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A Spatial Equilibrium Analysis of the World Sugar Economy

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CALIFORNIA AGRICULTURAL EXPERIMENT STATION

The major purpose of this study is to calculate the long-run price and trade effects of the United States embargo on Cuban sugar. Prior to the embargo, more than one-third of the sugar consumed in the United States was imported from Cuba. In pursuing this objective, this study determines whether, after the Cuban crisis, the United States chose the lowest cost source of sugar available.

For analytical purposes, this study uses the transportation and spatial price equilibrium models. The data used are sugar demand and supply relationships for consuming and producing regions and sugar shipping costs. The world sugar economy is divided into 42 regions for the transportation models and 34 regions for the spatial price models.

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A SPATIAL EQUILIBRIUM ANALYSIS OF THE WORLD SUGAR ECONOMY[1, 2, 3]

INTRODUCTION

AN ABRUPT CHANGE in the pattern of international trade in sugar occurred in the latter part of 1960. The world's largest importer of sugar, the United States, placed an embargo on shipments from its largest single supplier, Cuba. Since that time, no Cuban sugar has legally entered the United States. This embargo brought to an end a sizeable trade which had flourished since before the turn of the century.

As a result of severing imports from Cuba, United States officials have expressed concern about the future availability of sugar to satisfy domestic consumption requirements. Questions that have been raised include the following: Are domestic sugar prices likely to increase substantially? Will Cuba's increased sugar trade with the Communist countries alter the supply patterns of the major consuming centers in general and of the United States in particular? To what extent will sugar production increase in the United States? Has the cost of sugar imports to the United States increased? Did the Cuban embargo create large inefficiencies in the world sugar economy? How economically efficient is the world sugar economy and its various segments?

This study uses alternative spatial international trade models to answer these questions. Its specific objectives are:

1. Summarize data on world sugar production, consumption, and trade in recent years.
2. Estimate the per unit cost of transporting sugar in ocean-going vessels.
3. Calculate the total transportation cost for sugar traded in 1959 and 1963.
4. Ascertain the optimal trade pattern for these years.
5. Compute the inefficiencies in the world sugar economy.
6. Determine the actual interregional price structure in the world sugar economy in 1959 and 1963.
7. Predict 1970 sugar prices, production, consumption, and trade flows.
8. Determine whether, after the Cuban crisis, the United States chose the lowest cost source of sugar available.
9. Calculate the long-run price and trade effects of the United States embargo on Cuban sugar.

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[2] This study has been financed under regional project RRF-2229 (WM-51), "Economic Factors Affecting Sugar Marketing."

[3] The results of this study were initially presented by Bates (1966), and a summary of the findings was published by Bates (1967).

WORLD PRODUCTION, CONSUMPTION, AND TRADE IN SUGAR, 1957–1959 AND 1962–1964

Average production, exports, imports, and consumption of sugar for two three-year periods, 1957–1959 and 1962–1964, are summarized in tables 1 and 2.[4] The world sugar economy is divided into major production and consumption regions.

World production, exports, imports, and consumption of sugar increased considerably between the time period 1957–1959 and 1962–1964. Production increased from 46.9 to 54.7 million metric tons; and exports, from 15.2 to 19.6 million metric tons. The latter change appears to be primarily because of increases in world population and income.

Regardless of the years considered, the major areas of production are located in Eastern Europe and Central America. The largest single producer in each of these areas is the Soviet Union and Cuba, respectively. Likewise, there are only two major sugar consumers: the United States, followed by the Soviet Union. The remaining consumption is not centered in any one region. Also, tables 1 and 2 indicate that, with one exception, exports and imports are not geographically concentrated. By far the world's largest sugar exporter is Cuba, and the largest importer is the United States.

The ten largest sugar-producing and consuming countries for 1957–1959 and 1962–1964 are given in table 3. The ten leading producers in both periods were the same, except that Mainland China replaced the Philippines in the 1962–1964 period. The leading ten producers in 1957–1959 accounted for 25.9 million metric tons, which is 55.2 per cent of the world total production of 46.9 million metric tons. In 1962–1964 these countries produced 29.8 million metric tons, or 54 per cent of the 54.7 million metric ton total. The leading five producers were Cuba, U.S.S.R., Brazil, United States, and India.

In 1957–1959 the leading ten consumers accounted for 27.3 million metric tons of the 46.9 million metric ton total, or 58.2 per cent. For 1962–1964 these regions consumed 33.5 million metric tons, or 61.2 per cent of the 54.7 million metric ton total. In each time period, the five leading consuming areas were the United States, U.S.S.R., United Kingdom, India, and Brazil.

Table 4 summarizes the imports and exports of the ten major countries for 1957–1959 and 1962–1964. These ten countries in 1957–1959 imported 10.7 million metric tons, or 70.7 per cent of the total world imports of 15.2 million metric tons. In 1962–1964 they accounted for 13.9 million metric tons, which is 70.8 per cent of the 19.6 million metric ton total. In 1957–1959 the leading five importers were the United States, United Kingdom, Japan, Canada, and France. For 1962–1964 the U.S.S.R. replaced France as one of the top five importers.

The leading ten exporters made up 74.4 and 60.7 per cent, respectively, of the world exports for 1957–1959 and 1962–1964. These were 11.3 and 11.9 million metric tons of the world totals of 15.2 and 19.6 million metric tons. The leading five exporters, in order of im-

[4] Although sugar is available in several forms and from several sources (for example, sucrose, maple sugar, and starch), this study deals only with sucrose derived from (1) sugar cane (primarily a tropical and subtropical plant) and (2) sugar beets (a middle-latitude plant). The sugar cane or beet is processed whereby juice is extracted from the original product, boiled, and put through whirling centrifuges to obtain raw sugar that is about 97½ per cent pure sugar. It is then sent to the refinery where the raw sugar is diluted, filtered, and again put through centrifuges to remove the remaining impurities. This final product is refined sugar.

TABLE 1

AVERAGE PRODUCTION, EXPORTS, IMPORTS, AND CONSUMPTION OF SUGAR MAJOR COUNTRIES OF THE WORLD, 1957–1959

Region and country	Three-year average, 1957–1959			
	Production*	Exports	Imports	Consumption
	metric tons, raw value			
Europe	16,915,825	2,589,200	5,664,371	18,823,702
Western Europe	6,980,006	1,525,761	4,891,811	9,836,178
Finland	38,740	0	165,326	191,352
France	1,385,639	498,600	532,121	1,456,651
West Germany	1,621,750	17,276	291,873	1,662,576
Italy	1,117,881	128,393	45,822	965,260
Netherlands	486,892	39,616	234,751	596,562
Switzerland	35,936	3,213	219,450	249,720
United Kingdom	757,000	656,000	2,825,000	2,843,000
Other Western Europe†	1,536,168	182,663	577,468	1,871,057
Eastern Europe	9,935,819	1,063,439	772,561	8,987,522
East Germany	783,700	198,150	2,300	565,667
U.S.S.R.	5,565,000	215,281	466,826	5,380,500
Other Eastern Europe‡	3,557,119	650,008	303,435	3,041,355
North America	2,621,799	8,931	4,820,783	8,992,347
United States	2,478,135	8,146	4,158,745	8,206,259
Canada	143,664	785	662,038	786,088
Central America	10,156,578	7,107,546	29,630	1,862,462
Cuba	5,806,585	5,296,829	0	292,194
Dominican Republic	827,449	726,604	0	71,038
Puerto Rico and Virgin Islands (United States)	921,401	(820,731)§	(3,667)	99,667
Mexico	1,274,025	138,616	5,975	1,016,151
Other	1,327,119	945,496	23,655	383,413
South America	5,508,312	1,446,012	389,389	4,109,896
Brazil	2,941,993	596,881	0	2,130,651
Other	2,566,319	849,131	389,389	1,979,245
Asia	6,784,382	2,139,179	2,923,388	7,567,351
Mainland China	1,008,000	50,033	113,300	1,083,333
Taiwan	920,822	770,735	0	117,204
India	2,235,700	77,417	0	2,255,610
Japan	113,988	12,341	1,178,587	1,244,931
Philippines	1,272,164	970,135	0	300,183
Other	1,233,709	258,518	1,031,500	2,566,090
Africa	2,539,830	1,141,746	1,217,308	2,517,232
Union of South Africa	943,960	189,872	0	684,032
Other	1,595,870	951,874	1,217,308	1,833,200
Oceania	2,392,894	878,417	118,776	742,531
Australia	1,320,766	696,557	0	562,743
Hawaiian Islands	854,034	(798,294)	0	36,000
Other	218,095	181,860	118,776	143,788
World total	46,919,620	15,163,645	15,163,645	46,919,620

* Production plus imports does not necessarily equal imports plus consumption due to changes in stocks.
† Belgium-Luxemburg, Denmark, Greenland, Gibraltar, Iceland, Ireland, Malta, Norway, Portugal, Spain, and Sweden.
‡ Albania, Austria, Bulgaria, Cyprus, Czechoslovakia, Greece, Hungary, Poland, Rumania, Turkey, and Yugoslavia.
§ Figures in parentheses not included in world totals; figures denote trade between United States and its insular areas.
SOURCE: Computed from International Sugar Council, 1961, 1967.

TABLE 2

AVERAGE PRODUCTION, EXPORTS, IMPORTS, AND CONSUMPTION OF SUGAR MAJOR COUNTRIES OF THE WORLD, 1932-1964

Region and country	Three-year average, 1962–1964			
	Production*	Exports	Imports	Consumption
	metric tons, raw value			
Europe	20,081,986	3,826,420	7,392,693	23,225,687
Western Europe	8,303,773	1,586,044	4,760,248	11,357,343
Finland	53,141	0	151,944	197,805
France	1,983,060	763,714	445,028	1,633,659
West Germany	1,876,675	18,071	210,494	1,895,119
Italy	998,853	3,665	308,384	1,304,471
Netherlands	506,508	16,475	199,742	706,392
Switzerland	43,525	3,499	224,782	254,667
United Kingdom	828,000	423,999	2,443,177	2,890,666
Other Western Europe†	2,014,011	356,621	776,697	2,474,564
Eastern Europe	11,778,212	2,240,377	2,632,445	11,868,342
East Germany	754,350	210,765	215,567	564,101
U.S.S.R.	6,714,333	750,970	1,837,864	7,838,894
Other Eastern Europe‡	4,309,529	1,278,642	579,014	3,465,347
North America	3,611,730	28,376	6,423,317	9,813,484
United States	3,462,978	3,272	5,671,137	8,942,317
Canada	148,752	25,104	752,180	871,166
Central America	9,631,554	7,477,686	19,890	2,437,581
Cuba	4,408,600	4,275,832	0	410,177
Dominican Republic	844,393	726,167	0	113,266
Puerto Rico and Virgin Islands (United States)§	903,180	778,134	0	106,363
Mexico	1,732,769	416,225	0	1,328,378
Other	1,742,611	1,281,328	19,890	479,396
South America	6,330,761	1,409,808	238,550	5,108,134
Brazil	3,222,085	410,272	0	2,729,050
Other	3,108,676	999,536	238,550	2,379,084
Asia	8,619,319	2,939,705	3,948,263	9,783,242
Mainland China	1,700,000	343,576	617,647	1,973,333
Taiwan	794,766	702,333	0	122,660
India	2,790,544	386,534	0	2,666,099
Japan	346,021	1,145	1,357,008	1,652,032
Philippines	1,581,698	1,111,309	0	449,172
Other	1,406,291	394,808	1,973,608	2,919,946
Africa	3,205,240	1,714,732	1,420,438	2,987,123
Union of South Africa	1,225,321	559,501	14,924	714,784
Other	1,979,919	1,155,231	1,405,514	2,272,339
Oceania	3,227,183	2,500,429	147,236	845,492
Australia	1,910,186	1,265,546	0	644,514
Hawaiian Islands	1,027,226	976,532	0	38,664
Other	289,771	258,352	147,236	162,314
World total	54,707,774	19,590,387	19,590,387	54,707,774

* Production plus imports does not necessarily equal imports plus consumption due to changes in stocks.
† Belgium-Luxemburg, Denmark, Greenland, Gibraltar, Iceland, Ireland, Malta, Norway, Portugal, Spain, and Sweden.
‡ Albania, Austria, Bulgaria, Cyprus, Czechoslovakia, Greece, Hungary, Poland, Rumania, Turkey, and Yugoslavia.
§ Data source does not distinguish between United States, insular, and other areas as in table 1.
SOURCE: Computed from International Sugar Council, 1961, 1967.

TABLE 3
TEN LARGEST SUGAR PRODUCERS AND CONSUMERS
1957–1959 AND 1962–1964

Production (three-year average)				Consumption (three-year average)			
1957–1959		1962–1964		1957–1959		1962–1964	
Region	Production	Region	Production	Region	Consumption	Region	Consumption
1,000 metric tons, raw value							
1. Cuba	5,807	1. U.S.S.R.	6,714	1. United States	8,206	1. United States	8,942
2. U.S.S.R.	5,595	2. Cuba	4,407	2. U.S.S.R.	5,381	2. U.S.S.R.	7,839
3. Brazil	2,942	3. United States	3,463	3. United Kingdom	2,843	3. United Kingdom	2,891
4. United States	2,478	4. Brazil	3,222	4. India	2,256	4. Brazil	2,729
5. India	2,236	5. India	2,791	5. Brazil	2,131	5. India	2,666
6. West Germany	1,622	6. France	1,983	6. West Germany	1,663	6. Mainland China	1,973
7. France	1,386	7. Australia	1,910	7. France	1,457	7. West Germany	1,895
8. Australia	1,321	8. West Germany	1,877	8. Japan	1,242	8. Japan	1,652
9. Mexico	1,274	9. Mexico	1,733	9. Mainland China	1,083	9. France	1,634
10. Philippines	1,272	10. Mainland China	1,700	10. Mexico	1,016	10. Mexico	1,328
Total	25,933		29,800		27,278		33,549

SOURCE: Calculated from tables 1 and 2.

portance, for 1957–1959 were Cuba, the Philippines, the Virgin Islands, the Hawaiian Islands, and Taiwan. In 1962–1964 Cuba was still the largest exporter but is followed by Australia, the Philippines, the Hawaiian Islands, and the Virgin Islands.

