ESTIMATION OF WELFARE EFFECTS OF U.S. SUGAR POLICY WITH TIME-VARYING PARAMETERS

By

RONALD CANBY LORD

Bachelor of Arts
Earlham College
Richmond, Indiana
1976

Master of Arts
University of Wisconsin
Madison, Wisconsin
1981

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Thesis Approved:

Daniel S. Tilley
Thesis Adviser

Daryll E. Ray

David M. Henneberry

Linda J. Young

Norman N. Durham
Dean of the Graduate College

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TABLE OF CONTENTS

Chapter		Page

LIST OF TABLES

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Problem Statement

The current sugar policy of the United States, which is designed primarily to protect the domestic sugar industry through the use of quotas on imports, has long been criticized by economists as being unfair and inefficient (Johnson; Leu, Schmitz and Knutson; Ives and Hurley). Yet it has been basically unchanged through administrations of both parties since the 1930s. Sugar policy may not be achieving the goals for which it was designed. The supply and demand for sugar are undergoing dynamic changes which may force the U.S. to make very difficult policy choices in the near future.

Over the last two decades U.S. per capita total sweetener consumption has increased, yet per capita sugar consumption has declined dramatically as high fructose corn syrup (HFCS) has replaced sugar as an ingredient in many foods and beverages. The linkage between policy and these trends in sugar demand needs to be carefully examined.

U.S. sugar production has risen to record levels in recent years, during which time the price support level has been constant in nominal terms, and declining in real terms. To support the U.S. sugar price above the world price, the U.S. has had to reduce sugar import quotas each year since they were instituted in 1982. The countries which have traditionally exported sugar to the U.S. include many developing countries which suffer export revenue losses when U.S. sugar imports decline.

Objectives

The effects of U.S. sugar policy are felt by all sectors of the industry, domestic and foreign. The overall objective of this study is to analyze the effects of this policy. Specific objectives are to:

1) measure the effects of U.S. sugar quotas on producers, consumers, taxpayers, and foreign suppliers

2) measure the welfare effects of the recent trend of substitution of High Fructose Corn Syrup for sugar

3) evaluate the welfare effects of the alternative policies of an equivalent tariff and a deficiency payment program

4) forecast the welfare effects of continuation of the current quota policy for the next two years.

Organization of the Study

In Chapter II, a survey of U.S. sugar policy and recent supply and demand trends will be presented. Other studies of sugar policy and the sugar industry are evaluated.

The conceptual framework of the analysis is presented in Chapter III, which consists of three sections. The first section includes a discussion of the derivation and use of equilibrium demand and supply curves, which allow measurement within a single market of the welfare effects of policy upon a group of related markets, such as the corn sweetener and sugar markets. In the second section the analytical techniques used to measure producer and consumer surplus are presented, where use is made of the equilibrium demand and supply curves explained in the first section. In the final section justifications for the use of a random coefficients model are presented.

In Chapter IV empirical estimates of U.S. sugar supply and demand equations are presented.

The impacts of the U.S. quota policy on sugar users, producers, taxpayers and foreign suppliers are presented in Chapter V, based upon the empirical supply and demand equations of Chapter IV. A forecast of the welfare implications of continuing the current quota policy is made, based upon a forecast of supply, demand and imports, with special reference to trade implications. Conclusions are presented in Chapter VI.

CHAPTER II

SUMMARY OF U.S. SUGAR POLICY AND RECENT TRENDS IN THE SUGAR INDUSTRY

In order to develop an econometric model of sugar supply and demand it is important to understand the industry and trends occurring in recent years. The recent history of U.S. sugar policy, the U.S. sugar and sweetener industry, and recent trends in the supply and demand for U.S. sugar are described in the Chapter. The degree to which published econometric models have been able to capture these trends is also evaluated.

History of U.S. Sugar Policy

The United States first instituted a tariff on sugar on July 4, 1789, not long after a revolutionary war fought in part over tariffs on sugar. The justification then was revenue for the young country. Revenue has long since ceased as an objective of sugar policy, but government intervention continues.

Current legislation has its origins in the Sugar Act of 1934, also known as the Jones-Costigan Act. The Jones-Costigan Act was designed to assist sugar growers who faced lower priced sugar from abroad, and all subsequent sugar legislation has had the same basic purpose. Most sugar legislation since the 1930s has included the following provisions: (i) a duty on imported sugar, which is periodically adjustable (ii) strict import quotas allocated among exporting countries on political considerations (iii) allotments of domestic production among the various beet and cane growing areas (iv) mechanisms to guarantee to producers a minimum price, including a nonrecourse loan program (v) provision for equity of program impacts between cane and beet growers. Minimum wage rates for field workers and child labor provisions have been included in some of the acts.

Since the U.S. has always imported sugar, U.S. sugar policy is strongly affected by events in the world markets. The world sugar price from 1960-87 is shown in Table 1, and it is seen to fluctuate widely and rapidly, even on an annual average basis. In Figure 1 the world sugar price peaks of 1963, 1974 and 1980 are clearly seen. This sugar price cycle has been described by many experts in the following way. Each cyclical price peak in the world price has resulted in an expansion of production, which soon brings price lower. Due to protection and government subsidies, however, the higher supply capacity is maintained during periods of low prices. Eventually, consumption increases to the point where another price jump is triggered. U.S. prices follow world prices upward, but not downward.

The following is a brief description of U.S. sugar legislation since the early 1970s. More details can be found

TABLE 1

SUGAR PRICES, 1960-87

Year	World Raw (1)	New York Raw (2)	Chicago Refined (3)	U.S. Retail Refined (4)
	-----cents per pound----------			
1960	3.1	6.3	8.77	11.6
1961	2.9	6.3	8.59	11.8
1962	3.0	6.5	8.95	11.7
1963	8.5	8.2	10.34	13.6
1964	5.9	6.9	9.38	12.8
1965	2.1	6.8	9.15	11.8
1966	1.9	7.0	9.44	12.0
1967	2.0	7.3	9.70	12.1
1968	2.0	7.5	9.94	12.2
1969	3.4	7.8	10.23	12.4
1970	3.8	8.1	11.08	13.0
1971	4.5	8.5	11.59	13.6
1972	7.4	9.1	11.82	13.9
1973	9.6	10.3	12.38	15.1
1974	30.0	29.5	32.07	32.3
1975	20.5	22.5	27.87	37.2
1976	12.0	13.3	16.93	24.0
1977	8.1	11.0	15.08	21.6
1978	7.8	13.9	18.93	23.7
1979	9.7	15.6	19.68	24.9
1980	29.0	30.1	38.29	42.7
1981	16.9	19.7	28.26	40.0
1982	8.4	19.9	27.62	34.5
1983	8.5	22.0	26.10	36.2
1984	5.2	21.7	25.66	36.3
1985	4.0	20.3	23.18	35.3
1986	6.1	21.0	23.42	35.1
1987	6.7	21.8	23.60	35.3

Source: USDA Sugar and Sweetener Reports

(1) F.o.b. Caribbean, Contract No. 11
(2) C.i.f., duty/fee paid, Contract No. 12
(3) Wholesale refined beet sugar list price, Chicago-West market
(4) Refined sugar retail price, average

