRADE FLOWS UNDER FREE TRADE | TRADE FLOWS UNDER FREE TRADE

Source	Destination	Quantity Shipped	Source	Destination	Quantity Shipped
Austrália	Indonesia	416.88	Belgium	Belgium	383.71
Australia	Japan	1171.52	Belgium	U.K.	358.21
Australia	Singapore	129.69	France	France	1971.85
Australia	USSR VL	493.92	W. Germany	W. Germany	2346.26
Austria	Austria	360.17	W. Germany	Netherlands	14.76
Austria	Near East	9.83	Netherlands	Netherlands	356.02
Barbados	Barbados	12.77	Italy	Italy	1289.67
Barbados	Portugal	140.88	Fiji	Fiji	24.65
Bol. Chile	Bol. Chile	218.90	Fiji	Japan	386.15
Brazil	Brazil	4488.87	Finland	Finland	80.00
Brazil	Italy	419.82	E. Germany	E. Germany	725.58
Brazil	Portugal	114.62	E. Germany	Switzerland	52.81
Brazil	Switzerland	132.24	Greece	Greece	145.11
Brazil	N. Africa	675.82	Guatemala	Guatemala	148.32
Brazil	W. Africa	467.56	Guatemala	USA SFR	89.32
Canada E	Canada E	130.00	Guyana	Guyana	34.46
Sri Lanka	Sri Lanka	7.00	Guyana	Spain	262.43
China	China	2064.85	Guyana	U.K.	35.60
China	Korea	400.67	India	India	3637.34
China	USSR VL	684.48	Indonesia	Indonesia	483.77
Taiwan	Taiwan	286.13	Iran	Iran	830.02
Taiwan	Hong Kong	85.39	Ireland	Ireland	173.00
Taiwan	Japan	338.51	Jamaica	Jamaica	98.82
Colombia	Colombia	685.49	Jamaica	U.K.	512.53
Colombia	USA SFR	288.45	Japan	Japan	751.39
Cuba	Cuba	455.56	Mauritius	Sri Lanka	230.36
Cuba	USA NOR	899.14	Mauritius	India	258.08
Cuba	USA NY	4865.61	Mauritius	Mauritius	31.88
Czechoslovakia	Czechoslov.	655.79	Mauritius	Saudi Arabia	103.55
Czechoslovakia	Switzerland	68.21	Mexico	Canada W	358.05
Denmark	Denmark	236.37	Mexico	Canada E	95.88
Dom. Rep.	Canada E	490.53	Mexico	Mexico	2008.48
Dom. Rep.	Dom. Rep.	148.22	Mexico	USA NOR	641.30
Dom. Rep.	Ireland	40.12	Nicaragua	Nicaragua	81.40
Dom. Rep.	U.K.	233.83	Nicaragua	USA SFR	121.20

Table D.2. Continued

TRADE FLOWS UNDER FREE TRADE			TRADE FLOWS UNDER FREE TRADE		
Source	Destination	Quantity Shipped	Source	Destination	Quantity Shipped
Pak. Bangl.	Pak. Bangl.	427.00	USSR RI	Near East	225.89
Peru	Bol. Chile	332.87	U.K.	U.K.	982.19
Peru	Peru	453.89	Hawaii	Japan	879.01
Peru	USA SFR	41.44	Hawaii	USA HAW	35.01
Philippines	Indonesia	180.46	San Francisco	USA SFR	1706.00
Philippines	Philippines	719.46	New Orleans	Pak. Bang.	527.97
Philippines	Thailand	52.32	New Orleans	USA SFR	424.07
Philippines	Far East	1200.37	New Orleans	USA NOR	308.71
Poland	Netherlands	240.82	New York	USA NY	1170.04
Poland	Poland	1585.99	Puerto Rico	Puerto Rico	136.56
Poland	Sweden	125.65	Puerto Rico	N. Africa	28.97
Poland	E. Europe	525.50	Venezuela	Iceland	9.95
Portugal	Portugal	11.00	Venezuela	Venezuela	478.64
S. Africa	S. Africa	1063.44	Venezuela	N. Africa	98.71
S. Africa	Near East	418.83	E. Europe	E. Europe	1826.00
Spain	Spain	858.00	C. America	USA SFR	162.35
Sweden	Sweden	260.00	C. America	C. America	620.47
Switzerland	Switzerland	77.00	Par/Uruguay	Italy	100.96
Thailand	Thailand	385.72	Par/Uruguay	Par/Uruguay	46.99
Trin/Tob.	Trin/Tob.	47.31	Near East	Near East	103.00
Trin/Tob.	U.K.	228.43	Far East	Far East	119.00
Turkey	Italy	65.32	N. Africa	N. Africa	818.00
Turkey	Turkey	855.76	W. Africa	W. Africa	61.00
USSR RI	Denmark	42.79	N.E. Africa	N.E. Africa	271.00
USSR RI	France	207.58	E. Africa	E. Africa	319.00
USSR RI	Netherlands	43.87	S.C. Africa	Saudi Arabia	46.21
USSR RI	Iran	172.68	S.C. Africa	N.E. Africa	304.18
USSR RI	Norway	191.80	S.C. Africa	E. Africa	110.60
USSR RI	USSR RI	5586.06	S.C. Africa	S.C. Africa	454.02
USSR RI	USSR VL	4303.73	S.W. C. Africa	W. Africa	7.49
USSR RI	U.K.	547.47	S.W.C. Africa	S.W.C. Africa	164.51