The international sugar market is divided into two parts. "Free market" trade consists of all sugar trade except the following flows which are defined as "nonfree market."

1. Internal movements between overseas territories and their mother countries (with the exception of those between the United Kingdom and her dependencies).
2. Exports of foreign countries to the United States.
3. Exports of Czechoslovakia, Hungary, and Poland to the U.S.S.R.

Appendix table 1, Part A, yields the following conclusions regarding nonfree market trade:

1. Total trade outside the free market from 1954 to 1962 averaged about 7 million metric tons, or about 38.9 per cent of total world exports.
2. Trade outside the free market declined relatively, dropping from 43.2 per cent of the total world exports in 1954 to 31.4 per cent in 1961, despite the fact that this trade rose in absolute terms from 6.6 million metric tons in 1954 to 7.2 million metric tons in 1962.
3. Exports under internal movements averaged 2.7 million metric tons from 1954 to 1962 (equivalent to 39.3 per cent of all the exports outside the free market and 15.3 per cent of total world exports). Their

TABLE 4

TEN LARGEST SUGAR IMPORTERS AND EXPORTERS
1957–1959 AND 1962–1964

Imports (three-year average)				Exports (three-year average)			
1957–1959		1962–1964		1957–1959		1962–1964	
Region	Imports	Region	Imports	Region	Exports	Region	Exports
1,000 metric tons, raw value							
1. United States	4,159	1. United States	5,671	1. Cuba	5,297	1. Cuba	4,276
2. United Kingdom	2,825	2. United Kingdom	2,443	2. Philippines	970	2. Australia	1,266
3. Japan	1,179	3. U.S.S.R.	1,838	3. Virgin Islands*	821	3. Philippines	1,111
4. Canada	662	4. Japan	1,357	4. Hawaiian Islands	798	4. Hawaiian Islands	977
5. France	532	5. Canada	752	5. Taiwan	771	5. Virgin Islands*	778
6. U.S.S.R.	467	6. Mainland China	618	6. Dominican Republic	727	6. France	764
7. West Germany	292	7. France	445	7. Brazil	597	7. U.S.S.R.	751
8. Netherlands	235	8. Italy	308	8. France	499	8. Dominican Republic	726
9. Switzerland	219	9. Switzerland	225	9. Peru	469	9. Taiwan	702
10. Finland	165	10. East Germany	216	10. Czechoslovakia	342	10. Union of South Africa	556
Total	10,735		13,873		11,291		11,907

* Includes Puerto Rico.
SOURCE: Calculated from tables 1 and 2.

relative share in trade outside the free market dropped from 42.7 to 38.3 per cent and that in world trade from 18.4 to 13.5 per cent during this period.

4. Movements between the United States offshore areas and the United States mainland were far and away the most important of all internal movements, accounting for 65.2 per cent of the total. Second in importance was trade within the French community at 27.9 per cent, and third was that trade between Portuguese overseas provinces to Portugal, at 5 per cent.

In the period 1954–1962, the free-market trade averaged 10.9 million metric tons, or 61.1 per cent of total world trade. By definition, all trade between dependent and independent territories and countries of the British Commonwealth is part of the free market. However, a rather large part of this trade is subject to regulation under the Commonwealth Sugar Agreement and, as such, is subject to special conditions. Exports under this agreement, in the period 1954–1962, averaged 21.1 per cent of free market and 12.9 per cent of world exports. The balance of free-market trade constitutes a "residual" free-trade market; its share of free-market exports amounted to 74.5 per cent in 1954 and 83.3 per cent in 1962, averaging 78.9 per cent over this period. The residual market share in total world exports was 42.3 per cent in 1954 and 54.1 per cent in 1962, averaging 48.2 per cent over the period.

From 1954 to 1961 the free-market trade was regulated by the 1953 and 1958 International Sugar Agreements,

while trade outside the free market was not subject to the provisions of these agreements. Aside from the United States market, the markets of the French community and of Portugal are the only ones of those excluded from the provisions of the International Sugar Agreements that are comprehensively regulated. The policies regulating the United States trade in sugar are examined in detail at the conclusion of this study.

ANALYTICAL FRAMEWORK

This study uses two specific types of spatial equilibrium models to analyze international trade in sugar—the transportation and spatial price equilibrium models. Such models determine the most efficient sugar trade patterns and, therefore, provide a norm against which to compare the inefficiencies associated with the actual politically determined trade patterns discussed above.[5]

Transportation model

The spatial transportation model determines the minimum transportation cost of shipping commodities among countries.[6] Regional production and consumption requirements are given in the model and are, therefore, not specified to be a function of such factors as price and income. Given regional production and consumption, exports and imports, and shipping costs, the model determines a trade pattern which minimizes total transportation costs. From this minimum cost trade pattern, relative regional prices can be determined. These prices differ by the matrix of transportation costs specified among regions.

Spatial price model

The partial equilibrium analysis developed by Samuelson (1952), provides the basis for this model.[7] It contains three essential components—a transfer cost matrix, regional demand equations, and regional supply equations. Therefore, it differs from the transportation model in that regional production and consumption are endogenous to the analysis.

The model can be expressed in mathematical notation as follows:

Let:

$$\begin{aligned}
\text{Subscript } i &= \text{the producing area } (i = 1, \cdots, n)\\
\text{Subscript } j &= \text{the consuming area } (j = 1, \cdots, m)\\
Q_i^s &= \text{quantity produced in area } i\\
Q_j^c &= \text{quantity consumed in area } j\\
S_{ij} &= \text{quantity shipped from area } i \text{ to area } j\\
TC_{ij} &= \text{transfer cost from area } i \text{ to area } j
\end{aligned}$$

[5] The use of models to provide a standard against which to compare the actual economic performance of an industry is not new. See, for example, Henderson (1958).

[6] The transportation model has had numerous empirical applications. For examples, see Henry and Bishop (1957) or Bawden, *et al.* (1966). The programming algorithm used in this study to determine the minimum total transportation costs, given the amount of sugar traded, is similar to that used by the previous authors.

[7] Three examples which have used the spatial price framework in empirical research are King and Schrader (1963); Bawden, *et al.* (1966); and Dean and Collins (1967). To empirically determine the unknowns of the model—equilibrium production, consumption, shipping patterns, and prices for each region—the above authors use an algorithm similar to that outlined by Dean and Collins (1967, pp. 25 and 26). This algorithm is also used in this study. However, it is not the only means available for obtaining spatial price equilibrium solutions. Considerable emphasis has recently been given to the Takayama-Judge (1964) approach. For examples of empirical works which have used their method of solutions, see Bjarnason (1967) or Schmitz (1968).

P_i = producer price in area i

and

W_j = wholesale price in area j.

Given

$$Q_i^s = f(P_i/\cdot\ \cdot\ \cdot)$$

$$Q_j^c = f(W_j/\cdot\ \cdot\ \cdot)$$

$$TC_{ij}$$

find for a given time period

Q_i^s for all i (area production)
Q_j^c for all j (area consumption)
S_{ij} for all i and j

which minimizes

$$\sum_{i=1}^{n} \sum_{j=1}^{m} S_{ij}\, TC_{ij}$$

subject to

$$S_{ij} \geqq 0$$

$$Q_i^s = \sum_{j=1}^{m} S_{ij}$$

$$Q_j^c = \sum_{i=1}^{n} S_{ij}$$

$$\sum_{i=1}^{n} Q_i^s = \sum_{j=1}^{m} Q_j^c.$$ [8]

In essence, the spatial price model determines for each trading region equilibrium prices, production, consumption, and trade flows. These are based on estimates of supply and demand equations, transfer costs among regions, and policy considerations. The supply and demand estimates for sugar and other data included in the model are presented at a later point.

While supply and demand estimates and transfer costs for each region are the basic data of the model, policy considerations can also be taken into account. The procedure for incorporating price supports, tariffs, and other policies into the model is discussed by Bawden (1966). An empirical study using the spatial approach, which incorporates governmental policies including bilateral trade agreements, is that by Schmitz (1968).

To what extent the spatial price equilibrium model is predictive depends on the data used. For example, to predict sugar prices and trade flows for 1980, it is necessary to project the estimated supply and demand equations and transportation costs to that year. In this study the estimated regional supply and demand equations for sugar and transfer costs are projected to 1970. Therefore, regional sugar prices, consumption, production, and trade are predicted for that year.

Alternative Sugar Models

Within the framework of the two previous spatial models, this study develops five specific models to analyze the world sugar economy. These models differ principally in the length of time under consideration and the assumptions made concerning the producing and consuming activities. However, all five models assume (1) spatially separated markets; (2) constant storage levels for sugar; (3) a single product, raw sugar; and (4) competitive shipping activities. Also, regardless of the model used, it is necessary to specify for each region a production and consumption center. These represent the production and con-

[8] The spatial equilibrium model has alternative mathematical formulations. The recent work by Takayama and Judge (1964) maximizes "net social payoff." This is referred to by Samuelson (1952) as the area under the excess supply curves which can be derived from standard spatial analysis.

sumption activities of each region and form the basis from which to compute shipping costs. In all the models, the transportation costs used as data are the same.

Ex-post models

Two of the five models developed for the world sugar economy use the transportation framework in which regional supplies and demands are given. These two models differ in the emphasis given to studying the efficiency of the United States sugar economy. However, the problem common to each is to determine a trade pattern which satisfies all regional imports and minimizes total transportation costs.

These models are used for the following specific purposes:

1. To measure the efficiency of the world sugar trade in 1959 and 1963.
2. To determine which of the world sugar trading blocs is most efficient.
3. To evaluate what inefficiencies the United States embargo on Cuban sugar introduced into the world sugar economy.
4. To determine how this embargo affected the cost of United States sugar imports.[9]

Ex-ante models

Three of the five models developed use the spatial price equilibrium framework in which supply and demand are endogenously determined. Also, these models predict prices, consumption, production, and trade flows for each sugar region to 1970. They differ in the supply equations used and the restrictions placed on international trade. The first model assumes that the supply response in each region is perfectly price elastic. The second relaxes this assumption and predicts prices and trade flows allowing the United States to trade with Cuba. In the last model, trade between these two countries is assumed to be nonexistent.

The ex-ante models serve the following purposes:

1. To predict 1970 sugar prices, production, consumption, and trade for each sugar region.
2. To determine the transportation and pricing inefficiencies created by the United States embargo on Cuban sugar.
3. To determine if the United States imports sugar from the lowest cost sources available, both including and excluding trade with Cuba.
4. To study the economic rationale of the current and future United States sugar import quotas.

DATA COMPONENTS OF THE MODELS

The data needed to empirically apply the models previously discussed are (1) a delineation of the world sugar economy into producing and consuming regions, (2) transportation costs for shipping sugar among regions, (3) sugar demand functions by regions, and (4) area supply relationships for sugar production. These are discussed in order.

Demand and Supply Regions

The delineation of the world sugar economy into regions is geographical rather than political. In the transportation models, the world sugar economy is divided into 42 regions. These are presented in table 5 along with the corre-

[9] In using the transportation framework, "efficiency" relates to a specific trade pattern. The most efficient trade pattern is one which satisfies regional consumption requirements and minimizes total trade shipping costs.

TABLE 5

WORLD SUGAR REGIONS AND THEIR REPRESENTATIVE CENTERS

Supply areas for transportation models	Representative center	Supply areas for spatial price models	Representative center
1. Northwestern Europe	Oslo	1. Northwestern Europe	Oslo
2. United Kingdom	London	2. Western Europe	London
3. France	Bordeaux	3. North Central Europe	Danzig
4. Portugal	Lisbon	4. South Central Europe	Trieste
5. Other Western Europe	Antwerp	5. Northern and South Central Europe	Trieste
6. North Central Europe	Danzig	6. Soviet Union	Odessa
7. South Central Europe	Trieste	7. United States	New York
7a. North and South Central Europe	Trieste	8. Canada	Montreal
8. Soviet Union	Odessa	9. Central America and Caribbean	Santo Domingo
9. United States	New York	10. Cuba	Havana
10. Canada	Montreal	11. Western South America	Callao
11. Mexico	Santo Domingo	12. Eastern South America	Recife
12. Jamaica	Kingston	13. Northwestern Middle East	Izmir
13. Martinique	Point a Pitre	14. Western Middle East	Al Basrah
14. Puerto Rico	San Juan	15. Middle East	Colombo
15. Cuba	Havana	16. Northern Far East	Yokohama
16. Western South America	Callao	17. Northern Middle Far East	Shanghai
17. Eastern South America	Recife	18. Taiwan	Tanshui
18. Northwestern Middle East	Izmir	19. Middle Far East	Penang
19. Western Middle East	Al Basrah	20. Philippines	Manila
20. Middle East	Colombo	21. Southern Far East	Djakarta
21. Northern Far East	Yokohama	22. South Africa	Durban
22. Northern Middle Far East	Shanghai	23. Central Africa	Mombasa
23. Taiwan	Tanshui	24. Eastern North Africa	Port Said
24. Middle Far East	Penang	25. Southwestern North Africa	Lagos
25. Philippines	Manila	26. Northwestern North Africa	Casablanca
26. Southern Far East	Djakarta	27. Indian Ocean	Port Louis
27. Angola	L. Marquez	28. Australia	Brisbane
28. Madagascar	Matunga	29. Fiji Islands	Suva
29. Other South Africa	Durban	30. New Zealand	Wellington
30. Central Africa	Mombasa	31. Hawaiian Islands	Honolulu
31. Eastern North Africa	Port Said	32. Southern Oceania	Papeete
32. Southwestern North Africa	Lagos	33. United States Administrated Oceania	Apra
33. Northwestern North Africa	Casablanca	34. Rest of Southern Oceania	Port Moresby
34. Mauritius	Port Louis		
35. Reunion	Denis		
36. Australia	Brisbane		
37. Fiji Islands	Suva		
38. New Zealand	Wellington		
39. Hawaiian Islands	Honolulu		
40. Southern Oceania	Papeete		
41. United States Administrated Oceania	Apra		
42. Rest of Southern Oceania	Port Moresby		

sponding center chosen to represent the consumption and production activities in each region. The production center chosen is also used to represent consumption.