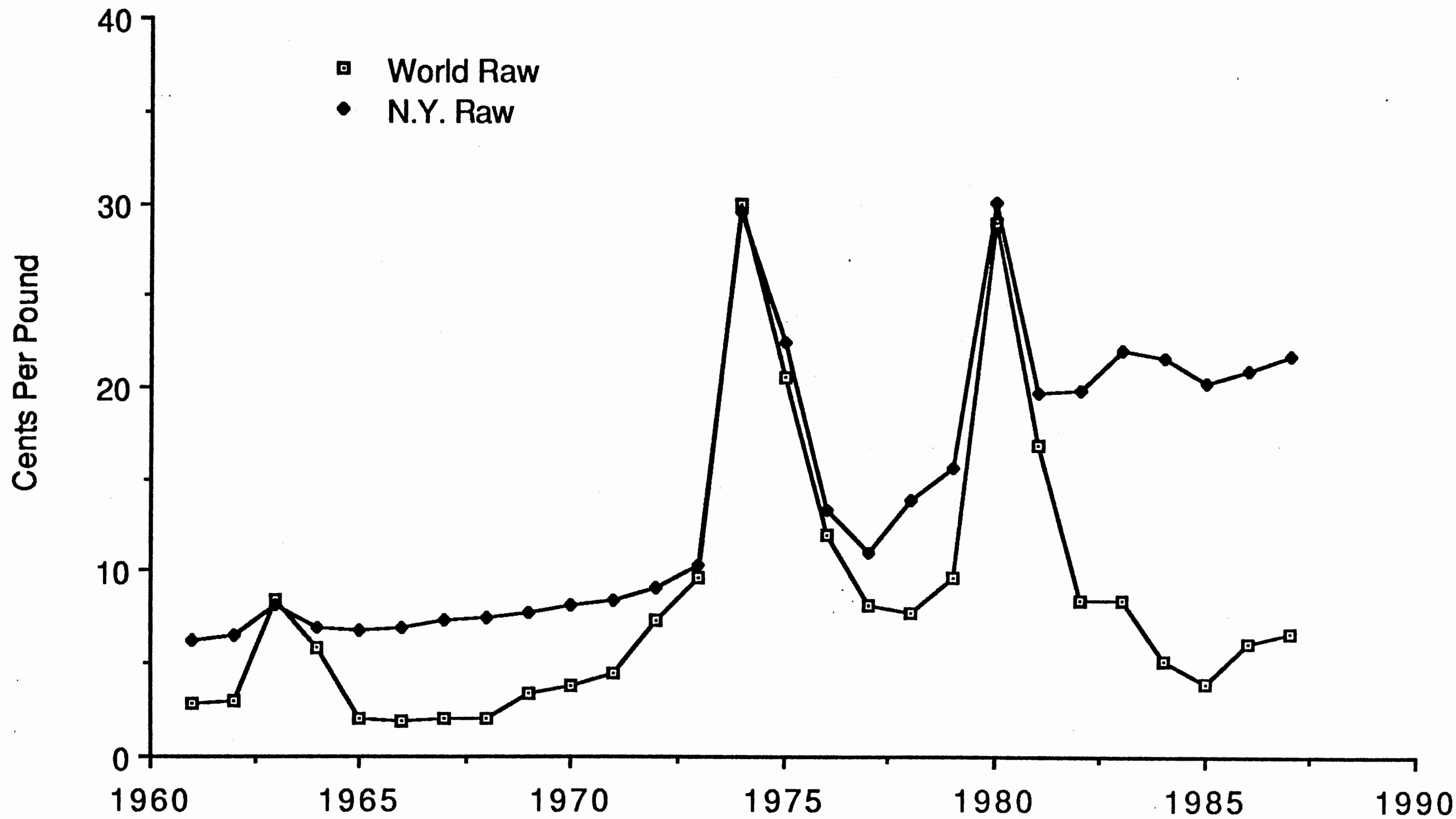


Figure 1. Sugar Prices, 1961-87

in the USDA Sugar and Sweetener Reports. In 1974, high world prices contributed to the fact that the existing sugar legislation, which expired on December 31, 1974 was not replaced. Consumers and producers had faced high sugar prices in 1974 and there was little political pressure for continuance of support for an industry which was apparently healthy.

However, by 1977 low world prices stimulated new legislation. The Food and Agriculture Act of 1977 provided support to the domestic industry in the form of non-recourse loans and import fees and duties to try to prevent forfeitures of sugar to the Commodity Credit Corporation. In 1979, sugar policy reverted to authority based on the Agriculture Act of 1949, and supported raw sugar prices in the range of 14-16 cents per pound, the same of the 1977 legislation. High world prices occurred again in 1980 and 1981, so that no government support was deemed necessary.

Following the 1981 price peak new legislation was enacted with a nonrecourse loan rate of 17 cents, which was to rise in several steps to 18 cents by 1985. It became an important goal of policy to avoid overt government expenditures on sugar. Strict quotas, at the time thought to be temporary, were instituted by the President in May 1982 and have continued to the present. A Market Stabilization Price (MSP) was established, which was designed to prevent the possibility of any expenditures on sugar by the federal government. The USDA is charged with periodically calculating the MSP, and ensuring that is it high enough to prevent any forfeitures of sugar under loan. Import quotas are then used to defend the MSP.

The 1985 Food Security Act provided for continuance of sugar policy more or less as it had been under the 1981 legislation, and continued the loan rate at 18 cents a pound for raw sugar. A significant change in the 1985 legislation was that the recommendation that sugar policy be conducted at no monetary cost to the federal government was made mandatory. Thus the MSP became an even more certain floor price for producers than it had been before, and the possibility of loan forfeitures was almost eliminated.

In 1987, the U.S. raw sugar price was about 21¢ per pound, while the world "free" market raw sugar price was about 6¢ per pound. Since the U.S. enacted the latest round of import quotas in 1982, the differential between the U.S. and world raw sugar price has averaged 14.6¢ per pound (USDA, 1987a).

Trends in U.S. Sugar Supply

Table 2 shows annual U.S. beet, cane and total sugar production from 1960 to 1987. Production has exhibited a rising trend from about 3.5 million metric tons refined value in 1960 to over 6 million metric tons in 1987, as is clearly seen in Figure 2.

Beet production has exceeded cane production in all years except from 1982-84. Figure 3 gives acreage harvested

TABLE 2

U.S. SUGAR PRODUCTION, 1960-87

Year	Cane	Beet	Total
	(thousand metric tons, refined value)		
1960	1327.7	2077.2	3404.9
1961	1653.3	2038.2	3691.5
1962	1672.0	2192.5	3864.5
1963	1936.5	2624.9	4561.4
1964	1972.1	2787.7	4759.8
1965	1968.7	2453.7	4422.4
1966	2075.5	2397.7	4473.2
1967	2245.1	2234.9	4480.0
1968	2074.7	2953.0	5027.7
1969	1911.0	2823.3	4734.4
1970	2048.4	2883.5	4931.9
1971	2065.4	3011.5	5076.9
1972	2323.1	3072.6	5395.7
1973	2161.2	2713.1	4874.3
1974	2129.8	2472.3	4602.1
1975	2487.6	3407.5	5895.1
1976	2309.5	3302.4	5611.9
1977	2275.6	2635.1	4910.7
1978	2214.6	2788.6	5003.1
1979	2289.2	2440.9	4730.1
1980	2312.9	2669.9	4982.8
1981	2401.9	2872.5	5274.4
1982	2596.9	2320.6	4917.5
1983	2484.2	2288.3	4772.5
1984	2549.5	2463.0	5012.5
1985	2571.5	2543.5	5115.0
1986	2781.8	2896.2	5678.0
1987	2855.5	3354.9	6210.5