All Products, All Markets 77575.2706

Table D.3

TARIFFS USED FOR BENCHMARK SOLUTION

COUNTRY	SPECIFIC TARIFF (CENTS PER POUND)	AD VALOREM TARIFF (PERCENT)
Argentina	0.00	140
Austrailia	0.00	0
Austria	0.00	0
Barbados	0.00	0
Bol. Chile	0.00	5
Brazil	0.00	50
Canada W.	1.77	0
Canada N.E.	1.77	0
Srilanka	0.00	10
China	0.00	0
Taiwan	0.00	0
Colombia	0.00	0
Cuba	0.00	0
Czechoslovakia	0.00	25
Denmark	0.00	20
Dominican Republic	0.00	0
Belgium	0.00	0
France	0.00	0
W. Germany	0.00	0
Netherlands	0.00	0
Italy	0.00	0
Fiji	0.00	0
Finland	0.00	0
E. Germany	0.00	25
Greece	4.00	0
Guatemala	0.00	0
Guyana	0.00	80
Hong Kong	0.00	0
Iceland	0.00	0
India	1.23	0
Indonesia	0.00	25
Iran	7.33	0
Ireland	0.00	0
Jamaica	0.00	0
Japan	5.98	0
Korea	0.00	25
Mauritius	0.00	10
Mexico	0.00	0
New Zealand	0.00	0
Nicaragua	0.00	0
Norway	0.68	0
Pak/Banglasesh	7.45	0
Peru	1.76	92
Philippines	0.00	0
Poland	0.00	25

Table D.3. Continued

TARIFFS USED FOR BENCHMARK SOLUTION

COUNTRY	SPECIFIC TARIFF (CENTS PER POUND)	AD VALOREM TARIFF (PERCENT)
Portugal	3.69	0
Saudi Arabia	0.00	0
Singapore	14.00	0
S. Africa	2.00	0
Spain	0.00	1
Sweden	0.00	0
Switzerland	2.09	0
Thailand	0.00	0
Trin/Tob	0.00	0
Turkey	0.00	150
USSR W.	0.00	5
USSR E.	0.00	5
U.K.	0.00	0
USA Hawaii	0.63	0
USA West	0.63	0
USA South	0.63	0
USA East	0.63	0
Puerto Rico	0.63	0
Venezuela	1.66	0
E. Europe	0.00	25
C. America	0.00	70
Par/Urug	0.00	25
Near East	2.05	0
Far East	0.00	20
N. Africa	0.00	50
W. Africa	0.00	25
NE Africa	0.00	70
E. Africa	2.24	0
SC Africa	0.00	25
SWC Africa	0.00	25

Table D.4. Quota Flows Under Benchmark Solution

Source	Destination		Quantity Shipped
Argentina	USA	New York	77.0000
Australia	USA	NY	343.0000
Barbados	U.K.		103.0000
Barbados	USA	NY	2.0000
Bolchile	USA	NY	6.0000
Brazil	USA	NY	597.0000
Taiwan	USA	NY	80.0000
Colombia	USA	NY	69.0000
Cuba	China		300.0000
Cuba	Czechos		150.0000
Cuba	Egerman		250.0000
Cuba	Korea		120.0000
Cuba	Poland		25.0000
Cuba	USSR		1500.0000
Cuba	E Europe		325.0000
Cuba	Far East		75.0000
Dom. Rep.	USA	NY	671.0000
Fiji	U.K.		142.0000
Fiji	USA	NY	41.0000
Guatemal	USA	NY	56.0000
Guyana	U.K.		209.0000
Guyana	USA	NY	29.0000
India	U.K.		25.0000
India	USA	NY	73.0000
Jamaica	U.K.		271.0000
Mauritiu	U.K.		386.0000
Mauritiu	USA	NY	41.0000
Mexico	USA	NY	578.0000
Nicaragu	USA	NY	70.0000
Peru	USA	NY	370.0000
Philippi	USA	NY	1308.0000
S. Africa	U.K.		86.0000
S. Africa	USA	NY	97.0000
Thailand	USA	NY	17.0000
Trin/Tob	U.K.		133.0000
Trin/Tob	USA	NY	9.0000
Venezuel	USA	NY	28.0000
C. Americ	U.K.		21.0000
C. Americ	USA	NY	289.0000
Par/Urug	USA	NY	6.0000
E. Africa	U.K.		7.0000
S.C. Africa	USA	NY	25.0000