For the spatial price models, the world sugar economy is divided into 34 regions. These are also presented in table 5 along with the corresponding reference point for each region. A less refined breakdown is used because some data were unavailable and the inclusion of 42 rather than 34 regions would have added to the complexity.

Transportation Costs

Both the transportation and spatial price models incorporate the costs of transporting sugar among the regions specified previously. Because freight rates are not available for all trade routes, they are estimated by multiple-

regression analysis.[10] The data for estimation were obtained from several sources[11] and were classified according to year (1959 and 1963), terms (f.i.o. and gross), origin, destination, rate, distance, volume, and season.

Statistical results

The multiple regression equation estimated by least squares is:

$$R = a + bV + cD \qquad (1)$$

where

R = total transportation costs
V = volume of shipment

and

D = distance of haul.[12]

The regression estimates of equation (1) are presented in table 6. Equations (1) to (4) in the table express shipping costs as a linear function of distance and volume for f.i.o. and gross rates, respectively, for 1959 and 1963. In equations (5) and (6), f.i.o. and gross rates are combined, and shift variables are used in estimation. The remaining equations combine these rates for each year.

On the basis of statistical criteria and economic judgment, equation (10) is used to calculate the rates used in this study. The f.i.o. equation is:[13]

$$R = 675 + .0571D - .02634V. \qquad (2)$$

To express equation (2) as a function only of distance, the average volume of 9,667.8 long tons is used. It is calculated from the actual data employed in estimation. Also, the seasonal variations are added together and divided by four, which gives an adjustment factor of –68.3. The final equation used in estimation after considering the above factor is:

$$R = 352.4 + .0571D. \qquad (3)$$

Sugar Demand Equations

The 1970 demand estimates used in this study are derived using the sugar consumption forecasts made in Food and Agriculture Organization (1961). These estimates for 1956, 1965, and 1970, along with population figures, are given in table 7 for each of the regions included in the spatial price models. The regions are grouped according to their level of per capita consumption.

In table 7, 1956 world sugar consumption is estimated to be 41.4 million metric tons. For 1970 consumption is estimated (using constant 1959 prices) to be 63.4 million metric tons. The income elasticities on which the 1970 estimates are based range from 2.15 in the low per capita consumption regions to 0.15 in the high consuming areas.

To determine price elasticities, price, income, and consumption data were analyzed for 60 countries by computing (1) cross-correlations of all countries for the years 1938, 1951, and 1956 and (2) cross-correlations for groups of countries, classified according to prices or incomes for varying numbers of years for each country. The price coefficients de-

[10] For a more detailed discussion of how transportation costs were estimated, see Bates (1966, pp. 125–72).

[11] *Norwegian Shipping News, Fairplay Shipping Journal, Shipping World,* and *Sugar Reports and Statistical Bulletins.*

[12] For those who feel that a reciprocal form, such as $R = a + \frac{bD}{V} + cD$, is more realistic, see Bates (1966, pp. 157–72) for an explanation of why this form was rejected.

[13] All calculations of transport costs are based on this 1959 cost function. It is assumed that the transport rates in 1970 will be either the same as in 1959 or that, if they increase, their relative increases will not change. If the latter occurs, the conclusions based on percentage comparisons remain valid.

TABLE 6
REGRESSION ESTIMATES OF SUGAR TRANSPORTATION COSTS

Basic equation†	Shift values*					R^2
	Type‡	Year§	Season‖			
			1	2	3	
(1) $R = 337 + 0.051D + 0.008V$ ..... (11.573) (1.970)	....	....	....	....	....	.67169
(2) $R = 1{,}159 + 0.032D - 0.043V$ ..... (3.852) (−5.493)	....	....	....	....	....	.25376
(3) $R = 1{,}124 + 0.075D - 0.071V$ ..... (11.297) (−5.633)	....	....	....	....	....	.64275
(4) $R = 518 + 0.083D - 0.012V$ ..... (14.039) (−.719)	....	....	....	....	....	.72027
(5) $R = 455 + 0.053D - 0.008V$ ..... (13.323) (−1.467)	274.561 (11.786)	....	....	....	....	.76883
(6) $R = 1{,}063 + 0.057D - 0.049V$ ..... (11.021) (−7.420)	79.207 (2.430)	....	....	....	....	.53767
(7) $R = 614 + 0.058D - 0.030V$ ..... (17.010) (−5.909)	182.209 (8.517)	148.371 (6.789)	....	....	....	.61510
(8) $R = 465 + 0.053D - 0.008V$ ..... (13.044) (−1.514)	280.926 (11.867)	....	− 12.010 (−0.383)	19.473 (0.646)	− 57.145 (−2.031)	.77627
(9) $R = 1{,}167 + 0.056D - 0.050V$ ..... (11.371) (−7.513)	79.912 (2.534)	....	−200.493 (−4.029)	−131.782 (−3.456)	−157.711 (−4.200)	.59068
(10) $R = 675 + 0.057D - 0.026V$ ..... (16.982) (−6.105)	183.610 (8.639)	162.998 (7.495)	−105.025 (−3.443)	− 57.056 (−2.187)	−111.310 (−4.438)	.63820

* Values presented are modifications to the "intercept" value in the basic equation.
† R = rate expressed in cents per long ton.
D = distance expressed in nautical miles.
V = volume expressed in long tons.
Figures in parentheses are t-ratios.
‡ *F.i.o.* is taken as base.
§ 1959 is the base year.
‖ October to December quarter (4) is the base.

termined, using this analysis, are presented in table 8 along with the income elasticities previously presented. The price elasticities computed are approximately of the same magnitude as the income elasticities.

It is assumed that the relationships found between the income and price elasticities will remain in 1970. Therefore, it is possible to compute consumption as a function of price. The resulting 1970 consumption estimates used in this study are given in Appendix table 2.

Sugar Supply Equations

The majority of supply estimates used in this study are based on data made available by the U. S. Department of Agriculture (1961). The projections made by the U. S. Department of Agriculture are the minimal quantities of centrifugal sugar to become available to the United States under three different United States import prices. These are: (1) 25 per cent below the 1959

level—$105.30 per metric ton, (2) no change from the 1959 level—$140.40 per metric ton, and (3) 25 per cent above the 1959 level—$175.70 per metric ton.

For certain of the world sugar-producing and consuming regions, data were unavailable to meaningfully compute supply equations specified as functions of such variables as prices. For these, as in past interregional studies, point estimates of supply were used.[14] Therefore, supply was assumed to be completely price inelastic. The actual supply equations used are given in Appendix table 3.

As indicated, for some of the regions data were unavailable to estimate supply as a function of such factors as price. Therefore, supply was assumed to be price inelastic. This may not be unrealistic for the following reasons:

1. Many of the countries represented by point projections are temperate, high-cost beet areas of Western Europe, Eastern Europe, the U.S.S.R., and Mainland China. The production policies of most of these countries are based on meeting domestic consumption needs rather than on an export basis. Indeed, as stated by Licht (1963):

   "With world sugar market prices at 3.25 cents or the minimum price declared in the International Sugar Agreement, exporting represents a losing business for the European beet sugar producing countries. Sugar is therefore usually exported only when there are excess supplies on hand. World market prices between 8 and 10 cents would, of course, change the situation for some countries. Since much skepticism has been expressed about the development of prices in the last decade in the European beet sugar areas, a fundamental expansion of acreage for exporting purposes is out of the question.... The increase of sugar production in the Western European countries will, therefore, be confined within the framework of increasing market possibilities within the countries themselves."
2. Several of the cane-producing countries are low-income, developing, tropical African countries which, as a general rule, have balance-of-payments problems. As a result, they often find it advantageous to expand their sugar production in order not to spend foreign exchange on sugar imports. Such expansion may be undertaken in spite of high internal costs, and the amount produced may be highly independent of prices in the world market.
3. A number of cane-producing countries produce under administratively contrived price structures and quotas for delivery to one of the large consuming countries of Western Europe or onto the world sugar market under the terms of the Commonwealth Sugar Agreement. Examples of such regions are Angola, Mozambique, Rhodesia, Malagasy, Kenya, Tanganyika, and Uganda.

EMPIRICAL RESULTS FROM FIVE INTERREGIONAL MODELS

The five spatial models discussed previously provide the basis for this study. This section presents and evaluates the empirical results obtained from each of these.

[14] For examples of spatial studies which incorporate point estimates of supply, see Bjarnason (1967) or Schmitz (1968).

TABLE 7

SUGAR CONSUMPTION ESTIMATES, GROUPS OF REGIONS, 1956, 1965, AND 1970

Region	Per capita consumption	1956				1965						1970					
		Total consumption	Population	Per capita consumption	Estimated annual compound rate of increase in per capita real income 1956–1970	Income elasticity	Estimated total increase in per capita real income 1956–1965	Income effect on consumption	Estimated per capita consumption	Population	Estimated total consumption	Income elasticity	Estimated total increase in per capita real income 1956–1970	Income effect on consumption	Estimated per capita consumption	Population	Estimated total consumption
	kilograms	*1,000 metric tons*	*millions*	*kilograms*	*per cent*		*per cent*		*kilograms*	*millions*	*1,000 metric tons*		*per cent*		*kilograms*	*millions*	*1,000 metric tons*
Northern Middle Far East Middle Far East Southwestern North Africa Rest of Southern Oceania	less than 5	1,566.7	772.8	2.0	2.0	2.5	19.5	48.8	3.0	904.2	2,712.6	2.15	32.0	68.8	3.4	1,000.6	3,402.0
Middle East Northern Far East Southern Far East Central Africa	5–10	4,662.5	764.1	6.1	3.0	1.75	30.5	53.4	9.4	870.2	8,179.9	1.45	51.2	74.2	10.6	958.8	10,163.3
South Central Europe Northwestern Middle East Western Middle East Taiwan Philippines Eastern North Africa	10.1–20	3,443.8	253.7	13.8	3.5	1.0	36.3	36.3	18.8	296.7	5,578.0	0.8	61.9	49.5	20.6	324.1	6,676.5
Soviet Union Central America and Caribbean Western South America South Africa Northwestern North Africa	20.1–30	8,099.9	374.8	21.6	3.5	0.5	36.3	18.2	25.5	413.8	10,551.9	0.4	61.9	24.8	27.0	457.2	12,344.4
Western Europe North Central Europe Eastern South America Indian Ocean Fiji Islands United States Administrated Oceania	30.1–44	12,782.4	381.3	33.5	2.3	0.4	22.7	9.1	36.5	427.1	15,589.2	0.3	37.5	11.3	37.3	454.1	16,937.9
Northwestern Europe United States Canada Cuba Australia New Zealand Hawaiian Islands Southern Oceania	over 44	10,839.1	222.2	48.8	2.0	0.2	19.5	3.9	50.7	253.5	12,852.5	0.15	32.0	4.8	51.1	271.0	13,848.1
Total		41,394.4	2,768.9	14.9					17.5	3,165.2	55,464.1				18.3	3,465.5	63,382.2

SOURCES: Food and Agriculture Organization of the United Nations, 1961, pp. 47 and 48. United Nations, Department of Economic and Social Affairs, 1958.

TABLE 8

PER CAPITA CONSUMPTION OF SUGAR AND INCOME AND PRICE ELASTICITIES GROUPS OF REGIONS, 1965 AND 1970

Region	Per capita consumption	Income elasticity		Price elasticity	
		1965	1970	1965	1970
	kilograms				
Northern Middle Far East, Middle Far East, Southwestern North Africa, Rest of Southern Oceania	less than 5	2.5	2.15	−2.65	−2.30
Middle East, Northern Far East, Southern Far East, Central Africa	5-10	1.75	1.45	−1.87	−1.56
South Central Europe, Northwestern Middle East, Western Middle East, Taiwan, Philippines, Eastern North Africa	10.1-20	1.0	0.8	−1.60	−0.86
Soviet Union, Central America and Caribbean, Western South America, South Africa, Northwestern North Africa	20.1-30	0.5	0.4	−0.58	−0.42
Western Europe, North Central Europe, Eastern South America, Indian Ocean, Fiji Islands, United States Administrated Oceania	30.1-44	0.4	0.3	−0.42	−0.32
Northwestern Europe, United States, Canada, Cuba, Australia, New Zealand, Hawaiian Islands, Southern Oceania	over 44	0.2	0.15	−0.21	−0.16

Ex-Post Models

Model 1

The export and import data used for this and Model 2 are presented in Appendix table 4. In Model 1, the United States is treated as one region. The solution gives the minimum total trade shipping costs and indicates the relative country sugar prices which would have existed had the minimum-cost trade pattern been followed.

Empirical results.—Model 1 was applied to the world sugar economy for 1959 and 1963. These years were selected to determine how the world sugar economy was affected by the United States sugar embargo on Cuba.

The optimal trade patterns derived for 1959 and 1963, in which free trade was allowed between the United States and Cuba, are indicated in tables 9 and 10. In both years Cuba, the largest world sugar producer and exporter, sold only to the United States. The exports listed in the tables represented 36.18 per cent of the world sugar trade in 1959, and 23.67 per cent in 1963.