Source: USDA, Sugar and Sweetener Reports

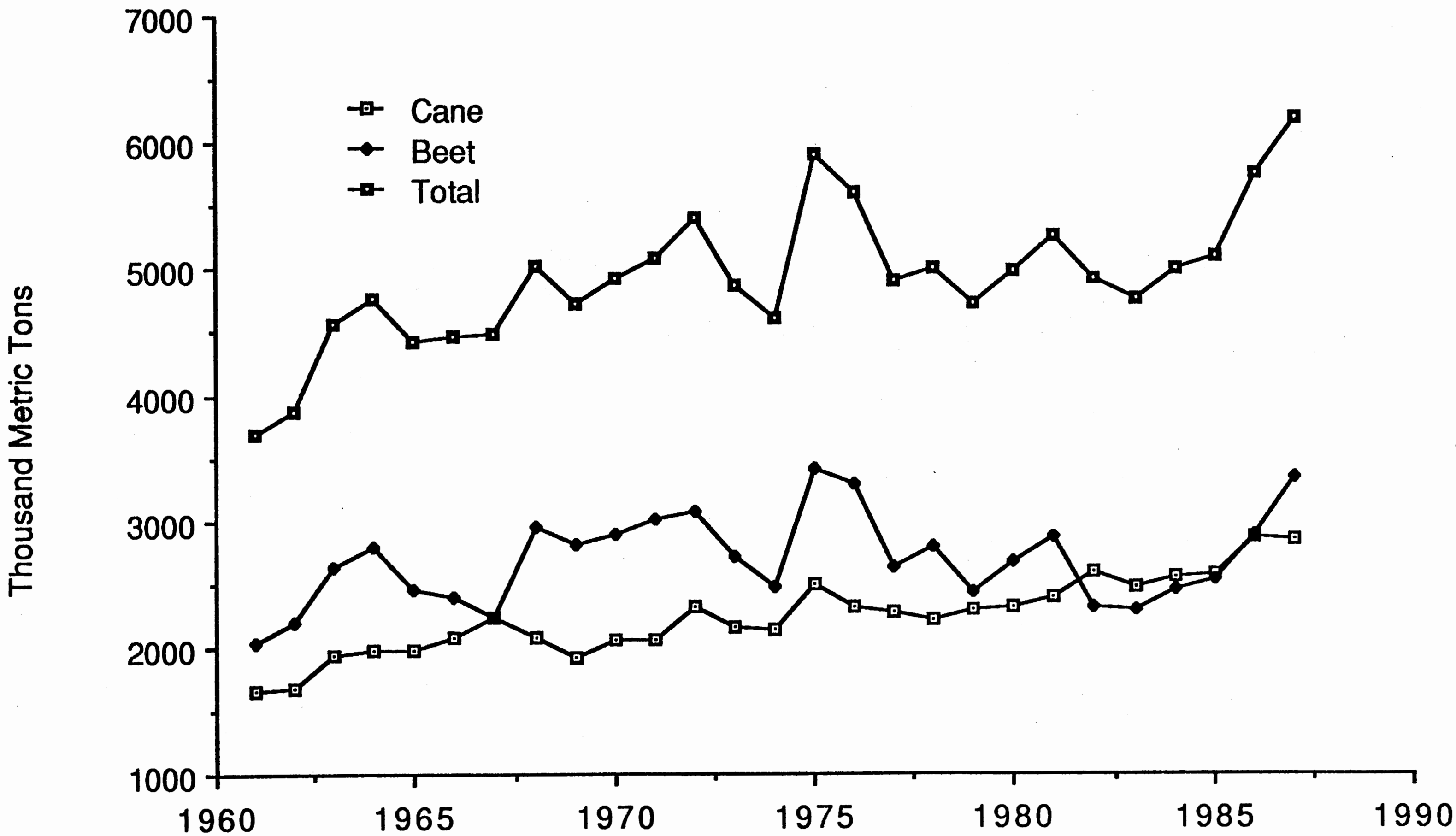


Figure 2. U.S. Sugar Production, 1961-87

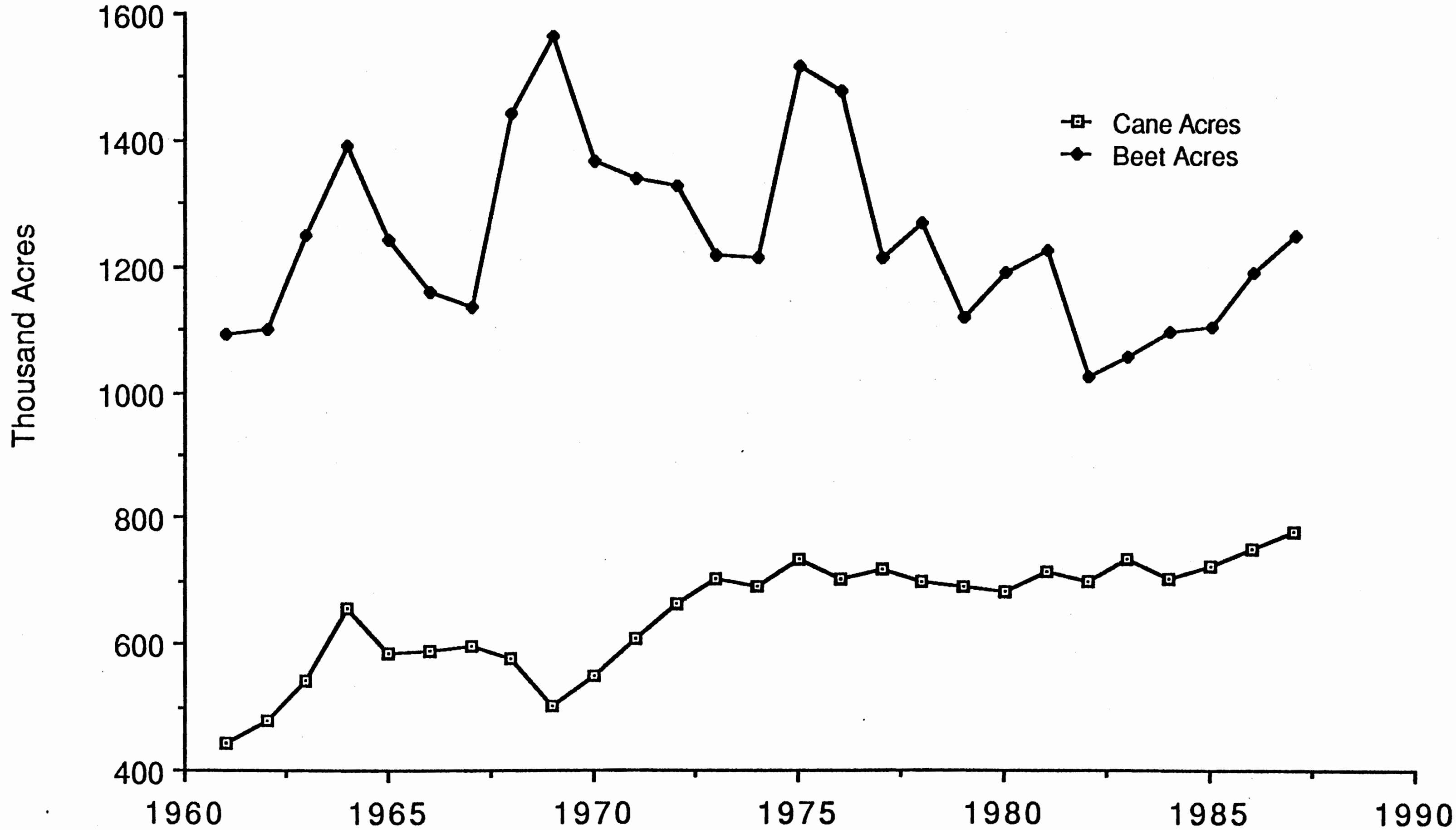


Figure 3. U.S. Sugar Acreage Harvested, 1961-87

of beet and cane, and shows a large drop in sugarbeet acreage starting in 1975, before the increasing trend which started in 1982. These declines in sugarbeet acreage were due primarily to the closing of sugarbeet refineries; in just one year, 1981-82, five factories closed. In 1970 there were 58 factories, with a total capacity of slicing 193,000 tons of beets per day, and in 1987 there were 36 factories, with a total slicing capacity of 168,000 tons of beets per day (USDA, Sugar and Sweetener Report). Thus, production has increased in recent years even as the number of factories has declined. Slicing capacity per factory has risen, however, as has the utilization of capacity, which can be extended not only by increasing the amount of beets sliced per day, but also by extending the length of the slicing season.

Yields are shown in Figure 4. Both cane and beet yields show considerable variation, which is due primarily to weather and disease. Since 1983 both acreage harvested and yield have increased for both beet and cane, except for a small decline in beet yield in 1985. The yield of cane sugar increased about 7.5 percent between 1975-80 and 1981-85, compared to a yield increase for beet sugar of about 2.3 percent over the same period.

Figure 5 shows real sugar price and U.S. production of sugar on a normalized scale from 1970-87. The real price has declined since 1981, and yet since 1983, production has been increasing. This phenomenon will be important to capture in the specification of the supply equation. For the moment it