BIBLIOGRAPHY

BIBLIOGRAPHY

Agricultural Stabilization and Conservation Service. (undated). "Returns, Costs and Profits, Florida 1967-69 Crops." U.S. Department of Agriculture, Washington, D.C.

________. (undated). "Returns, Costs and Profits, Hawaiian Sugar Plantations, 1967-69 Crops." U.S. Department of Agriculture, Washington, D.C.

________. (undated). "Returns, Costs and Profits, Louisiana 1969-71 Crops." U.S. Department of Agriculture, Washington, D.C.

Aitchison, J. and Brown, J. A. C. (1954). "A Synthesis of Engel Curve Theory." Review of Economic Studies, 22, (1), pp. 34-46.

Ballinger, R. A. (1971). "A History of Sugar Marketing." Agricultural Economics Report No. 197, U.S. Department of Agriculture, Washington, D.C.

________. (1972). "Economic Behavior in the U.S. Sugar Market." California Agricultural Experiment Station, Bulletin No. 859.

Bates, T. H. (1965). The World Sugar Economy and U.S. Supply Policy. Unpublished Ph.D. Dissertation, University of California, Berkeley.

Berndt, E. R. and Christensen, L. R. (1973). "The Translog Function and the Substitution of Equipment and Labor in U.S. Manufacturing, 1929-1968." Journal of Econometrics, 1, (1), pp. 81-114.

Binswanger, H. (1974). "A Cost-Function Approach to the Measurement of Factor Demand and Substitution." American Journal of Agricultural Economics, 56, (2), (May), pp. 377-386.

Campbell, J. (various). "Returns, Costs and Profits from Sugar Cane Farms." Louisiana State University, Department of Agricultural Economics.

Choudhury, P. (1967). An Economic Appraisal of the Aggregate Sugar Supply Response for Selected Major Producing Countries. Unpublished Ph.D. Dissertation, University of Hawaii.

Christensen, L. R., Jorgenson, D. W. and Lau, L. J. (1971). "Conjugate Duality and the Transcendental Logarithmic Production Function." Econometrica, 39, (4), (July), pp. 255-256.

Comité Européen des Fabricants de Sucre. (annual). Recueil Annuel de Statistiques. Paris: Comité Européen des Fabricants de Sucre, 45 Avenue Montaigne.

Commodity Research Bureau Inc. (1974). Commodity Yearbook. New York: Commodity Research Bureau, Inc.

Compagnie Financiére Sucres et Denrées. (1974). The Rise of Sugar Prices: Its Effect on Consumption. Paris: Compagnie Financiére Sucres et Denrées.

Council on Wage and Price Stability. (1975). Staff Report on Sugar Prices. Office of Wage Price Monitoring, Washington, D.C.: Government Printing Office.

De Leeuw, F. (1962). "The Demand for Capital Goods by Manufacturers: A Study of Quarterly Time Series." Econometrica, 30, (3), (July), pp. 407-423.

Durbin, J. (1970). "Testing for Serial Correlation in Least-Squares Regression when Some of the Regressors are Lagged Dependent Variables." Econometrica, 38, (3), (May), pp. 410-421.

Egbert, A. C. and Kim, H. M. (1975). "Analysis of Aggregation Errors in L. P. Models." American Journal of Agricultural Economics, 57, (2), (May), pp. 292-301.

European Economic Community. (1974). Agricultural Markets, No. 8, Brussels: E.E.C.

European Economic Community Statistical Office. (undated). Enquete sur la Structure des Exploitations Agricoles, 1966/67. Luxemburg: E.E.C. Statistical Office.

Fan, C. L. (1967). Determination of Sugar Supply Functions for Taiwan. Unpublished Ph.D. Dissertation, University of Hawaii.

Griliches, Z., Maddala, R., Lucas, R. and Wallace, N. (1962). "Notes on Estimate Aggregate Quarterly Consumption Functions." Econometrica, 30, (3), pp. 491-500.