The second, third, and fourth largest exporters in 1959 (the Philippines, Jamaica, and the Hawaiian Islands) accounted for 21.08 per cent of world sugar exports. Therefore, the top four exporters realized almost 60 per cent of the export sales. The Philippines shipped largely to the Northwestern Middle East area; Jamaica, to the United States; and the Hawaiian Islands, to Canada. In 1963 Jamaica, Mexico, and Australia were the second, third, and fourth largest exporters. These three, in addition to Cuba, accounted for 47.74 per cent of total exports. Jamaica shipped exclusively to the United States; Mexico to the United Kingdom; and Australia principally to the United States and the Northern Far East.

The dual prices to Model 1 are presented, along with the actual prices for 1959 and 1963, in tables 11 and 12. These show the relative area prices corresponding to the previously derived minimum-cost trade patterns. For the exporting regions (table 11), the dual prices were the highest for the Middle East in 1959 and for Cuba in 1963. The prices for the importing regions (table 12) were high-

TABLE 9

WORLD SUGAR TRADE PATTERN—1959 EX-POST MODEL

Exporting region	Shipments	Importing region
	100 metric tons	
North Central Europe	3,671	Northwestern Europe
	3,657	United Kingdom
	1,205	Soviet Union
Mexico	8,487	United Kingdom
Jamaica	504	Portugal
	3,624	Other Western Europe
	5,813	United States
Martinique	193	Northwestern North Africa
Puerto Rico	4,426	United Kingdom
	1,594	France
	842	Portugal
	2,351	Northwestern North Africa
Cuba	50,076	United States
Western South America	3,109	United Kingdom
Eastern South America	699	Southwestern North Africa
	3,695	Northwestern North Africa
Taiwan	5,739	Northern Far East
	992	Northern Middle Far East
Philippines	4,448	Western Middle East
	1,607	Middle East
	1,311	Northern Far East
	3,288	Middle Far East
Southern Far East	47	Middle East
Angola	1,033	Central Africa
	330	Southwestern North Africa
Madagascar	53	Central Africa
	276	Eastern North Africa
Other South Africa	1,685	Southwestern North Africa
Mauritius	1,833	South Central Europe
	1,907	Northwestern Middle East
	1,170	Western Middle East
	219	Eastern North Africa
Reunion	1,566	Eastern North Africa
Australia	5,418	Northern Far East
	989	New Zealand
	33	United States Administrated Oceania
	107	Rest of Southern Oceania
Fiji Islands	1,753	United States
	81	Southern Oceania
Hawaiian Islands	1,786	United States
	6,838	Canada

est for the European countries.

A comparison of the actual and shadow prices in table 11 indicates that the world sugar economy is highly non-competitive. For instance, the actual price in the Philippines in 1959 was $120.63 per metric ton, whereas the shadow price was $92.37. The difference between the actual and the shadow prices in Reunion was +$45.55 per metric ton, for the Hawaiian Islands +$40.57 per metric ton, and for Mar-

TABLE 10

SUGAR TRADE PATTERN—1963 EX-POST MODEL

Exporting region	Shipments	Importing region
	100 metric tons	
France	5,000	United Kingdom
Mexico	12,052	United Kingdom
Jamaica	12,134	United States
Martinique	2,618	Other Western Europe
Puerto Rico	4,071	United Kingdom
	4,032	Other Western Europe
Cuba	35,048	United States
Western South America	1,501	United States
Eastern South America	1,262	Northwestern Europe
	633	United Kingdom
	1,431	Portugal
	5,957	Northwestern North Africa
Middle East	2,144	Western Middle East
Taiwan	2,645	Northern Far East
	4,130	Northern Middle Far East
Philippines	7,571	Northern Far East
	3,070	Middle Far East
Southern Far East	1,310	Western Middle East
Angola	1,551	Soviet Union
Madagascar	641	Soviet Union
	56	Eastern North Africa
Other South Africa	498	United Kingdom
	209	Central Africa
	1,909	Eastern North Africa
	2,938	Southwestern North Africa
Mauritius	3,276	North and South Central Europe
	2,060	Northwestern Middle East
	442	Western Middle East
Reunion	1,922	Western Middle East
	302	Eastern North Africa
Australia	5,913	United States
	4,087	Northern Far East
	1,213	New Zealand
	135	South Oceania
	36	United States Administrated Oceania
	84	Rest of Southern Oceania
Fiji Islands	2,617	United States
Hawaiian Islands	2,190	United States
	7,098	Canada

tinique $35.73 per metric ton.

Tables 13 and 14 present the actual and minimum shipping costs for sugar traded in 1959 and 1963. The minimum shipping costs are computed from tables 9 and 10. The world sugar regions are aggregated into five regions—the United States, Commonwealth Sugar

TABLE 11

COMPARISON OF ACTUAL AND SHADOW PRICES FOR SUGAR AT SUPPLY SOURCE, 1959 AND 1963 EX-POST MODELS

Region	Actual price		Shadow price		Actual-shadow price	
	1959	1963	1959	1963	1959	1963
	dollars per metric ton					
France	—*	180.61	—	—	—	—
North Central Europe	95.73	—	—	—	—	—
Mexico	114.63	139.27	93.89	178.73	+20.74	−39.46
Jamaica	97.63	133.31	93.69	178.78	+ 3.94	−45.47
Martinique	129.92	134.24	94.19	178.93	+35.73	−44.69
Puerto Rico	125.63	169.05	94.00	178.84	+31.63	− 9.79
Cuba	94.83	184.47	94.10	179.19	+ 0.73	+ 5.28
Western South America	73.31	113.22	92.66	177.61	−19.35	−64.39
Eastern South America	84.14	157.03	94.12	178.62	− 9.98	−20.69
Middle East	—	110.32	95.73	178.03	—	−67.71
Taiwan	65.62	158.71	92.72	177.59	−27.10	−18.88
Philippines	120.63	142.70	92.37	177.24	+28.26	−34.54
Southern Far East	73.39	167.17	92.98	176.84	−19.59	− 9.67
Angola	89.70	89.75	93.27	177.19	− 3.57	−87.44
Madagascar	114.03	122.81	93.71	177.69	+50.32	−54.88
Other South Africa	88.23	90.14	93.45	177.07	− 5.22	−86.93
Mauritius	110.54	146.34	93.41	177.42	+17.13	−31.08
Reunion	139.00	148.65	93.45	177.43	+45.55	−28.78
Australia	80.68	137.21	91.13	176.00	−10.45	−38.79
Fiji Islands	100.16	127.11	91.73	176.82	+ 8.43	−49.71
Hawaiian Islands	133.82	171.15	93.25	178.34	+40.57	− 7.19
Total absolute deviation					378.29	745 37
Average absolute deviation					21.02	39.23

* Dashes indicate that either data were unavailable or the region, between 1959 and 1963, changed from an exporter to an importer or vice versa.

Agreement countries, France, Portugal, and residual markets.[35]

The analysis indicates the following:

1. The total transportation costs corresponding to the actual sugar trade in 1959 and 1963 were $89.0 million and $107.4 million, respectively. The corresponding optimal costs were $65.5 million and $73.5 million. The percentage in inefficiency (actual cost divided by optimal cost times 100) was 136 in 1959 and 146 in 1963.
2. The world sugar economy was less efficient in 1963 than in 1959.
3. The French sugar bloc was by far the least efficient part of the world sugar economy in both years.
4. The United States was the most efficient part of the world sugar economy even *after* the Cuban embargo.
5. The residual market was the second most efficient part of the world sugar economy in 1959 and the third most efficient in 1963.

Evaluation of results.—The above transportation model is used to determine the efficiency of actual trade patterns. The results indicate that, even

[35] The United States sugar bloc is comprised of all countries receiving quotas under United States legislation. The Commonwealth Sugar Agreement bloc includes the United Kingdom, Canada, Jamaica, Hong Kong in Northern Middle Far East, Mauritius, Australia, Fiji Islands, New Zealand, and Rhodesia and Union of South Africa in Other South Africa in 1959. The French sugar bloc includes France, Martinique, Madagascar, French Equatorial Africa and West Africa in Southwestern North Africa, Reunion, and Algeria and Sahara departments in Northwestern North Africa in 1959. The Portuguese sugar bloc includes Portugal and Angola. The residual market includes all other shipments.

TABLE 12

COMPARISON OF ACTUAL AND SHADOW PRICES FOR SUGAR AT SUPPLY DESTINATION, 1959 AND 1963 EX-POST MODELS

Region	Actual price		Shadow price		Actual-shadow price	
	1959	1963	1959	1963	1959	1963
	dollars per metric ton					
Northwestern Europe	110.13	159.26	99.56	186.45	+ 1.57	−27.19
United Kingdom	87.10	161.72	99.70	186.17	−12.60	−24.45
France	128.32	—*	99.56	—	+28.76	—
Portugal	103.27	103.01	99.34	185.58	+ 3.93	−82.57
Other Western Europe	86.97	153.61	99.67	186.19	−12.70	−32.58
North and South Central Europe	84.94	146.23	99.67	185.31	−14.73	−39.08
Soviet Union	79.11	148.49	99.51	185.48	−20.40	−36.99
United States	126.51	169.27	97.97	184.69	+28.54	−15.42
Canada	85.42	157.79	98.16	184.88	−12.74	−27.09
Northwestern Middle East	76.90	143.69	99.39	185.03	−22.49	−41.34
Western Middle East	89.10	94.39	98.89	184.53	− 9.79	−90.14
Middle East	112.04	—	97.56	—	+14.48	—
Northern Far East	81.11	125.42	96.90	183.40	−15.79	−57.98
Northern Middle Far East	84.48	95.14	96.50	183.00	−12.02	−87.86
Middle Far East	94.07	140.96	96.86	183.36	− 2.79	−42.40
Central Africa	124.37	149.45	97.66	183.20	+26.71	−33.75
Eastern North Africa	100.72	155.83	99.22	184.83	+ 1.50	−29.00
Southwestern North Africa	142.37	186.26	99.04	184.29	+43.33	+ 1.97
Northwestern North Africa	119.53	108.05	99.33	185.46	+20.20	−77.41
New Zealand	72.61	239.46	95.48	181.98	−22.87	+57.48
South Oceania	100.63	111.44	96.30	183.00	+ 4.33	−71.56
United States Administrated Oceania	138.44	186.44	96.17	182.67	+42.27	+ 3.77
Rest of Southern Oceania	151.04	261.43	95.37	181.87	+55.67	+79.56

* Dashes indicate that either data were unavailable or the region, between 1959 and 1963, changed from an exporter to an importer or vice versa.

before the United States embargo on Cuban sugar, the actual trade shipping costs were substantially higher than the minimum costs derived from the optimum trade pattern. The actual cost increased after the Cuban embargo because of the extra shipping distance. However, the inefficiencies created by the embargo are not as large as one might expect. From a world standpoint, in 1959 the actual cost of shipping sugar was $6.43 per metric ton and increased to $7.25 per metric ton in 1963. The optimal per unit cost was $4.73 and $4.96 per metric ton, respectively. This represented a difference between the optimal and actual per metric ton sugar prices in 1959 of $1.70 and a difference of $2.29 in 1963. One explanation as to why larger inefficiencies did not occur may be that large differences appeared between the actual and optimal cost prior to the embargo. Therefore, the Cuban embargo appeared to have offset some of the original distortions by rerouting international trade in sugar.

The minimum-cost shipping pattern previously derived is based on estimated transportation costs since actual data are not available. If there are large deviations of the actual freight rates from those estimated, the absolute differences between the actual and shadow prices calculated previously could either be over- or understated. Likewise, this could change the previous efficiency ranking of world sugar regions. However, in view of the large discrepancies between the actual and shadow prices for many of the regions, it is unlikely that the use of estimated rather than actual transportation cost data greatly affected the results.

TABLE 13

RELATIVE SUGAR BLOC INEFFICIENCIES, 1959 ACTUAL AND OPTIMAL SHIPPING COSTS*

Sugar bloc	Actual cost	Optimal cost	$\frac{\text{Actual cost}}{\text{Optimal cost}} \times 100$
	dollars		
United States	28,463,905	23,780,640	119.7
Commonwealth Sugar Agreement countries	23,060,867	15,154,921	152.2
France	6,319,888	2,742,524	230.4
Portugal	1,000,554	734,388	136.2
Residual	30,186,169	23,054,026	130.9
World total	89,031,383	65,476,799	136.0

* The actual and optimal costs are calculated using the transportation cost function developed earlier. This eliminates the effects resulting from changes in actual transportation rates.

TABLE 14

RELATIVE SUGAR BLOC INEFFICIENCIES, 1963 ACTUAL AND OPTIMAL SHIPPING COSTS*

Sugar bloc	Actual cost	Optimal cost	$\frac{\text{Actual cost}}{\text{Optimal cost}} \times 100$
	dollars		
United States	32,304,061	26,416,239	122.3
Commonwealth Sugar Agreement countries	25,664,645	14,651,027	175.2
France	4,026,859	950,300	423.7
Portugal	1,079,982	762,723	141.6
Residual	44,331,680	30,682,756	144.5
World total	107,407,247	73,463,045	146.2

* The actual and optimal costs are calculated using the 1959 transportation cost function developed earlier. This eliminates the effects resulting from changes in actual transportation rates.

Model 2

This model was to determine whether and to what extent United States sugar imports minimized total transportation costs. The two time periods chosen were 1959 and 1963. For this model the United States was divided into three consuming regions served by one of three ports—San Francisco, New Orleans, or New York.[16] The total sugar imports for each of the three regions for 1959 and 1963 are presented in table 15.