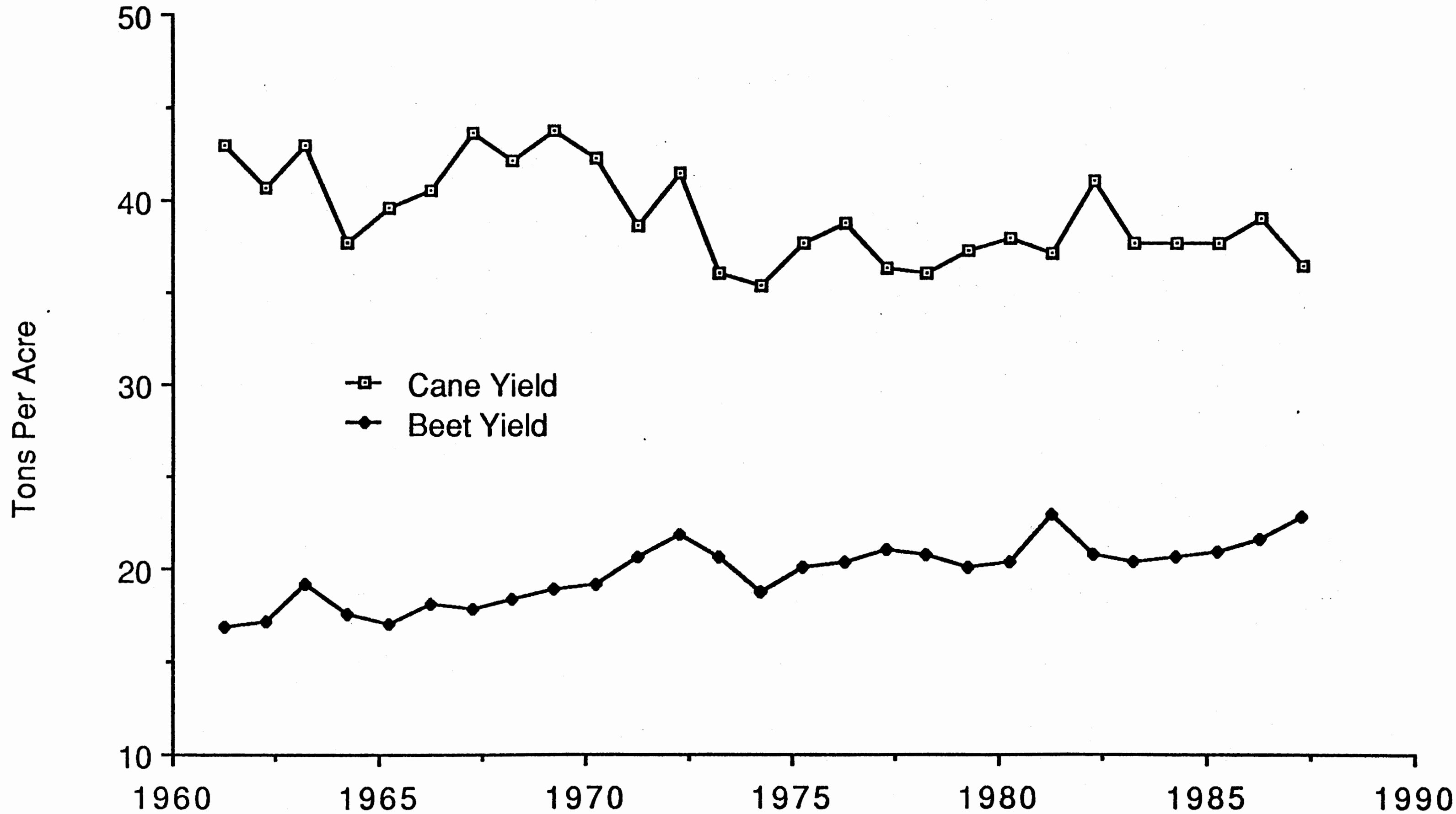


Figure 4. U.S. Sugar Beet and Cane Yields, 1961-87

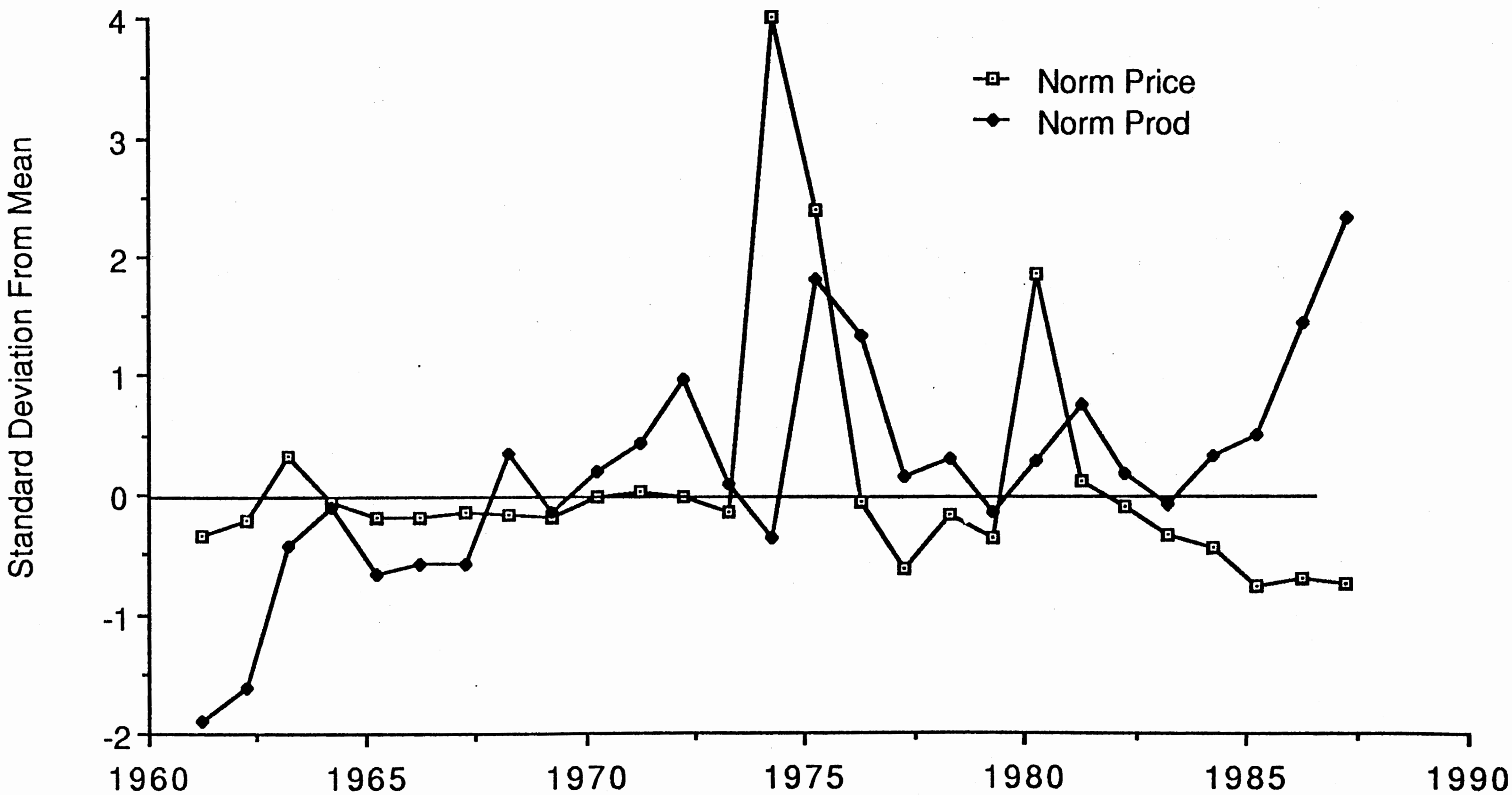


Figure 5. U.S. Sugar Price and Production, Normalized, 1961-87

will merely be noted that when producers know that price can not fall below a certain level, one important source of risk is removed. This reduction of future price risk, which lasts for the duration of the legislation, provides an increase in the expectation of profitability to sugar producers. It is also possible for current production to be influenced by expected future legislation.

Trends in U.S. Sugar Demand

Table 3 shows U.S. per capita consumption of various sweeteners from 1960 to 1987. Per capita sugar consumption was fairly steady at almost one hundred pounds per person per year during the 1960s and early 1970s, though trending slowly upwards. From 1960 to 1971, per capita sugar consumption rose by about 5 pounds per year. But after 1971, per capita consumption fell almost continuously until 1987, when it rose slightly from 1986 levels. The decline from 1971 to 1986, from about 100 to about 60 pounds, is about forty percent. This decline is strongly associated with sugar policy and the rising consumption of corn sweeteners and low calorie sweeteners.

In contrast to declining sugar consumption, per capita consumption of all sweeteners has risen steadily during the last three decades. Total caloric sweetener consumption rose from 111.2 pounds per person in 1960 to 132.4 pound per person in 1987, an increase of 21 pounds or about 20 percent.

TABLE 3

U.S. PER CAPITA CONSUMPTION OF VARIOUS SWEETENERS, 1960-1987

Year	Refined Sugar	Corn Sweeteners	Total Low Calorie	Total Caloric	Total All Sweeteners
	------ pounds per capita ------				
1960	97.6	11.6	2.2	111.2	113.4
1961	97.8	12.0	2.5	111.7	114.2
1962	97.9	12.9	2.9	112.8	115.7
1963	97.3	14.2	3.7	113.3	117.0
1964	96.8	15.0	4.8	113.5	118.3
1965	97.0	15.1	5.7	113.9	119.6
1966	97.3	15.4	6.4	114.4	120.8
1967	98.5	16.1	6.9	116.1	123.0
1968	99.2	16.9	7.2	118.0	125.2
1969	101.0	18.2	6.9	120.8	127.7
1970	101.8	19.3	5.8	122.6	128.4
1971	102.1	20.8	5.1	124.3	129.4
1972	102.3	21.1	5.1	124.9	130.7
1973	100.8	23.4	5.1	125.6	130.7
1974	95.7	25.1	5.9	121.9	127.8
1975	89.2	27.5	6.1	118.1	124.2
1976	93.4	29.7	6.1	124.4	130.5
1977	94.2	31.2	6.6	126.8	133.4
1978	91.4	33.7	6.9	126.6	133.5
1979	89.3	36.3	7.3	127.1	134.4
1980	83.6	40.2	7.7	125.1	132.8
1981	79.4	44.5	8.2	125.1	133.3
1982	73.7	48.2	9.4	123.2	132.6
1983	71.1	52.2	13.0	124.6	137.6
1984	67.4	57.8	15.8	126.6	142.5
1985	63.0	66.5	18.0	130.9	142.4
1986	60.2	67.1	18.5	128.7	148.9
1987	62.2	68.8	19.0	132.4	147.2