Griliches, Z. (1967). "Distributed Lags: A Survey." Econometrica, 35, (1), (Jan.), pp. 16-49.

Gupta, Y. P. (1969). "Least Squares Vàriant of the Dhrymes Two-Step Estimation Procedure of the Distributed Lag Model." International Economic Review, 10, (1), pp. 112-113.

Harris, S. and Smith, I. (1973). World Sugar Markets in a State of Flux. London: Trade Policy Research Centre.

Hayami, Y. and Ruttan, V. W. (1971). Agricultural Development: An International Perspective. Baltimore: Johns Hopkins Press.

Hayenga, M. (1967). "Sweetener Competition and Sugar Policy." Journal of Farm Economics, 49, (4), (Dec.), pp. 1362-1366.

Hee, O. (1958). "The Effect of Price on Acreage and Yield of Potatoes." Agricultural Economics Research, 10, (4), (Oct.) pp. 131-141.

Henderson, J. and Quandt, R. (1958). Microeconomic Theory. New York: McGraw-Hill.

Hoch, I. (1958). "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function." Econometrica, 26, (3), (Oct.), pp. 566-578.

Hughes, H. (1971). Analysis of Sugar Cane Production in Sao Paulo. Unpublished Ph.D. Dissertation, University of Missouri, Columbia.

Ilag, L. M. (1970). An Econometric Analysis of the Impact of the U.S. Sugar Program on the Philippine Sugar Industry. Unpublished Ph.D. Dissertation, Purdue University.

Ingersent, K. A. (1975). "Sugar Prices and Stocks." Journal of Agricultural Economics, 26, (2), (May), pp. 227-238.

International Customs Tariff Bureau. (various). International Customs Journal. Brussels: I.C.T.B.

International Labor Office. (various). Bulletin of Labor Statistics. Geneva: United Nations International Labor Office.

International Monetary Fund. (various). International Financial Statistics. Washington, D.C.: International Monetary Fund.

International Sugar Council. (1963). The World Sugar Economy: Structure and Policies. London: International Sugar Council (now Organization), 28 Haymarket, S.W.1

International Sugar Organization. (annual). Sugar Yearbook. London: International Sugar Organization, 28 Haymarket, S.W.1.

Johnson, D. Gale. (1974). The Sugar Program: Large Costs and Small Benefits. Washington, D.C.: American Enterprise Institute.

Johnson, G. L. and Quance, L. (1972). The Overproduction Trap in U.S. Agriculture. Baltimore: Johns Hopkins Press for Resources for the Future, Inc.

Johnson, H. G. (1966). Economic Policies Towards Less Developed Countries. New York: Brookings Institution.

Josling, T. E. (1969). "A Formal Approach to Agricultural Policy." Journal of Agricultural Economics, 20, (2), (May), pp. 175-192.

Just, R. E. (1974). Econometric Analysis of Production Decisions with Government Intervention: The Case of California Field Crops. Monograph No. 33, Giannini Foundation, California Agricultural Experiment Station.

King, R. A. and Ho, F. S. (1972). Reactive Programming: A Market Simulating Spatial Equilibrium Algorithm. Economics Research Report No. 21, Department of Economics, North Carolina State University.

Klein, L. R. (1953). A Textbook of Econometrics. New York: Row, Peterson and Company.

Kmenta, J. and Joseph, M. E. (1963). "A Monte-Carlo Study of Alternative Estimates of the Cobb-Douglas Production Function." Econometrica, 31, (3), (July), pp. 363-385.

Kmenta, J. (1964). "Some Properties of Alternative Estimates of the Cobb-Douglas Production Function." Econometrica, 32, (1), (Jan.), pp. 183-188.

________. (1971). Elements of Econometrics. New York: Macmillan.

Licht, F. O. (various). International Sugar Newsletter. Ratzeburg, West Germany: F.O. Licht.

Mundlak, Y. (1961). "Empirical Production Function Free of Management Bias." Journal of Farm Economics, 41, (1), (Feb.), pp. 45-56.

Nerlove, M. (1958). The Dynamics of Supply: Estimation of Farmers' Response to Price. Baltimore: Johns Hopkins Press.

Organization for Economic Cooperation and Development. (1973). Supply Control in Agriculture. Paris: O.E.C.D.

Oury, B. (1966). A Model for Wheat and Feedgrains in France. Amsterdam: North Holland Publishing Company.

Pignalosa, F. (1974). Personal Communication. F.A.O.: Rome.

Pringle, G. E. (1969). A Temporal-Spatial Analysis of Sugar Production and Marketing in Puerto Rico. Unpublished Ph.D. Thesis, University of Wisconsin.