Empirical results.—Table 16 presents the trade patterns for 1959 and 1963 which minimize the total transport cost between San Francisco, New Orleans, and New York and the world supply regions. For these years United States sugar imports totaled 6,066,200 and 5,910,100 metric tons, respectively. The associated minimum transportation costs for these two years were $24.4 million and $24.2 million.

In both years Central America and the Caribbean, Cuba, and the Hawaiian Islands accounted for more than 90 per cent of United States sugar imports. Of these, Cuba made up about 50 per cent.

[16] Region I (western states) is served by the port of San Francisco; Region II (southern and northwest central states), by New Orleans; and Region III (New England, mid-Atlantic, and northeast central states), by New York.

TABLE 15

SUGAR IMPORTS BY REGION,* UNITED STATES, 1959 AND 1963

Region	Sugar imports	
	1959	1963
	1,000 hundredweight	
I	25,321	27,628
II	80,500	91,483
III	65,776	68,351
Total imports	171,607	187,462

* See footnote 16.

TABLE 16

UNITED STATES SUGAR TRADE PATTERNS, 1959 AND 1963 EX-POST MODEL 3

Exporting region	1959		Exporting region	1963	
	Shipments	Importing region*		Shipments	Importing region*
	100 metric tons			*100 metric tons*	
Central America and Caribbean	2,603	III	Central America and Caribbean	11,200	III
Cuba	28,450	II	Cuba	28,841	II
	20,631	III		6,610	III
Fiji Islands	574	I	Western South America	3,762	III
Hawaiian Islands	8,404	I	Hawaiian Islands	8,688	I
Total imports, United States	60,662		Total imports, United States	59,101	
Total transport costs	$24,409,505		Total transport costs	$24,197,471	

* See footnote 16.

The actual United States sugar import pattern for 1959 and 1963 is given in table 17. In 1959 the United States imported sugar from nine separate sources; approximately 50 per cent of the total from Cuba and more than 25 per cent of the remainder was from Central America and the Caribbean, and the Philippines. In 1963, after severing its trade with Cuba, the United States imported sugar from 14 separate sources. The top four suppliers in order of importance were Central America and the Caribbean, the Philippines, the Hawaiian Islands, and Eastern South America. These supplied approximately 70 per cent of the United States sugar.

Table 18 gives the transportation costs for 1959 and 1963 associated with the previous optimum sugar trade pattern and the actual trade pattern. In 1959, the cost for the actual trade pattern was $5.15 per metric ton compared to $4.04 per metric ton for the optimal trade pattern. In 1963, cost of the actual trade pattern was $6.00 per metric ton and of the optimal pattern, $4.21 per metric ton. Actual costs expressed as a percentage of optimal costs were 127.6 per cent in 1959 and 142.3 per cent in 1963.

Evaluation of results.—The results suggest that the minimum transportation cost import pattern for the United States is one in which only four regions supply the total import requirements. As pointed out, this is fewer than the number of actual United States sugar suppliers. The three major suppliers are Cuba, Central America and the Caribbean, and the Hawaiian Islands. This suggests that, even prior to the

TABLE 17
ACTUAL UNITED STATES SUGAR IMPORTS, 1959 AND 1963

Exporting region	1959 Shipments	1959 Importing region*	Exporting region	1963 Shipments	1963 Importing region*
	100 metric tons			*100 metric tons*	
Western Europe	37	III	Western Europe	536	III
Central America and Caribbean	10,820	II	Canada	3	III
Cuba	15,215	II	Central America and Caribbean	20,407	III
	14,271	III	Western South America	4,077	II
Western South America	902	II	Eastern South America	6,080	III
Eastern South America	105	II	Middle East	410	III
Northern Middle Far East	10	I	Northern Middle Far East	17	II
Taiwan	35	I	Taiwan	638	I
Philippines	465	II	Philippines	538	II
	9,647	III		10,194	III
Hawaiian Islands	753	I	South Africa	1,214	III
	1,100	II	Indian Ocean	671	II
	195	III	Australia	1,608	II
			Fiji Islands	424	II
			Hawaiian Islands	7,964	I
				1,232	II
				207	III

* See footnote 16.

embargo placed on Cuban sugar, the United States in giving allotments to foreign suppliers did not use transportation costs as a selection criterion. In spite of the errors which may have been created by estimating the transportation costs used in this analysis, it is unlikely that the optimum trade pattern would consist of 10 or more United States sugar suppliers as is the case for the actual trade patterns.

On the basis of the analysis, the total transportation cost saving to the United States in 1959 would have been $6.8 million had the optimal trade pattern been followed. In 1963, the saving would have been $10.6 million. This is because, in the latter case, transportation costs could have been reduced by approximately $2.00 per metric ton.

To what extent the transportation inefficiencies computed above compare with those resulting from distorted sugar prices cannot be determined using this model. As pointed out, supply and demand are exogenous. The following models relax this assumption.

Ex-Ante Models

In a free-trade situation, the price paid by sugar importers is the export price plus transportation costs. The previous models do not take export prices into account. Each region's production, consumption, and trade are determined independently of prices (that is, these quantities are exogenously determined). The ex-post models merely determine trade patterns which minimize total transportation costs. These minimum-cost solutions are then used as norms with which to compare actual trade patterns.

The following ex-ante models incorporate absolute sugar prices. The optimal trade pattern is one which minimizes the following total import costs:

$$\sum_i \sum_j (P_i + C_{ij}) Q_j$$

where

P_i = price at supply region i
C_{ij} = transportation cost between region i and j

and

Q_j = the quantity of sugar supplied to consuming region j.

Therefore, the ex-ante models in this section determine both the transportation and pricing inefficiencies existing at a given point in time.

TABLE 18
ACTUAL AND OPTIMAL UNITED STATES SHIPPING COSTS 1959 AND 1963 EX-POST MODEL

	1959	1963
Actual tonnage (metric tons)	6,041,020	5,742,000
Actual total cost (dollars)	31,147,810	34,436,615
Optimal total cost (dollars)	24,409,505	24,197,471
Actual as percentage of optimal (per cent)	127.6	142.3
Actual cost per ton (dollars)	5.15	6.00
Optimal cost per ton (dollars)	4.04	4.21

SOURCE: Calculated from tables 16 and 17.

Model 3

This model predicted optimal trade patterns for 1970. It was assumed that each region could supply without limit sugar at its lowest 1959 supply price (that is, supply was assumed to be infinitely price elastic). Regional consumption was projected to 1970 on the basis of 1959 prices.

Empirical results.—Production and exports corresponding to the least-cost solution are presented in table 19. Cuba, Eastern South America, the Middle East, and Taiwan are assumed to produce the total 1970 world sugar requirements. However, since Eastern South America produces solely for its home market, there are only three world exporters of sugar, Cuba being the largest.

The least-cost trade pattern and the corresponding total import costs for each region are presented in table 20. Cuba exports to 14 of the 34 regions included in the model. Taiwan is second, shipping to 12 regions. The United States is the largest sugar importer totaling 10.3 million metric tons; the associated total import cost (including

TABLE 19
PREDICTED PRODUCTION AND EXPORTS OF SUGAR 1970 EX-ANTE MODEL 3

Supply region	Production	Exports
	1,000 metric tons	
Cuba	41,180	40,720
Eastern South America	4,770	0
Middle East	9,810	3,870
Taiwan	8,370	8,150
Total	64,130	52,740

the export price and transportation costs) is $715.4 million. The second, third, and fourth largest importers are the U.S.S.R., Western Europe, and North Central Europe, respectively. Their imports are 7.2, 7.0, and 5.0 million metric tons, with associated costs of $521.9 million, $499.6 million, and $362.1 million.

Evaluation of results.—In the above, total sugar import costs are smaller than in the remaining two ex-ante models. This is because supply in each region is assumed to be perfectly elastic. As a result, production in such high-cost areas as the United States becomes nonexistent.

To what extent sugar production is a constant cost industry is an empirical question. If costs rise rapidly before the output in the optimal solution can be obtained by each of the regions, then the assumption of perfectly elastic supplies is unrealistic. Unfortunately, to what extent sugar production is an increasing cost industry is difficult to determine,

TABLE 20

SUGAR TRADE PATTERN AND COSTS: 1970 EX-ANTE MODEL 3

Supply region	Shipment	Destination	Consuming region	Total sugar cost
	10,000 metric tons			*10,000 dollars*
Cuba	110	Northwestern Europe	Northwestern Europe	7,882.6
	699	Western Europe	Western Europe	49,964.5
	504	North Central Europe	North Central Europe	36,212.8
	262	South Central Europe	South Central Europe	18,924.5
	724	Soviet Union	Soviet Union	52,186.0
	1,032	United States	United States	71,538.7
	102	Canada	Canada	7,179.9
	265	Central America and Caribbean	Central America and Caribbean	18,419.9
	46	Cuba	Cuba	3,011.2
	126	Western South America	Western South America	8,840.0
	98	Northwestern Middle East	Eastern South America	33,108.6
	48	Southwestern North Africa	Northwestern Middle East	7,077.6
	100	Northwestern North Africa	Western Middle East	8,732.8
			Middle East	39,361.7
	2	Southern Oceania	Northern Far East	15,353.8
Eastern South America	477	Eastern South America	Northern Middle Far East	14,502.5
Middle East	122	Western Middle East	Taiwan	1,443.6
	594	Middle East	Middle Far East	6,051.8
	123	South Africa	Philippines	4,034.5
	44	Central Africa	Southern Far East	10,127.5
	94	Eastern North Africa	South Africa	41,858.7
	4	Indian Ocean	Central Africa	3,154.4
			Eastern North Africa	6,788.7
Taiwan	220	Northern Far East	Southwestern North Africa	3,454.1
	209	Northern Middle Far East	Northwestern North Africa	7,118.0
	22	Taiwan	Indian Ocean	285.7
	86	Middle Far East	Australia	5,364.8
	58	Philippines		
	144	Southern Far East	Fiji Islands	143.7
	75	Australia	New Zealand	1,012.4
	2	Fiji Islands	Hawaiian Islands	358.3
	14	New Zealand	Southern Oceania	144.2
	5	Hawaiian Islands	United States Administrated Oceania	70.0
	2	Southern Oceania	Rest of Southern Oceania	70.9
	1	United States Administrated Oceania		
	1	Rest of Southern Oceania		

because the unrestricted supply response is not known. Supply in the potentially large exporting regions is restricted because many of the sugar importers use price supports to encourage domestic production. The following models indicate, for example, that the largest importer—the United States—does not allocate import quotas to the lowest-cost suppliers.

To assume that supplies are perfectly price elastic is perhaps unrealistic; thus, this assumption is dropped in the following two models. However, even if supply is not completely price elastic, large pricing inefficiencies are likely to exist in the world sugar economy. That is, the difference between the United States import costs of $715.4 million in the above model and the actual cost of approximately $1.5 billion would not be completely eliminated.

Model 4

In this model supplies are not perfectly price elastic. Predictions to 1970

were made for production, consumption, and trade for each region using the supply and demand equations and transportation costs developed in an earlier section. To examine the overall transportation and pricing inefficiencies which resulted from the United States embargo on Cuban sugar, trade was allowed between these two countries.

Empirical results.—Table 21 presents the production, consumption, price, and cost predictions by region for 1970. The four largest producers are Cuba, Eastern South America, Central America and the Caribbean, and North Central Europe, producing 9.0, 7.6, 6.8, and 6.6 million metric tons of sugar, respectively. This accounts for 49.2 per cent of the 61.0 million metric ton world total.

None of the four largest consumers is among the top producers. They are, in order of importance, the United States, Western Europe, the Middle East, and the Soviet Union, comprising 50 per cent of world sugar consumption.

The prices presented in table 21 differ by the matrix of transportation costs. The domestic price in the United States, for example, of $102.95 per metric ton differs from the Cuban price (the

TABLE 21

SUGAR PRODUCTION, CONSUMPTION, PRICES, AND TOTAL CONSUMPTION COST (INCLUDING UNITED STATES TRADE WITH CUBA), 1970 EX-ANTE MODEL 4

Consuming region	Production	Consumption	Prices	Total consumption cost
	1,000 metric tons		*dollars per metric tons*	*10,000 dollars*
Northwestern Europe	346	1,096	104.69	11,473.3
Western Europe	4,948	6,806	104.39	71,046.0
North Central Europe	6,626	4,943	101.57	50,206.1
South Central Europe	2,242	1,856	101.02	18,749.3
Soviet Union	2,057	6,228	105.35	65,607.7
United States	1,687	10,763	102.95	110,796.0
Canada	200	984	103.58	10,191.5
Central America and Caribbean	6,772	2,735	98.58	26,961.6
Cuba	9,000	1,071	99.08	10,611.5
Western South America	2,119	1,090	97.84	10,664.6
Eastern South America	7,648	4,608	98.81	45,531.6
Northwestern Middle East	921	948	105.06	9,959.7
Western Middle East	4,809	1,044	104.89	10,949.4
Middle East	0	6,680	103.56	69,176.2
Northern Far East	0	1,308	102.90	13,458.0
Northern Middle Far East	0	1,105	102.50	11,325.2
Taiwan	1,452	129	98.72	1,273.5
Middle Far East	0	691	102.86	7,107.0
Philippines	2,711	671	98.37	6,600.6
Southern Far East	1,659	672	98.98	6,651.5
South Africa	2,108	1,250	99.09	12,386.3
Central Africa	0	557	103.59	5,769.4
Eastern North Africa	0	909	105.22	9,563.6
Southwestern North Africa	0	783	103.73	8,121.3
Northwestern North Africa	0	1,049	104.02	10,910.6
Indian Ocean	1,074	45	99.41	447.3
Australia	1,964	725	97.13	7,041.9
Fiji Islands	363	23	97.15	223.4
New Zealand	0	135	101.48	1,369.9
Hawaiian Islands	247	56	98.67	552.6
Southern Oceania	0	19	101.72	193.3
United States Administrated Oceania	0	10	102.17	102.1
Rest of Southern Oceania	0	24	101.37	243.3

largest exporter to the United States) by $3.87 per metric ton. Of immediate interest is the price predicted for the United States—$102.95 per metric ton, as compared with the 1959 price of $126.51 per metric ton. In both cases trade is allowed with Cuba. The cost of the United States sugar imports derived from the optimal solution is $1.11 billion as compared to $1.36 billion using 1959 prices—a difference of $250 million.