Source: USDA Sugar and Sweetener Reports

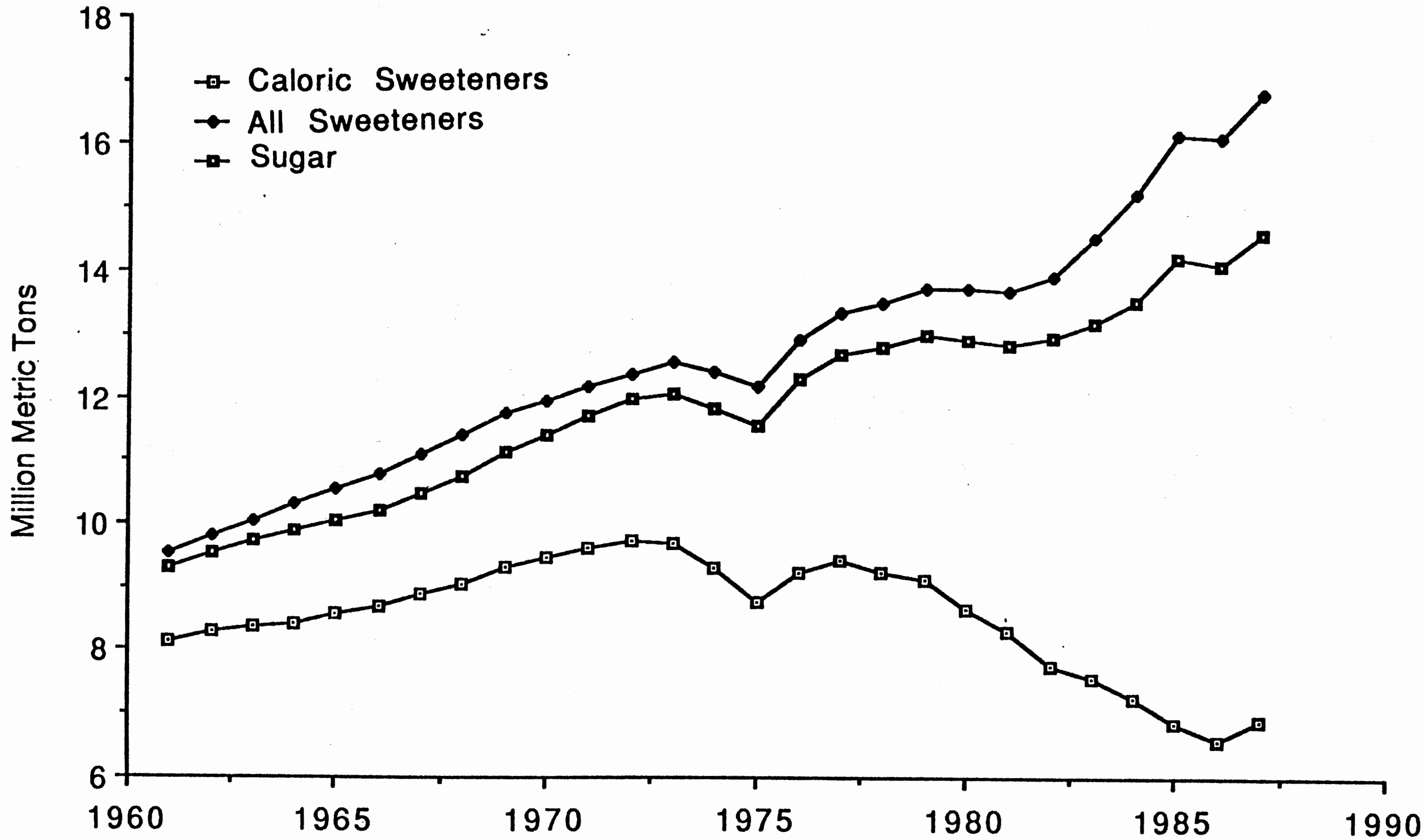


Figure 6. Total U.S. Sweetener Consumption, 1961-87

Low Calorie Sweeteners

Low calorie sweetener use has been trending upwards in the U.S. since the early 1960s. From 1960 to 1971, consumption of all low calorie sweeteners rose from 2.2 to 5.1 pounds per person per year (sugar-weight equivalent basis), rising in most years, but slackening off somewhat during a period of "cancer scare" when sweeteners containing cyclamates were banned in 1970. From 1970 to 1982, the dominant artificial sweetener was saccharin. Table 4 shows consumption of saccharin, aspartame and total low calorie sweeteners from 1960 to 1987. The introduction of aspartame in 1982 shows dramatically in Table 4, as consumer acceptance of aspartame has been good. Figure 7 shows the dramatic decline in per capita sugar consumption at the same time that per capita low calorie sweetener consumption is rising.

The Food and Drug Administration has recently approved a new artificial sweetener, acesulfame K, for certain uses; it has about the same sweetening power as aspartame (200 times that of sugar) but is more stable and possibly cheaper. The Center for Science in the Public Interest says the sweetener, to be marketed under the brand name Sunette, caused tumors in laboratory animals (New York Times, 7/27/88). Similar concerns have been raised about aspartame, but these concerns have not reduced consumption significantly. It is likely that new products will continue to be developed, and in time low calorie sweeteners could cut further into the market share of the caloric sweeteners.

TABLE 4

U.S. PER CAPITA CONSUMPTION OF LOW CALORIE SWEETENERS 1960-1987

Calendar Year	Sacc-harin and Other	Aspar-tame	Total Low Calorie Sweeteners
	pounds per capita		
1960	2.2	0.0	2.2
1961	2.5	0.0	2.5
1962	2.9	0.0	2.9
1963	3.7	0.0	3.7
1964	4.8	0.0	4.8
1965	5.7	0.0	5.7
1966	6.4	0.0	6.4
1967	6.9	0.0	6.9
1968	7.2	0.0	7.2
1969	6.9	0.0	6.9
1970	5.8	0.0	5.8
1971	5.1	0.0	5.1
1972	5.1	0.0	5.1
1973	5.1	0.0	5.1
1974	5.9	0.0	5.9
1975	6.1	0.0	6.1
1976	6.1	0.0	6.1
1977	6.6	0.0	6.6
1978	6.9	0.0	6.9
1979	7.3	0.0	7.3
1980	7.7	0.0	7.7
1981	8.0	0.2	8.2
1982	8.4	1.0	9.4
1983	9.5	3.5	13.0
1984	10.0	5.8	15.8
1985	6.0	12.0	18.0
1986	5.5	13.0	18.5
1987	5.5	13.5	19.0

Source: USDA Sugar and Sweetener Reports

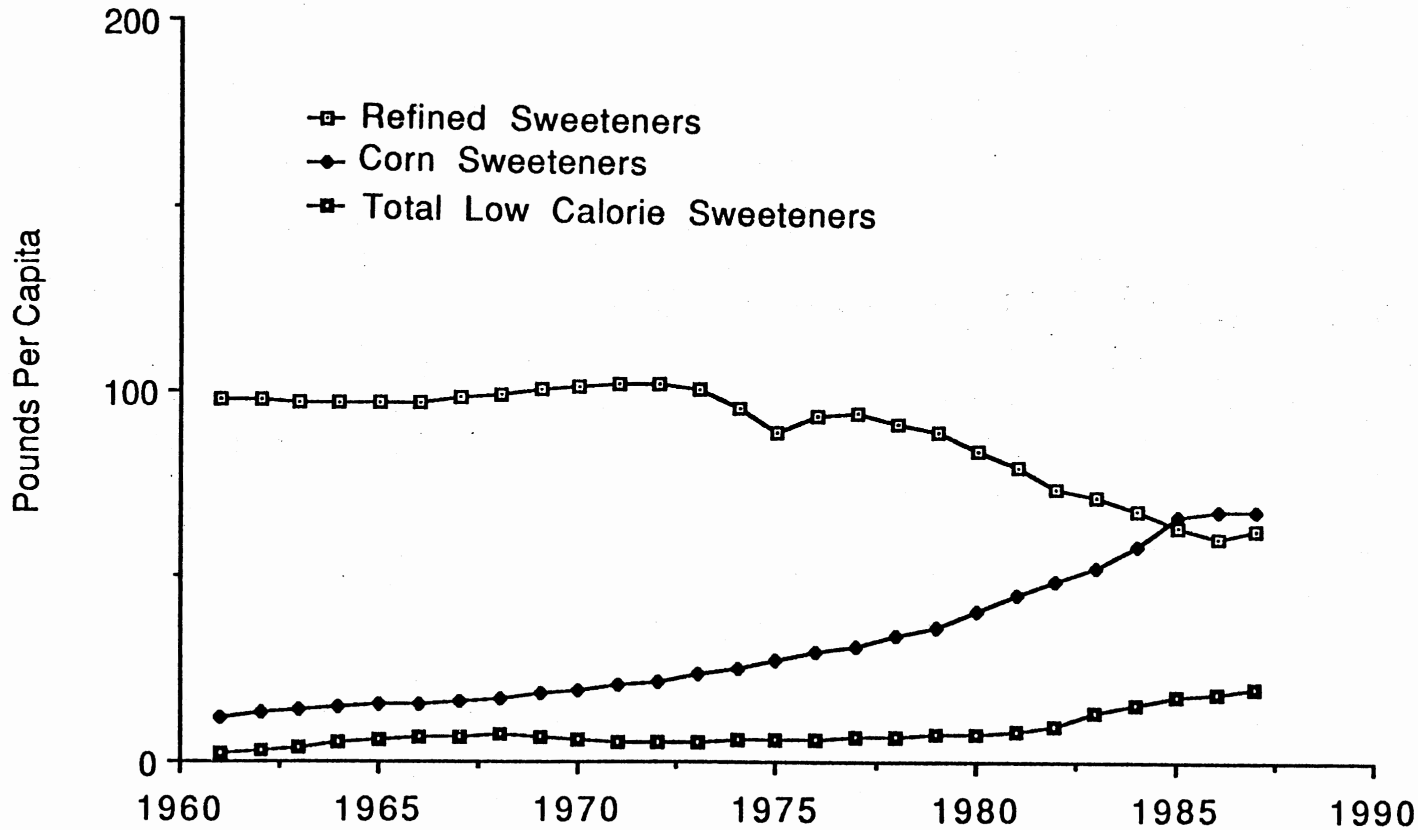


Figure 7. U.S. Per Capita Consumption Various Sweeteners, 1961-87

Corn Sweeteners

U.S. annual per capita consumption of corn sweeteners rose from 11.6 pounds in 1960 to 67.9 pounds in 1987, as Table 3 shows. This is an increase of about 600 percent in just twenty-seven years. Figure 7 clearly shows the rising per capita corn sweetener consumption trend since about 1970, along with the declining sugar consumption trend. As is also seen in Figure 7, per capita consumption of corn sweeteners exceeded per capita consumption of sugar for the first time in 1985.