Ramsey, J. B. (1972). "Limiting Functional Forms for Market Demand Curves." Econometrica, 40, (2), pp. 327-341.

_______. (1973). "Classical Model Selection through Specification Error Tests." In Zarembka, P. ed. Frontiers in Econometrics. New York: Academic Press.

_______. (1974). "Limiting Functional Forms for Demand Functions: Tests of Some Specific Hypotheses." Review of Economics and Statistics, 56, (4), (Nov.), pp. 468-477.

Samuelson, P. A. (1952). "Spatial Equilibrium and Linear Programming." American Economic Review, 42, (3), (June), pp. 283-303.

Sanchez, N. (1972). The Economics of Sugar Quotas. Unpublished Ph.D. Dissertation, University of Southern California.

Smith, V. L. (1963). "Minimization of Economic Rent in Spatial Price Equilibrium." Review of Economic Studies, 30, (1), (Feb.), pp. 24-31.

Snape, R. H. (1969). "Sugar: Costs of Protection and Taxation." Economica, 36, (141), (Feb.), pp. 29-41.

Storr, N. and Warnken, P. (1974). The Location of Sugarbeet Production in the U.S. Unpublished manuscript, University of Missouri, Columbia.

Sturrock, F. G. (1969). "Sugar Beet or Sugar Cane." Journal of Agricultural Economics, 20, (1), (Jan.), pp. 125-132.

Storrock, F. G. and Thompson, M. C. (1972). "Sugarbeet: A Study of Sugar Production in the U.K. and Feasibility of Expansion." Economic Report No. 7, Department of Land Economy, Cambridge Univeristy.

Takayama, T. and Judge, G. G. (1964). "Spatial Equilibrium and Quadratic Programming." Journal of Farm Economics, 46, (1), (Feb.), pp. 67-93.

Thomas, G. B. (1968). Calculus and Analytic Geometry. Reading, Mass.: Addison Wesley.

Tramel, T. E. and Seale, A. D. (1963). "Reactive Programming Techniques." In Interregional Competition Research Methods Workshop. North Carolina State University, January 10-11.

United Nations. (1974). Demographic Yearbook. New York: United Nations.

_______. (1975). Yearbook of National Accounts Statistics, 1973. New York: United Nations.

United Nations Food and Agriculture Organization. (1971). Agricultural Commodity Projections, 1970-1980. Rome: U.N.F.A.O.

United Nations Food and Agriculture Organization. (annual). Production Yearbook. Rome: U.N.F.A.O.

U.S. Agency for International Development. (1974). Gross National Product: Growth Rates and Trend Data. Washington, D.C.: U.S.A.I.D.

U.S. Department of Agriculture. (various). Sugar Statistics and Related Data. Vol. 1 and 2. Washington, D.C.: U.S.D.A.

United States Naval Oceanographic Office. (1964). Distances Between Ports. Washington, D.C.: U.S. Government Printing Office.

Viton, A. and Pignalosa, F. (1961). Trends and Forces of World Sugar Consumption. Commodity Bulletin No. 32, United Nations Food and Agriculture Organization, Rome.

Walter, B. J. (1972). The Wholesale Pricing System for Sugar. Unpublished Research Report, University of California, Berkeley.

________. (1973). "Sweetener Economics." Paper presented at the 165th National Meeting of the American Chemical Society, Dallas, Texas, April 8-13, 1973.

Waugh, F. V. (1964). "Cobweb Models." Journal of Farm Economics, 46, (4), (Nov.), pp. 732-750.

Weather Bureau. (1964). Climatic Summary of the United States. Washington, D.C.: U.S. Department of Commerce.

Weymar, F. H. (1968). The Dynamics of the World Cocoa Market. Cambridge, Massachusetts: M.I.T. Press.

Young, K. H. (1969). Demand for Sugar in the United States: A Synthesis of Time Series and Cross Section Analysis. Unpublished Ph.D. Dissertation, Columbia University.

Zellner, A., Kmenta, J. and Dreze, J. (1965). "Specification and Estimation of Cobb-Douglas Production Function Models." Econometrica, 33, (4), pp. 784-795.

Zellner, A. and Revankar, N. S. (1969). "Generalized Production Functions." Review of Economic Studies, 36, (2), (April), pp. 241-250.

Zusman, P., Melamed, A., and Katzir, I. (1969). Possible Trade and Welfare Effects of EEC Tariff and Reference Price Policy on the European-Mediterranean Market for Winter Oranges. Giannini Foundation Monograph No. 24, California Agricultural Experiment Station.