The 1970 trade pattern corresponding to the least-cost solution is presented in table 22. The four largest exporters in order of importance are Cuba, Central America and the Caribbean, the Western Middle East, and Eastern South America, accounting for 62.7 per cent of world total sugar exports of 29.9 million metric tons. The two largest importers are the United States and the Middle East, accounting for 52.7 per cent of the total imports.

The extent to which the trade pattern predicted using this model deviates from that proposed under the recently negotiated sugar act is discussed in a later section. An evaluation of the above results is made in conjunction with Model 5.

Model 5

As in Model 4, 1970 predictions were made for each region's production, consumption, and trade. The same data were used as previously except that no trade was allowed between Cuba and the United States.

Empirical results.—The 1970 production, consumption, prices, and consumption costs are presented in table 23. The four largest producers are the same as in Model 4—Cuba, Eastern South America, Central America and the Caribbean, and North Central Europe, accounting for approximately 50 per cent of the 60.6 million metric tons predicted production. The four largest consumers are also the same as in the previous model—the United States, Western Europe, the Middle East, and the Soviet Union.

As in Model 4, prices among regions differ by the matrix of transportation costs. However, overall prices are above those in Model 4 as a result of the United States embargo on Cuban sugar. For example, in the previous model the total cost of United States sugar consumption is $1.10 billion. Table 23 indicates that the cost increases to $1.13 billion when trade is not allowed between the United States and Cuba.

The minimum-cost 1970 trade pattern is presented in table 24. It indicates that the four largest exporters—Cuba, Central America and the Caribbean, Eastern South America, and the Philippines—account for 65 per cent of the total sugar exports of 26.4 million metric tons. In the model, the United States and the Soviet Union are the largest importers, constituting approximately 50 per cent of the sugar imports. The United States alone imports 35 per cent of the total.

In the previous model the United States imports from Central America and the Caribbean, Cuba, and Western South America. The above results indicate that, when trade with Cuba is not allowed, the United States imports from Central America and the Caribbean, Western South America, Eastern South America, Australia, the Fiji Islands, and the Hawaiian Islands. Of the total imports of 8.87 million metric tons, close to 50 per cent comes from Central America and the Caribbean. These patterns are compared in a later section with the actual 1970 United States sugar import allotments.

Evaluation of models 4 and 5.—These two models were constructed to determine the minimum total cost trade pattern for 1970, both including and excluding United States trade with Cuba. When trade with Cuba is excluded from the model, the United States domestic

TABLE 22

SUGAR TRADE PATTERN (INCLUDING UNITED STATES TRADE WITH CUBA) 1970 EX-ANTE MODEL 4

Supply region	Shipments	Destination	Consuming region	Exports	Imports
	1,000 metric tons			*1,000 metric tons*	
Northwestern Europe	346	Northwestern Europe	Northwestern Europe		750
Western Europe	4,948	Western Europe	Western Europe		1,858
North Central Europe	4,943	North Central Europe	North Central Europe	1,683	
	1,683	Soviet Union	South Central Europe	386	
South Central Europe	1,856	South Central Europe	Soviet Union		4,171
	359	Soviet Union	United States		9,076
	27	Northwestern Middle East	Canada		784
Soviet Union	2,057	Soviet Union	Central America and Caribbean	4,037	
United States	1,687	United States	Cuba	7,929	
Canada	200	Canada	Western South America	1,029	
Central America and Caribbean	750	Northwestern Europe	Eastern South America	3,040	
	1,858	Western Europe	Northwestern Middle East		27
	119	United States	Western Middle East	3,765	
	272	Canada	Middle East		6,680
	2,735	Central America and Caribbean	Northern Far East		1,308
	1,038	Northwestern North Africa	Northern Middle Far East		1,105
Cuba	7,929	United States	Taiwan	1,323	
	1,071	Cuba	Middle Far East		691
Western South America	1,029	United States	Philippines	2,040	
	1,090	Western South America	Southern Far East	987	
Eastern South America	2,129	Soviet Union	South Africa	918	
	4,608	Eastern South America	Central Africa		557
	117	Eastern North Africa	Eastern North Africa		909
	783	Southwestern North Africa	Southwestern North Africa		783
	11	Northwestern North Africa	Northwestern North Africa		1,049
Northwestern Middle East	921	Northwestern Middle East	Indian Ocean	1,029	
Middle East	4,809	Middle East	Australia	1,239	
Taiwan	219	Northern Far East	Fiji Islands	340	
	1,105	Northern Middle Far East	New Zealand		135
	129	Taiwan	Hawaiian Islands	191	
Philippines	446	Western Middle East	Southern Oceania		19
	884	Middle East	United States Administrated Oceania		10
	19	Northern Far East	Rest of Southern Oceania		24
	691	Middle Far East			
	671	Philippines			
Southern Far East	987	Middle East			
	672	Southern Far East			
South Africa	1,250	South Africa			
	557	Central Africa			
	361	Eastern North Africa			
Indian Ocean	598	Western Middle East			
	431	Eastern North Africa			
	45	Indian Ocean			
Australia	1,070	Northern Far East			
	725	Australia			
	135	New Zealand			
	10	United States Administrated Oceania			
	24	Rest of Southern Oceania			
Fiji Islands	321	Canada			
	725	Australia			
	135	New Zealand			
	10	United States Administrated Oceania			
	24	Rest of Southern Oceania			
Hawaiian Islands	191	Canada			
	56	Hawaiian Islands			

TABLE 23

SUGAR PRODUCTION, CONSUMPTION, PRICES, AND TOTAL CONSUMPTION COST (EXCLUDING UNITED STATES TRADE WITH CUBA) 1970 EX-ANTE MODEL 5

Consuming region	Production	Consumption	Prices	Total consumption cost
	1,000 metric tons		*dollars per metric ton*	*100,000 dollars*
Northwestern Europe	346	1,095	104.63	11,489.1
Western Europe	3,949	6,798	104.75	71,207.2
North Central Europe	6,626	4,943	101.57	50,206.1
South Central Europe	2,242	1,856	101.39	18,818.0
Soviet Union	1,324	6,228	105.35	65,607.0
United States	1,866	10,740	105.45	113,244.5
Canada	200	984	103.66	10,199.3
Central America and Caribbean	6,833	2,715	101.08	27,443.2
Cuba	9,000	1,071	98.72	10,572.9
Western South America	2,122	1,076	100.34	10,796.6
Eastern South America	7,655	4,601	99.81	45,922.6
Northwestern Middle East	922	948	105.43	9,994.7
Western Middle East	0	1,036	105.58	10,937.0
Middle East	4,813	6,580	104.82	69,121.4
Northern Far East	0	1,249	104.16	13,008.3
Northern Middle Far East	0	1,025	103.76	10,634.4
Taiwan	1,457	125	99.98	1,249.8
Middle Far East	0	665	104.12	6,923.3
Philippines	2,727	666	99.63	6,635.4
Southern Far East	1,659	635	100.24	6,365.2
South Africa	2,170	1,247	99.52	12,410.1
Central Africa	0	554	104.02	5,762.1
Eastern North Africa	0	904	105.65	9,549.9
Southwestern North Africa	0	780	104.73	8,168.2
Northwestern North Africa	0	1,047	104.45	10,934.9
Indian Ocean	1,075	45	100.10	450.6
Australia	1,972	723	98.39	7,113.6
Fiji Islands	367	23	99.21	228.2
New Zealand	0	135	102.74	1,386.9
Hawaiian Islands	278	56	100.73	564.1
Southern Oceania	0	19	103.76	197.1
United States Administrated Oceania	0	10	103.43	103.4
Rest of Southern Oceania	0	24	102.63	246.3

production is predicted to be 1.9 million metric tons as compared to actual production of 3.8 million metric tons averaged for 1964–1966. This is not surprising because the United States is one of the highest-cost sources of sugar. The results indicate that, if domestic price supports were removed, much of the domestically produced sugar would be replaced by imports.

The models point out that United States imports from three sources when trade with Cuba is allowed and from six sources when trade with Cuba is excluded. This is because Cuba, prior to the embargo in 1960, was the largest exporter of sugar to the United States. Therefore, when trade with Cuba is excluded, the United States must import from several smaller sources in order to make up the previous level of imports from Cuba. Not only do the optimal models indicate this but so do the actual data on the number of suppliers of United States sugar.

A priori, one would expect that the impact of the United States embargo on Cuban sugar would be greater than the models indicate. The total cost of sugar to the United States (including domestic

TABLE 24

SUGAR TRADE PATTERN
(EXCLUDING UNITED STATES TRADE WITH CUBA)
1970 EX-ANTE MODEL 5

Supply region	Shipments	Destination	Consuming region	Exports	Imports
	1,000 metric tons			*1,000 metric tons*	
Northwestern Europe	346	Northwestern Europe	Northwestern Europe		749
Western Europe	4,949	Western Europe	Western Europe		1,849
North Central Europe	4,943	North Central Europe	North Central Europe	1,683	
	1,683	Soviet Union	South Central Europe	386	
South Central Europe	1,856	South Central Europe	Soviet Union		4,904
	26	Northwestern Middle East	United States		8,874
	360	Eastern North Africa	Canada		784
Soviet Union	1,324	Soviet Union	Central America and Caribbean	4,118	
United States	1,866	United States	Cuba	7,929	
Canada	200	Canada	Western South America	1,046	
Central America and Caribbean	4,118	United States	Eastern South America	3,054	
	2,715	Central America and Caribbean	Northwestern Middle East		26
Cuba	749	Northwestern Europe	Western Middle East		1,036
	1,849	Western Europe	Middle East		1,767
	3,221	Soviet Union	Northern Far East		1,249
	784	Canada	Northern Middle Far East		1,025
	1,071	Cuba	Taiwan	1,332	
	279	Eastern North Africa	Middle Far East		665
	1,047	Northwestern North Africa	Philippines	2,061	
Western South America	1,046	Canada	Southern Far East	1,024	
	1,076	Western South America	South Africa	923	
Eastern South America	2,274	United States	Central Africa		554
	4,601	Eastern South America	Eastern North Africa		904
	780	Southwestern North Africa	Southwestern North Africa		780
Northwestern Middle East	922	Northwestern Middle East	Northwestern North Africa		1,047
Middle East	4,813	Middle East	Indian Ocean	1,030	
Taiwan	307	Northern Far East	Australia	1,249	
	1,025	Northern Middle Far East	Fiji Islands	344	
	125	Taiwan	New Zealand		135
Philippines	645	Middle East	Hawaiian Islands	222	
	751	Northern Far East	Southern Oceania		19
	665	Middle Far East	United States Administrated Oceania		10
	666	Philippines	Rest of Southern Oceania		24
Southern Far East	1,024	Middle East			
	635	Southern Far East			
South Africa	104	Western Middle East			
	1,247	South Africa			
	554	Central Africa			
	265	Eastern North Africa			
Indian Ocean	932	Western Middle East			
	98	Middle East			
	45	Indian Ocean			
Australia	870	United States			
	191	Northern Far East			
	723	Australia			
	135	New Zealand			
	19	Southern Oceania			
	10	United States Administrated Oceania			
	24	Rest of Southern Oceania			
Fiji Islands	344	United States			
	23	Fiji Islands			
New Zealand	222	United States			
	56	Hawaiian Islands			

production) is $1.10 billion when trade with Cuba is allowed and $1.13 billion excluding Cuban trade. If the data in the models are reasonable approximations of sugar-producing regions, the results indicate that the alternative cost sources of sugar supply in the model are only slightly greater than the cost of imports from Cuba.

Regardless of the accuracy of the models in predicting the inefficiencies from severing trade with Cuba, Models 4 and 5 appear to give the optimal trade pattern which minimizes total consumption costs in each region. These provide norms against which to compare the sugar import quotas proposed by the United States for 1970.

THE SPATIAL MODELS AND UNITED STATES SUGAR SUPPLY POLICY[17]

Models 4 and 5 were used to determine if the United States uses efficiency as a a criterion in allocating sugar quotas to various countries. These models served this purpose because they showed the optimum trade pattern the United States should pursue if its policy was to minimize total consumption costs.

The Present Sugar Policy

On October 22, 1965, Congress passed and, on November 8, 1965, the President approved H.R. 11135, a bill to amend and extend the provisions of the Sugar Act of 1948, as amended. The following provisions are of particular interest in this study (U. S. Congress, 1965):

1. The Sugar Act is extended for five years to December 31, 1971.
2. The mainland beet sugar quota was increased by 375,000 short tons, and the mainland cane sugar quota by 205,000 short tons. The domestic sugar-producing areas now have the following quotas as compared with the 1962 amendments:

Area	*1962 amendment* (short tons)	*1965 amendment* (short tons)
United States		
Domestic beet sugar.....	2,650,000	3,025,000
Mainland cane sugar.....	895,000	1,100,000
Hawaiian Islands.....	1,110,000	1,110,000
Puerto Rico.....	1,140,000	1,140,000
Virgin Islands.....	15,000	15,000
	5,810,000	6,390,000

To or from the above total of 6,390,000 short tons, raw value, there will be added or subtracted, as the case may be, a quantity equal to 65 per cent of the amount by which the Secretary of Agriculture's determination of requirements of consumers for the calendar year exceeds 10,400,000 short tons or is less than 9,700,000 short tons, raw value. This amount will be apportioned between the domestic beet area and the mainland cane area.