Table 5 shows the per capita consumption of the corn sweeteners. Glucose and dextrose are used primarily in baking and confectionery products, and their market share has remained relatively constant, although per capita dextrose consumption doubled from 1960 to 1987. The most dramatic increases are seen with the High Fructose Corn Syrups, HFCS-42 and HFCS-55. HFCS-42, which was introduced in 1969, has been substituted for sugar in many commercial products, and has risen to a per capita consumption level of 18.9 pounds in 1987. HFCS-55, which was not introduced until 1981, has achieved a per capita consumption level of 28.4 pounds in 1987.

HFCS-42 derives its name from the fact that it contains 42 percent fructose, the remainder being dextrose and other polysaccharides. HFCS-55 contains 55 percent fructose, 42 percent dextrose, and 3 percent other polysaccharides. The HFCS products have a low potential for crystallization which

TABLE 5

U.S. PER CAPITA CONSUMPTION OF CORN SWEETENERS, 1960-87

Year	HFCS-42	HFCS-55	Total HFCS	Glucose Corn Syrup	Dextrose	All Corn Sweeteners
	------- pounds per capita per year ---------					
1960	0.0	0.0	0.0	8.0	3.6	11.6
1961	0.0	0.0	0.0	8.6	3.4	12.0
1962	0.0	0.0	0.0	9.3	3.6	12.9
1963	0.0	0.0	0.0	9.9	4.3	14.2
1964	0.0	0.0	0.0	10.9	4.1	15.0
1965	0.0	0.0	0.0	11.0	4.1	15.1
1966	0.0	0.0	0.0	11.2	4.2	15.4
1967	0.0	0.0	0.0	11.9	4.2	16.1
1968	0.0	0.0	0.0	12.6	4.3	16.9
1969	0.0	0.5	0.5	13.2	4.5	18.2
1970	0.0	0.7	0.7	14.0	4.6	19.3
1971	0.0	0.9	0.9	14.9	5.0	20.8
1972	0.0	1.3	1.3	15.4	4.4	21.1
1973	0.0	2.1	2.1	16.5	4.8	23.4
1974	0.0	3.0	3.0	17.2	4.9	25.1
1975	0.0	5.0	5.0	17.5	5.0	27.5
1976	0.0	7.2	7.2	17.5	5.0	29.7
1977	0.0	9.5	9.5	17.6	4.1	31.2
1978	0.0	12.1	12.1	17.8	3.8	33.7
1979	0.0	14.9	14.9	17.9	3.6	36.4
1980	0.0	19.1	19.1	17.6	3.5	40.2
1981	4.2	16.8	21.0	17.8	3.5	42.3
1982	6.6	19.7	26.3	18.0	3.5	47.8
1983	9.0	21.0	30.0	18.0	3.5	51.5
1984	14.3	21.5	35.8	18.0	3.5	57.3
1985	22.5	22.5	45.0	18.1	3.5	66.6
1986	27.4	18.2	45.6	18.0	3.6	67.2
1987	28.4	18.9	47.3	18.0	3.5	68.8

Source: USDA Sugar and Sweetener Reports

is often a problem in products with high solids and high sucrose content (Carmen and Thor). Each different sweetener has characteristics which make it more desirable for certain uses, even at a higher price. At the same time, there is a wide range for varying the percent of any one sweetener in most commercial applications; and many products contain three or four sweeteners, the precise mix being determined by technological and market conditions at any one time. The same trend of increasingly easy substitutability is seen is other markets such as the oilseeds.

Until it was rescinded on October 29, 1974, the Food and Drug Administration had a regulation which placed a ceiling of 25 percent of total sweetener content in jams, jellies, and preserved which could be obtained from corn sweeteners (Carmen and Thor). While the U.S. has eliminated regulatory restraint of corn sweetener use, Japan, the European Community and several other countries continue to restrict the use of corn sweetener in order to protect sugar interests.

The soft drink market plays a particularly important role as a consumer of HFCS. The major soft drink companies were hesitant to risk changing their formulas in the early 1980s, when HFCS-55 came onto the market. But in December 1984, the soft drink industry decided to allow HFCS substitution of up to 100 percent for sucrose in its syrups (Lin and Novick). Soft drink consumers have not generally objected to the substitution.

At the same time that HFCS-55 was being developed and allowed to penetrate new markets such as soft drinks, the soft drink market was growing rapidly. In 1986, for the first time Americans drank more soft drinks than any other liquid, including water. Table 6 shows the market penetration of HFCS in 1987 by sector. HFCS has achieved the most dominance in the beverage market, where it had achieved a 96 percent market share of sweeteners used in the industry in 1987. The right column of the table provides an estimate of the long-run maximum penetration of HFCS in each market. For beverages, baking, canning, processed foods, and dairy products, it appears that HFCS has achieved its limit of market penetration; and in confections its potential limit of 5 percent leaves little room for growth.

Econometric Studies of the Sweetener Industry

A study of HFCS substitution for sugar was done by Carman and Thor in 1979, who used a logistic growth curve model to project HFCS market penetration. Their projections to 1985 are shown in Table 7, along with actual 1985 data. The projections for glucose and dextrose and the minor sweeteners (honey and maple syrup) were quite accurate, and exactly correct on a per capita basis. But their projection for per capita consumption of HFCS was too low by almost 100 percent, a forecast of 24.7 pounds compared with an actual consumption rate of 45 pounds. Similarly, their forecast of 1985 per capita sugar consumption, 82.6 pounds, was almost 20

TABLE 6

HFCS PENETRATION BY MARKET CATEGORY

Sector	HFCS Share of Caloric Sweeteners 1987	Long-term Theoretical Penetration
	----- percent -----	
Beverages	96	90-100
Baking	25	25
Canning	66	60-70
Processed Foods	66	60-70
Dairy Products	35	35
Confections	3	5

Source: Lin and Novick

TABLE 7

U.S. CONSUMPTION OF SWEETENERS, PROJECTED AND ACTUAL, 1985

	Per Capita		Total	
	Projected	Actual	Projected	Actual
Glucose	22.8	22.8	2630	2776
Minor Sweeteners	1.4	1.4	161	170
HFCS	24.7	45	2848	5390
Sugar	82.6	63.3	9527	7579
Total	131.5	131.4	15166	15716

Source: Projected -Carmen and Thor (1979)
Actual -USDA, Sugar and Sweetener Report

pounds higher than the actual consumption rate was 63.3 pounds. Events such as the major soft drink bottlers switching to 100 percent usage of HFCS in their products, and the extent of the increase in the popularity of soft drinks, were apparently not anticipated in 1979.

In a study for the World Bank, de Vries (1980) made projections for U.S. sugar consumption, production and imports, as shown in Table 9. The table gives data in total metric tons. de Vries' projection for total U.S. sugar consumption was 10,181 tons, compared to the actual 1985 value of 7540 tons. That level of actual total consumption was below any year since the 1940s.

de Vries also made projections for world sugar price, shown in Table 8. The ranges shown for the projected prices were calculated by making 500 runs of the model using stochastic changes in the explanatory variable "stock changes", and setting the range such that 2.5 percent of all projections fell above and below it. The quoted price range was presented by de Vries as a 95 percent confidence interval on expected prices. But the actual price was outside the 95 percent confidence interval in the first projected year, and in fact in only one year of six (1981) did actual price fall with the 95 percent confidence interval.

These forecasting errors could be due to numerous causes. The studies quoted above relied on traditional, fixed coefficient econometric techniques, and did not include a variables for "policy". It is difficult, if not

TABLE 8

PROJECTED AND ACTUAL SUGAR PRICES

Year	Projected	Actual
	--cents per pound--	
1980	13-26	29.0
1981	15-38	16.9
1982	17-46	8.4
1983	14-38	8.5
1984	11-30	5.2
1985	7-24	4.0

Sources: Projected price - de Vries
Actual Price - USDA Sugar
and Sweetener Report

TABLE 9

U.S. ACTUAL AND PROJECTED SUGAR PRODUCTION, CONSUMPTION AND IMPORTS

	Actual 1974-76 Average	1985 Projected	1985 Actual
	-------Thousand metric tons----		
Production	5930	5787	7278
Consumption	9822	10181	7540
Imports	4331	4768	2113

Source: Projected -de Vries, p. 59
Actual -USDA Sugar and Sweetener Reports

impossible, to endogenize policy variables in models, but without a specification which can include policy impacts, results are likely to be disappointing. Random coefficients models provide a technique to capture policy impacts which could not be explicitly specified in a conventional model, and will be discussed in the next chapter.