3. A quota will be given to the Philippines in the amount of 1,050,000 short tons, raw value, plus 10.86 per cent of the amount, not exceeding 700,000 short tons, raw value, by which the Secretary's determination of requirements for consumption for the calendar year exceeds 9,700,000 short tons, raw value.
4. The Cuban share of 50 per cent was prorated to the various foreign countries listed, in accordance with their basic quotas, until such time as Cuba's quota is restored following its return to the free world, except that the portion of the Cuban share arising from consumption

[17] For a summary discussion of Models 4 and 5 and how their results are used to determine the efficiency of the United States sugar supply program see Bates (1968).

requirements in excess of 10 million short tons, raw value, will be prorated only to countries which are members of the Organization of American States.

5. Assigned to the Philippines was a share amounting to 47.22 per cent of all deficits under the above quotas beginning in 1966, except that a deficit of a country which is a member of the Central American Common Market will first be allocated to other member countries. The remainder of deficits arising in a domestic area or any Western Hemisphere country will be prorated to other Western Hemisphere countries. The remainder of deficits arising elsewhere will be prorated to other non-Western Hemisphere countries. In making deficit allocations to Western Hemisphere countries, special consideration will be given to those countries purchasing United States agricultural commodities.

The Efficiency of the United States Sugar Act Supply Pattern

Table 25 compares this future supply pattern with that suggested by models 4 and 5 and indicates the following:

1. If the United States embargo on Cuban sugar is continued, the actual trade pattern specified in the Sugar Act for 1970 will increase United States transportation costs by approximately 10 per cent above those if free trade with Cuba were restored.
2. The estimated total cost of the United States sugar supply in 1970 for the actual trade patterns specified in the Sugar Act (including trade with Cuba) is approximately $1.6 billion. This cost would drop to $1.1 billion if trade restrictions were removed—a 31 per cent reduction in costs.
3. If trade with Cuba is excluded, the optimum trade pattern gives a total cost of approximately $1.3 billion, which is 25 per cent lower than the actual trade pattern specified in the Sugar Act (excluding trade with Cuba).

In table 26 regional sugar supplies specified under the Sugar Act are compared with those predicted using models 4 and 5. The table includes actual and optimal trade patterns, both including and excluding trade with Cuba. One of the striking features of these data is that, while the Sugar Act places a heavy emphasis on domestic supply sources (41.8 per cent of total sugar by weight both including and excluding Cuba), in Model 4 only 15.7 per cent of total requirements by weight would come from domestic sources. In Model 5 this figure increases to 17.4 per cent. The two efficiency models indicate that United State production of raw sugar would drop to less than 2,000,000 metric tons from the 4,319,132 metric tons proposed by the latest sugar legislation. This indicates that the United States is a high-cost source of sugar.

The results show that the total cost per metric ton to the United States, under the proposed Sugar Act supply pattern, would be $147.39 per metric ton excluding trade with Cuba. If the world sugar economy were efficient in the way the ex-ante models suggest, then United States sugar costs would be lowered to $105.50 per metric ton.

SUMMARY AND CONCLUSIONS

Five spatial equilibrium models were developed. Two include 42 world sugar-producing and consuming regions. The three others include 34 regions. These models were used to (1) determine the extent of inefficiency in the world sugar

TABLE 25

ALTERNATIVE TRADE PATTERNS IN 1970 UNDER 1948 UNITED STATES SUGAR ACT AS AMENDED, 1965 COMPARED WITH PREDICTIVE MODELS 4 AND 5

Source countries under United States Sugar Act	Quantity shipped		Transporting costs for quantity shipped		Total cost*	
	Including Cuba	Excluding Cuba	Including Cuba	Excluding Cuba	Including Cuba	Excluding Cuba
	metric tons		*1,000 dollars*			
United States	4,319,132	4,319,132	0	0	606,387.6	606,387.6
Ireland	4,854	4,854	26.6	26.6	754.7	754.7
Puerto Rico	1,034,208	1,034,208	4,519.5	4,519.5	378,965.5	378,965.5
Virgin Islands	13,608	13,608	59.5	59.5	1,827.6	1,827.6
Bahamas	9,072	9,072	39.6	39.6	1,012.2	1,012.2
Mexico	225,180	486,124	984.0	2,124.4	23,335.4	50,377.1
Dominican Republic	220,229	475,408	962.4	2,077.5	17,012.7	36,725.2
British West Indies	87,975	138,186	384.5	603.9	9,511.0	14,939.3
French West Indies	27,674	43,469	120.9	190.0	3,716.3	5,837.5
Costa Rica	25,926	55,979	113.3	244.6	2,435.0	5,257.5
Nicaragua	25,926	55,979	113.3	244.6	2,344.8	5,062.7
Guatemala	21,848	47,198	95.5	206.3	2,437.4	5,265.5
Panama	16,313	35,190	71.3	153.8	2,485.6	5,361.8
El Salvador	16,022	34,607	70.0	151.2	2,154.9	4,654 6
Haiti	12,235	26,408	53.5	115.4	1,547.9	3,340.9
British Honduras	6,409	13,818	28.0	60.4	498.0	1,073.7
Honduras	2,622	5,691	11.5	24.8	292.6	633.7
Cuba	1,456,539	0	5,622.2	0	143,742.1	0
Peru	175,659	379,203	895.9	1,933.9	13,404.6	28,936.9
Colombia	23,305	50,299	118.9	256.5	2,099.8	4,531.9
Ecuador	32,044	69,152	163.4	352.7	2,579.5	5,476.8
Brazil	220,229	475,408	1,239.9	2,676.6	16,526.0	35,674.7
Argentina	27,092	58,497	152.5	329.3	3,375.1	7,287.5
Venezuela	11,070	23,890	62.3	134.5	1,173.5	2,532.6
Bolivia	2,622	5,681	14.8	32.0	211.5	458.1
India	41,948	65,890	353.6	555.5	3,152.4	4,951.7
Taiwan	43,696	68,635	293.6	461.2	3,160.9	4,965.0
Thailand	9,613	15,100	87.9	138.0	1,241.5	1,950.0
Philippines	1,021,525	1,021,525	7,222.2	7,222.2	130,445.7	130,445.7
South Africa	30,879	48,503	241.8	379.8	2,966.3	4,659.2
Malagasy Republic	4,952	7,778	38.8	60.9	752.0	1,181.2
Swaziland	3,787	5,948	29.7	46.6	378.1	593.8
Southern Rhodesia†	3,787	5,948	29.7	46.6	378.1	593.8
Mauritius	9,613	15,100	84.0	132.0	1,146.6	1,801.2
Australia	104,871	164,725	739.3	1,161.3	9,200.3	14,451.3
Fiji Islands	23,013	36,148	143.4	225.2	2,448.4	3,845.8
Hawaiian Islands	1,006,992	1,006,992	4,742.9	4,742.9	139,499.6	139,499.6
Total‡	10,322,400	10,322,400	29,930.2	31,729.8	1,534,601.2	1,521,313.9

* Transport costs from source countries to United States plus price at source countries.

† On December 8, 1965, the Secretary of Agriculture announced that the quota for Southern Rhodesia had been withheld and prorated to western countries pursuant to Presidential directive of November 20 and to Section 202 (d) (1) (B) of the Sugar Act. It is assumed this quota will be returned by 1970.

‡ Figures may not add to totals because of rounding.

TABLE 26

SUGAR SUPPLY SOURCES IN 1970 UNDER AMENDED 1948 UNITED STATES SUGAR ACT AND EX-ANTE MODELS 4 AND 5

Region	Quantity shipped including Cuba	Per cent of total	Quantity shipped excluding Cuba	Per cent of total	Model 4	Per cent of total	Model 5	Per cent of total
	metric tons		*metric tons*		*metric tons*		*metric tons*	
United States	4,319,132	41.84	4,319,132	41.84	1,686,000	15.66	1,866,000	17.37
Western Europe	4,854	.05	4,854	.05	0	0	0	0
Central America and Caribbean	1,745,247	16.91	2,474,935	23.98	119,000	1.11	4,118,000	38.34
Cuba	1,456,539	14.11	0	0	7,929,000	73.67	0	0
Western South America	231,008	2.24	498,654	4.83	1,029,000	9.56	1,046,000	9.74
Eastern South America	261,013	2.53	563,470	5.46	0	0	2,274,000	21.17
Middle East	41,948	.41	65,890	.64	0	0	0	0
Taiwan	43,696	.42	68,035	.66	0	0	0	0
Middle Far East	9,613	.09	15,100	.15	0	0	0	0
Philippines	1,021,525	9.90	1,021,525	9.90	0	0	0	0
South Africa	43,405	.42	68,177	.66	0	0	0	0
Indian Ocean	9,613	.09	15,100	.15	0	0	0	0
Australia	104,871	1.02	164,725	1.60	0	0	870,000	8.10
Fiji Islands	23,013	.22	36,148	.35	0	0	344,000	3.20
Hawaiian Islands	1,006,992	9.76	1,006,992	9.76	0	0	222,000	2.07
Total*	10,322,400	100.00	10,322,400	100.00	10,763,000	100.00	10,740,000	100.00
Region	Total cost† including Cuba	Per cent of total	Total cost† excluding Cuba	Per cent of total	Model 4	Per cent of total	Model 5	Per cent of total
	10,000 dollars		*10,000 dollars*		*10,000 dollars*		*10,000 dollars*	
United States	60,638.8	39.51	60,638.8	39.85	17,357.4	15.67	19,677.0	17.37
Western Europe	75.5	.05	75.5	.05	0	0	0	0
Central America and Caribbean	44,957.8	29.30	52,033.8	34.20	1,225.0	1.11	43,420.1	38.34
Cuba	14,374.2	9.37	0	0	81,621.1	73.67	0	0
Western South America	1,808.5	1.18	3,894.6	2.56	10,592.5	9.56	11,029.1	9.74
Eastern South America	2,126.7	1.39	4,595.2	3.02	0	0	23,977.1	21.17
Middle East	315.2	.21	495.2	.33	0	0	0	0
Taiwan	316.1	.21	496.5	.33	0	0	0	0
Middle Far East	124.2	.08	195.0	.13	0	0	0	0
Philippines	13,044.6	8.50	13,044.6	8.57	0	0	0	0
South Africa	447.4	.29	702.8	.46	0	0	0	0
Indian Ocean	114.7	.07	180.1	.12	0	0	0	0
Australia	920.0	.60	1,445.1	.95	0	0	9,173.3	8.10
Fiji Islands	244.8	.16	384.6	.25	0	0	3,627.1	3.20
Hawaiian Islands	13,950.0	9.09	13,950.0	9.17	0	0	2,340.8	2.07
Total*	153,460.1	100.00	152,131.4	100.00	110,796.0	100.00	113,244.5	100.00
Total cost per metric ton	$148.67		$147.39		$102.94		$105.44	

* Figures may not add to totals because of rounding.
† Transport costs from source regions to United States plus price at source regions.

economy and (2) ascertain whether the United States imports sugar from its lowest-cost sources. The models used differ principally in the length of time under consideration and the assumptions made concerning the consuming and producing activities in each region.

No attempt was made to compare the actual United States sugar policies (either in the past or in the immediate

future) with a suboptimal world supply system (in which sources politically committed would be taken into account and the residual treated as the supply actually available). This was done because (1) our primary interest was to establish an optimally efficient world sugar economy and then determine how the United States import policies deviated from it and (2) in the optimal solutions of the supply allocated to the United States, only small amounts were politically committed to other destinations.

The ex-post models developed in this study are subject to the usual criticisms. The models simply take production and consumption as de facto magnitudes and indicate what pattern of trade shipments minimize total transport costs. Because production costs are not considered, these models cannot point out, for example, to what extent United States protection to domestic sugar producers affects the efficiency of both the United States and world sugar economies. Despite the shortcomings of these models, we were able to conclude that transport efficiency was not as important a determinant of sugar prices as might have been expected. A saving of only $1.70 and $2.30 per metric ton, respectively, was realized in the optimal transport pattern over the actual trade pattern in 1959 and 1963. Also, it was found that the "efficient" prices varied as much as $50–$100 per metric ton from actual prices in 1959 and 1963, which suggests that political considerations are considerably more important in the determination of sugar prices than are transport costs.

At one stage in the analysis, the world sugar economy was divided into five regions. The ex-post models suggested that the United States, Portuguese, and the residual markets were relatively efficient when compared with the world sugar economy as a whole. Efficiency was defined as the deviation of an actual trade pattern from an optimal one measured in terms of total transport costs. The Commonwealth Sugar Agreement countries and the French sugar economies were considerably more inefficient.

The ex-ante models predicted optimum 1970 regional production, consumption, international trade patterns, and prices. A removal of international barriers to trade and domestic price supports to sugar producers would have the following aggregate effects:

1. Production in the Soviet Union and the United States would decline by approximately 30 and 65 per cent, respectively.
2. Substantial increases in production in Central America and the Caribbean and Cuba would be forthcoming; a number of small, inefficient regions would discontinue sugar production.
3. Sugar prices would fall in the United States, the Philippines, and the Hawaiian Islands.
4. Sugar prices would increase in South America, Taiwan, and Cuba.
5. A long-run policy of embargo on Cuban sugar would increase sugar costs to the United States by approximately $2.50 per metric ton.

The models pointed out that the major inefficiency in the United States sugar economy results from its heavy reliance on domestic, Hawaiian, Puerto Rican, and Philippine sources of supply. In the absence of political barriers, the major supplier of United States sugar would be Cuba. If trade with Cuba is excluded, Latin America and the South Pacific would become the major suppliers. Given these findings, it is clear that economic efficiency is not the major criterion used in formulating United States sugar policy.