CHAPTER III

CONCEPTUAL FRAMEWORK OF ANALYSIS

This chapter provides a conceptual framework for the welfare measures which are derived in Chapter V, and for the supply and demand equation estimations of Chapter IV. The first section describes the theory underlying the equilibrium demand curves used for welfare analysis. The next section outlines the analytical techniques to be used in evaluating alternative U.S. sugar policy options. The last section describes the Cooley-Prescott random coefficient model used in the empirical estimation of the supply and demand curves.

Derivation of Equilibrium Demand Curves

Given appropriate supply and demand curves, economic theory can be used to derive measures of the welfare effects of various policies on different economic groups. The following analysis, based on the work of Just, Hueth and Schmitz (1982, Chapter 9), provides a technique to capture welfare impacts in several related markets.

Let there be two horizontally related industries, A and B, producing goods A and B which are substitutes in consumption. Figure 8 shows the industries in initial equilibrium at prices P_A^0 and P_B^0. Since the goods are

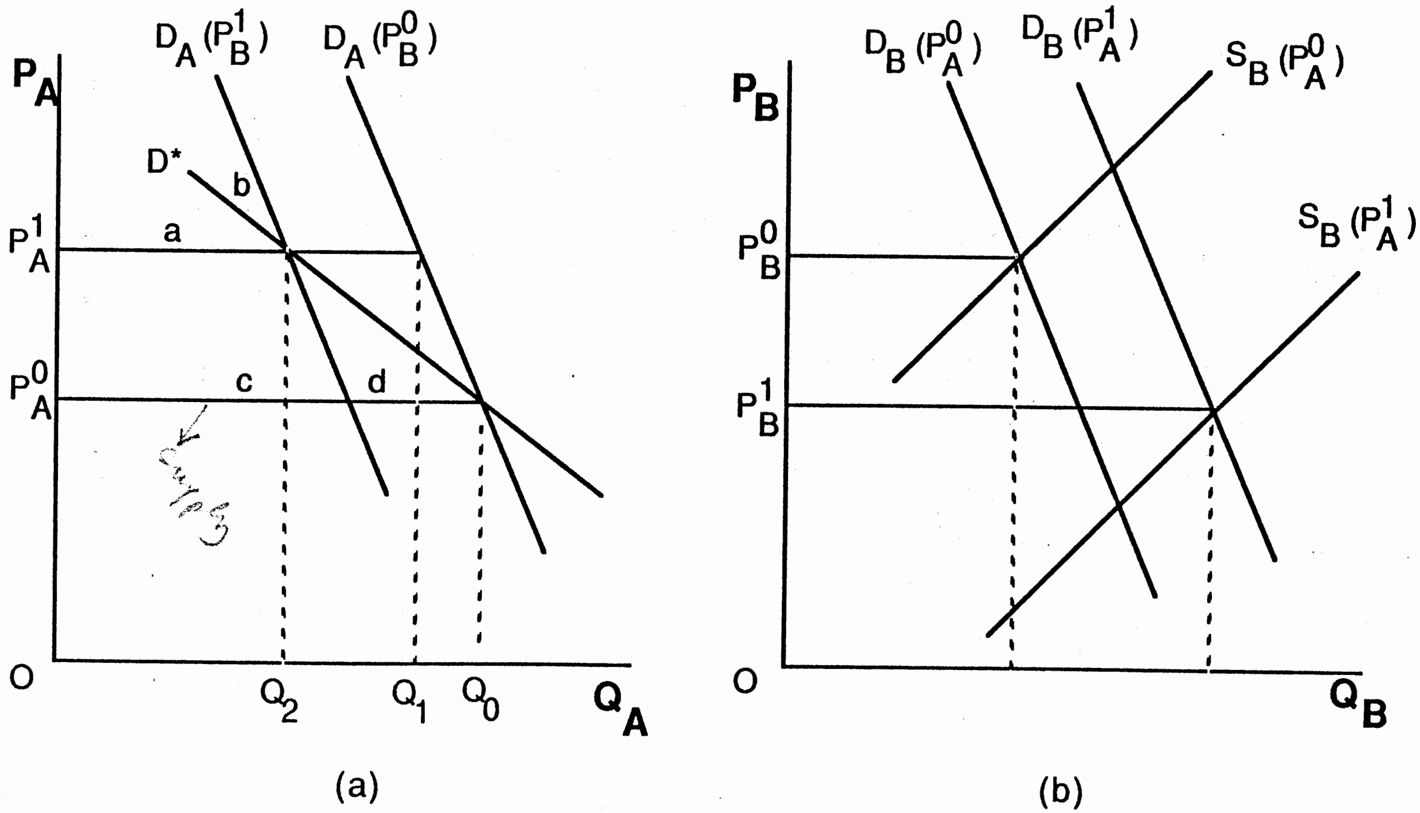


Figure 8. Horizontally Related Markets.

Source: Just, Hueth & Schmitz

substitutes in consumption, the demands for each good are a function of the price of the other good, and initial equilibrium demands are $D_A(P_B^0)$ and $D_B(P_A^0)$. Supply of good B is $S_B^0(P_A^0)$, while the supply curve for good A is horizontal at the (controlled) price line, P_A^0, assuming marginal cost is less than the price.

Initially the price of good A is fixed at P_A^0. Now suppose that authorities raise the price of good A to P_A^1. In a partial equilibrium framework, ceteris paribus, consumers would reduce purchases, cutting consumption from Q_0 to Q_1.

But the price increase for good A has effects in the market for good B. Given the higher price P_A^1, the demand for good B shifts to $D_B(P_A^1)$, and the supply of good B shifts outward from $S_B(P_A^0)$ to $S_B(P_A^1)$, perhaps as a result of economies of scale. The net result is a drop in the price or good B from P_B^0 to P_B^1.

This change of price for good B will cause the demand curve for good A to shift from $D_A(P_B^0)$ to $D_A(P_B^1)$, so that instead of producing at Q_1, industry A will end up producing at Q_2.

The actual demand curve facing industry A, then, is D^*, which is the "equilibrium" demand curve associated with the price change from P_A^0 to P_A^1 after taking into account equilibrium adjustments in the related market. By assumption, good B is the only significant substitute good in this example.

An important property of a curve such as D^* is that the change in consumer surplus defined with respect to an equilibrium demand curve measures the net change in producer/consumer surplus for all affected industries for which adjustments are considered in the equilibrium demand curve. If D * was an equilibrium demand curve in the sugar market, for example, and corn sweetener was the only other industry in the sector, then welfare measures based on D * would capture the surplus measures for sweetener users, sweetener-containing product users, and corn sweetener manufacturers.

Partial equilibrium surplus measures, traditionally associated with partial equilibrium supply and demand curves, measure returns to fixed factors in those markets only. For example, the producer surplus associated with a competitive supply curve conditioned on fixed input prices measures returns or quasi-rent to the associated fixed production factors. All other prices are uninfluenced by the behaviour of such a firm; and the producer surplus does not capture effects in any other markets. A fully general equilibrium model would capture producer and consumer impacts of a policy-induced price change of the entire economy. Such a fully general equilibrium model is, however, not possible to construct. This analysis uses assumptions which effectively isolate the relevant markets from the rest of the economy, so that equilibrium statements about the sector can be made.

To see this more clearly, imagine a hypothetical merger of the above two industries, A and B, into a single competitive industry. Given that they were competitive, this would imply identical behaviour under profit maximization as if they were separate industries, with identical quasi-rents and consumer surplus areas. In Figure 8, after the price increase of good A from P_A^0 to P_A^1, consumer surplus in the hypothetical merged industry falls by area c + d. Thus, the net social welfare loss over the affected industries is area c + d, measured in the diagram for the first industry.

Since the discussion of curves such as D^* in Figure 8 involves dynamic responses, it is necessary to clarify why D^* is in fact a single-period equilibrium demand curve. In Figure 9, suppose demand is initially D_1 and equilibrium price and quantity are P_0 and Q_0, respectively. Consider a two-period analysis, where in the first period (short run) consumers respond along D_1 since other prices are held fixed. In the second period, other prices are assumed to have adjusted, so that the demand curve shifts, for example to D_1'.

Suppose that policy-determined price is increased from P_0 to P_1. In the first period, consumers would reduce consumption from Q_0 to Q_1. In the second period, prices of substitute goods would have adjusted, causing the demand curve to shift to D_1', and so consumers would further reduce consumption to Q_2.