APPENDIX TABLE 1

SUMMARY OF WORLD SUGAR EXPORTS BY TYPES OF MARKETS, 1954–1962

Exports	1954	1955	1956	1957	1958	1959	1960	1961	1962
	A. Exports excluded from provisions of International Sugar Agreements								
	metric tons, raw value								
Internal exports									
United States offshore areas to United States mainland	1,934,000	1,943,000	2,040,000	1,766,765	1,323,887	1,766,424	1,585,342	1,851,886	1,813,500
United States mainland to offshore areas	8,000	8,000	5,000	5,000	4,000	6,000	6,000	8,000	6,000
France to overseas departments and territories	400,276	363,745	377,803	438,185	406,127	290,263	299,102	335,076	308,391
French overseas departments and territories to France	380,110	417,864	384,474	427,038	435,480	342,795	416,647	412,531	437,737
Portuguese overseas provinces to Portugal	79,807	100,885	125,441	154,952	148,597	140,933	161,010	157,097	166,778
Belgium to Congo (Leopoldville)	6,268	5,427	8,059	7,845	7,468	6,480	254	53	321
Congo (Leopoldville) to Belgium	0	0	0	0	0	1,001	9,520	0	0
Netherlands to overseas provinces	1,168	1,843	2,381	2,102	2,420	3,216	3,408	2,628	461
Dutch overseas provinces to Netherlands	468	0	898	807	241	1,543	3,454	1,184	8
Spain to Canary Islands	15,671	0	4,371	8,760	7,047	8,527	10	0	0
Japan to Ryukyu Islands	2,955	0	0	1,148	2,829	11,138	14,123	0	0
Ryukyu Islands to Japan	1,186	3,045	6,345	3,322	2,722	11,986	25,580	0	0
Tanganyika to Kenya	584	812	2,138	200	58	2,033	111	54	0
Uganda to Kenya	40	13,384	11,219	16,921	16,395	10,579	31,373	33,531	36,415
Uganda to Tanganyika	0	367	1,932	6,201	7,035	3,351	1	0	0
Total internal exports	2,830,533	2,858,972	2,970,661	2,839,336	2,304,306	2,606,269	2,555,935	2,800,040	2,769,611
Percentage of world exports	18.4	17.3	18.3	16.5	13.8	15.7	13.3	12.5	13.5
Foreign exports to the United States (excluded under Article 17 of International Sugar Agreements)	3,432,585	3,604,461	3,851,924	3,829,388	4,442,452	4,259,782	4,387,619	3,938,928	4,215,998
Percentage of world exports	22.4	21.9	23.8	22.2	26.0	25.6	22.8	17.7	20.5
Exports to U.S.S.R. (excluded under Article 14(2) (a) of International Sugar Agreements)									
Czechoslovakia to U.S.S.R.	135,984	110,765	58,372	118,918	137,071	124,941	128,441	131,360	83,622
Hungary to U.S.S.R.	*			73	0	0	10,871	870	0
Poland to U.S.S.R.	230,672	233,696	26,087	0	54,348	81,522	108,695	127,213	154,369
Total	366,656	344,461	84,459	118,991	191,419	206,463	248,007	259,443	237,991
Percentage of world exports	2.4	2.1	0.5	0.7	1.1	1.2	1.3	1.2	1.1
TOTAL EXPORTS OUTSIDE FREE MARKET	6,629,774	6,807,894	6,907,044	6,787,715	6,998,177	7,072,514	7,191,561	6,998,411	7,223,600
Percentage of world exports	43.2	41.3	42.6	39.4	40.9	42.5	37.4	31.4	35.1
	B. Free market exports								
Exports other than under Commonwealth Sugar Agreement	6,480,500	7,446,695	6,961,704	8,065,081	7,804,505	7,271,546	9,721,046	12,822,260	11,126,643
Percentage of world exports	42.3	45.1	43.0	46.7	45.7	43.7	50.5	57.6	54.1
Exports under Commonwealth Sugar Agreement	2,222,574	2,235,484	2,333,553	2,393,663	2,288,034	2,307,046	2,319,313	2,433,520	2,223,244
Percentage of world exports	14.5	13.6	14.4	13.9	13.4	13.8	12.1	11.0	10.8
TOTAL FREE MARKET EXPORTS	8,703,074	9,682,179	9,295,257	10,458,744	10,092,539	9,578,592	12,060,359	15,255,780	13,349,887
Percentage of world exports	56.8	58.7	57.4	60.6	59.1	57.5	62.6	68.6	64.9
	C. World exports								
TOTAL (A AND B)	15,332,848	16,490,073	16,202,301	17,246,459	17,090,716	16,651,106	19,251,920	22,254,191	20,573,487

* Blanks indicate no data available.
SOURCE: International Sugar Council, 1963, p. 164.

APPENDIX TABLE 2

1970 SUGAR CONSUMPTION ESTIMATES, PRICE ELASTICITIES, AND DEMAND RELATIONSHIPS

Region	1970 estimated consumption, 1959 constant prices	1959 regional average price	Estimated 1970 price elasticities	Demand relationships
	1,000 metric tons			
Northwestern Europe	1,102.0	101.13	−0.16	Q = 1,278,573 − 1,746p
Western Europe	6,986.5	96.60	−0.32	Q = 9,222,210 − 23,144p
North Central Europe	5,041.4	95.73*	−0.32	Q = 6,655,121 − 16,857p
South Central Europe	2,620.7	75.44	−0.86	Q = 4,875,677 − 29,891p
Soviet Union	7,236.5	79.11	−0.42	Q = 10,276,223 − 38,424p
United States	10,322.4	140.40†	−0.16	Q = 11,973,925 − 11,763p
Canada	1,019.0	85.42	−0.16	Q = 1,182,067 − 1,909p
Central America and Caribbean	2,645.5	107.19*	−0.42	Q = 3,756,524 − 10,365p
Cuba	455.7	94.83*	−0.16	Q = 1,147,106 − 769p
Western South America	1,257.2	73.31*	−0.42	Q = 1,757,981 − 6,831p
Eastern South America	4,772.6	89.20*	−0.32	Q = 6,299,793 − 17,121p
Northwestern Middle East	979.0	76.90	−0.86	Q = 1,063,206 − 1,095p
Western Middle East	1,223.8	89.10	−0.86	Q = 2,276,249 − 11,812p
Middle East	5,936.1	112.04	−1.56	Q = 15,191,500 − 82,608p
Northern Far East	2,200.8	81.11	−1.56	Q = 5,634,511 − 42,834p
Northern Middle Far East	2,089.1	84.48	−2.36	Q = 6,892,886 − 56,863p
Taiwan	223.8	65.62*	−0.86	Q = 416,329 − 2,934p
Middle Far East	865.4	94.07	−2.30	Q = 2,855,169 − 21,152p
Philippines	577.6	120.63*	−0.86	Q = 1,074,475 − 4,119p
Southern Far East	1,437.6	73.39*	−1.56	Q = 3,679,958 − 30,554p
South Africa	1,228.1	102.92*	−0.42	Q = 1,744,038 − 5,013p
Central Africa	439.8	124.37	−1.56	Q = 1,125,701 − 5,515p
Eastern North Africa	940.8	100.72	−0.86	Q = 1,750,085 − 8,035p
Southwestern North Africa	482.4	142.37	−2.30	Q = 1,591,749 − 7,792p
Northwestern North Africa	994.5	119.53	−0.42	Q = 1,412,257 − 3,495p
Indian Ocean	41.8	124.77*	−0.32	Q = 55,150 − 107p
Australia	748.0	80.68*	−0.16	Q = 867,648 − 1,483p
Fiji Islands	22.4	100.16*	−0.32	Q = 29,612 − 72p
New Zealand	144.2	72.61	−0.16	Q = 167,290 − 318p
Hawaiian Islands	54.2	133.82*	−0.16	Q = 62,872 − 64.8p
Southern Oceania	18.7	100.63	−0.16	Q = 21,689 − 29.7p
United States Administrated Oceania	9.6	138.44	−0.32	Q = 12,673 − 22.2p
Rest of Southern Oceania	13.6	151.04	−2.30	Q = 44,865 − 207p

* Using average region export price

† Price based on 1959 average for United States imports of raw sugar, New York, duty paid, but excluding the excise tax, which was 6.24 cents per pound.

Appendix Table 3
SUGAR SUPPLY ESTIMATES, 1970

Region and country	Sugar supply estimates	Region and country	Sugar supply estimates
Denmark	Q = 378,362 + 646.2p	British Guiana	Q = 358,019 + 1,292p
Finland	Q = 75,000	Paraguay	Q = 43,810 + 258.5p
Sweden	Q = 375,000	Surinam	Q = 16,000
		Uruguay	Q = 90,000
Belgium	Q = 171,786 + 909.5p	Venezuela	Q = 450,000
France	Q = 1,874,021 + 1,292.3p		
Ireland	Q = 193,036	Israel	Q = 45,000
Netherlands	Q = 521,577 + 646.2p	Syria	Q = 18,000
Spain	Q = 625,000	Turkey	Q = 722,926 + 1,292p
Switzerland	Q = 65,000		
United Kingdom	Q = 1,200,000	Iran	Q = 200,000
		Ceylon	Q = 25,000
Austria	Q = 410,000	India	Q = 4,518,037 + 2,585p
Czechoslovakia	Q = 1,400,000	Pakistan	Q = 450,000
East Germany	Q = 925,000		
West Germany	Q = 1,613,760 + 265p	Japan	Q = 450,000
Hungary	Q = 525,000		
Poland	Q = 2,250,000	Mainland China	Q = 2,500,000
Bulgaria	Q = 300,000	Taiwan	Q = 1,199,917 + 2,585p
Greece	Q = 150,000		
Italy	Q = 1,592,300	Burma	Q = 90,000
Rumania	Q = 750,000	Thailand	Q = 240,000
Yugoslavia	Q = 650,000		
		Philippines	Q = 1,446,503 + 12,923p
U.S.S.R.	Q = 11,000,000		
		Indonesia	Q = 1,659,000
United States	Q = −7,892,624 + 93,046p		
		Angola	Q = 90,000
Canada	Q = 200,000	Rhodesia	Q = 225,000
		Malagasy	Q = 135,000
British Honduras	Q = 10,256 + 258.5p	Mozambique	Q = 300,000
Costa Rica	Q = 81,928 + 258.5p	Union of South Africa	Q = 1,298,580 + 2,585p
Dominican Republic	Q = 1,319,202 + 2,585p		
El Salvador	Q = 56,745 + 310p	Republic of the Congo	
Guadaloupe and Martinique	Q = 383,727 + 1,292p	(Leopoldville)	Q = 60,000
Mexico	Q = 2,268,942 + 2,585p	Kenya	Q = 55,000
Nicaragua	Q = 53,986 + 516.9p	Tanzania	Q = 60,000
Panama	Q = 30,271 + 129.2p	Uganda	Q = 165,000
Puerto Rico and Virgin			
Islands	Q = −1,657,027 + 20,677p	Ethiopia	Q = 72,000
Guatemala	Q = 164,790 + 259p	Somalia	Q = 25,000
Haiti	Q = 26,455 + 517p	Egypt	Q = 700,000
West Indies	Q = 944,015 + 1,938.5p		
		Republic of Congo	
Cuba	Q = 9,000,000	(Brazzaville)	Q = 50,000
Chile	Q = 160,000	Mauritius	Q = 708,763 + 646.2p
Colombia	Q = 492,088 + 387.7p	Reunion	Q = 237,111 + 646.2p
Ecuador	Q = 192,449 + 258.5p		
Peru	Q = 1,084,454 + 1,292p	Australia	Q = 1,465,960 + 5,169.2p
Argentina	Q = 908,282 + 3,618.4p	Fiji Islands	Q = 111,984 + 2,585p
Bolivia	Q = 125,000		
Brazil	Q = 4,590,715 + 10,338p	Hawaiian Islands	Q = −1,792,899 + 20,677p

APPENDIX TABLE 4

QUANTITY OF SUGAR EXPORTED AND IMPORTED, BY REGION 1959 AND 1963

Region	1959	1963
	metric tons	
Exports		
France	0	500,041
North Central Europe	853,348	0
Mexico	848,712	1,205,169
Jamaica	994,126	1,213,400
Martinique	19,260	261,793
Puerto Rico	921,268	810,272
Cuba	5,007,589	3,504,829
Western South America	310,937	380,030
Eastern South America	439,353	928,339
Middle East	0	214,418
Taiwan	673,078	677,528
Philippines	1,065,392	1,064,134
South Far East	4,670	130,966
Angola	136,283	155,082
Madagascar	32,918	69,658
Other South Africa	168,497	555,386
Mauritius	512,874	577,792
Reunion	156,595	222,370
Australia	654,692	1,146,779
Fiji Islands	183,382	261,683
Hawaiian Islands	857,393	928,803
Total exports	13,840,367	14,808,472
Imports		
Northwestern Europe	367,090	356,052
United Kingdom	1,967,870	2,225,422
France	159,366	0
Portugal	134,603	143,088
Other Western Europe	362,899	664,993
South Central Europe	183,258	0
North and South Central Europe	0	327,562
Soviet Union	120,500	219,227
United States	5,937,843	5,940,236
Canada	683,773	709,813
Northwestern Middle East	190,732	205,965
Western Middle East	561,776	581,804
Middle East	165,408	0
Northern Far East	1,246,819	1,430,334
Northern Middle Far East	99,176	412,977
Middle Far East	328,839	307,011
Central Africa	108,553	20,915
Eastern North Africa	206,110	226,718
Southwestern North Africa	271,376	293,796
Northwestern North Africa	623,928	595,745
New Zealand	98,862	121,311
South Oceania	8,070	13,494
United States Administrated Oceania	3,300	3,600
Rest of Southern Oceania	10,716	8,409
Total imports	13,840,367	14,808,472

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