If price P_0 had continued, inducing no change in the demand curve, consumer surplus would be measured by a+b+c+d+e+f+g. With the higher price P_1 and demand curve D_2,

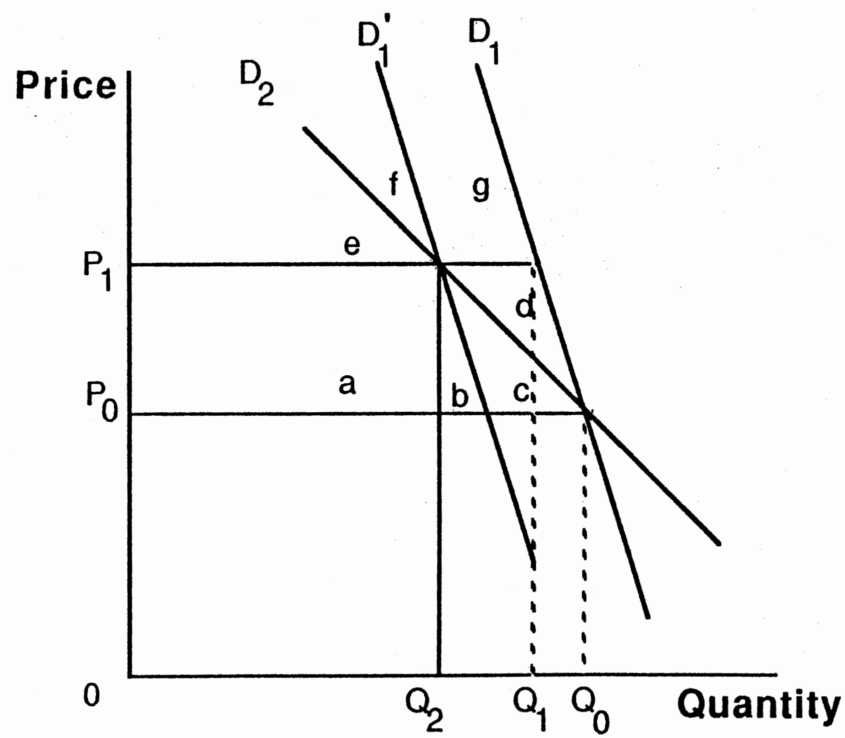


Figure 9. Demand in Two Separate Time Periods
Source: Just, Hueth & Schmitz

consumer surplus is area e+f. The change in short-run consumer surplus resulting from the price increase would appear to be the difference, a+b+c+d+g.

But the movement between equilibria, from (Q_0, P_0) to (Q_2, P_1) traces out an intermediate run demand curve, D_2, which is the relevant marginal valuation curve of consumers, allowing for two-period demand adjustments. Total surplus changes are found by summing or integrating over the relevant marginal curves between the prices. Thus the correct measure of the change in consumer surplus in the second time period, as viewed from the beginning of the first time period, is the intermediate run consumer surplus area, a+b+c.

The change in consumer surplus over the two periods is not the sum of all the short-run consumer surpluses for each period, but the sum of the consumer surpluses of variable lengths of run, as viewed from the initial point of time.

In Figure 9, adding up the change in consumer surplus in the first time period, a+b+c+d, to the change in short run consumer surplus for the second time period, a+b+c+d+g, does not yield a correct measure of the change in consumer surplus resulting from the price increase over the two periods from P_0 to P_1. The total change for the two periods would be the change in surplus corresponding to D_1 for the first period, a+b+c+d, plus the change in surplus corresponding to D_2 in the second period, a+b+c.

Generalizing, the change in consumer surplus for any particular period is determined by calculating the change in consumer surplus corresponding to the one-period demand curve for the first period, the two-period demand curve for the second period, the three-period demand curve for the third period, and so on.

To see why the area a+b+c is not a measure of two-period surplus, instead of a measure of the second-period surplus, note that the horizontal axis in Figure 8 measures quantities for a single time period, regardless of the demand curve being drawn. Consider a diagram which measures the aggregated two-period demand curve, such as Figure 10. D_1 and D_2 are duplicated from Figure 9, and are horizontally summed to yield D_{1+2}, the appropriate demand curve for the two periods taken together. Note that the horizontal axis measures quantity over two periods of time. In the first period, responses will be along D_1. The correct "marginal valuation" curve for the aggregate two-period diagram, however, is D_{1+2}. Mathematically, area a'+b'+c' equals area a+b+c; thus, the aggregate two-period surplus change associated with the price increase from P_0 to P_1 is a+b+c+d+a'+b'+c'. An equivalent result extends to any number of time periods. Thus, the change in consumer surplus <u>in the second period</u> is measured by the area a+b+c, confirming the results from Figure 9.

Welfare Analytics of Alternative Sugar Policies

This section graphically depicts the U.S. and world sugar markets and describes the techniques used to compare

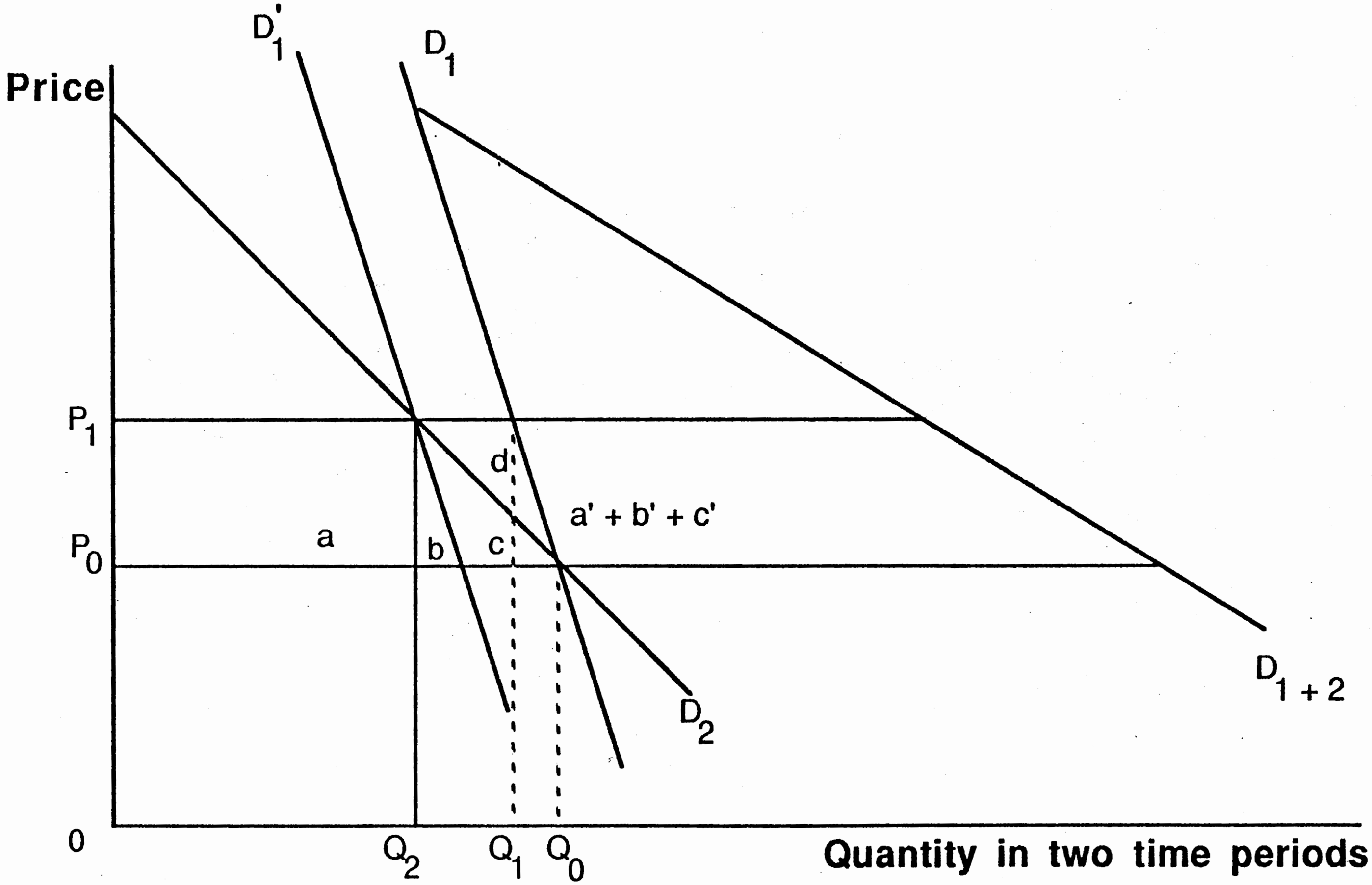


Figure 10. Demand Added Over Two Time Periods

Source: Just, Hueth and Schmitz

the welfare results of alternative U.S. sugar policies. The analysis follows that of Leu et. al. (1987).

The definition of producer surplus used in this study is the area below the price line and the marginal cost curve of the producer. This area equals total revenue minus total variable costs; it also equals profit plus total fixed costs. For an individual consumer, consumer surplus equals the area above the price line and below the demand curve. It is not a measure of utility; it is a money measure which can be taken to represent a change in utility. If the demand curve represents the derived demand curve of a profit-maximizing firm, then the consumer surplus measure (of the demanding firm) is exactly analogous to the producer surplus measure.

Existing Program: Quotas

Figure 11 shows the U.S. and world sugar markets, under the assumption that the U.S. is a large enough participant in world sugar markets to influence the world price. The initial supply and demand curves are S_o and D_o. Subtracting the supply curve from the demand curve yields the excess demand curve, ED_o. ES_o is the world excess supply curve.

The domestic target price to be achieved by use of quotas is P^T. In the absence of U.S. interference in the sugar market world price would be P_o. Under free trade, U.S. production would be Q^{s*}, consumption would be Q^{d*}, and imports would be Q^{d*}-Q^{s*} which equals 0-Qfo in Figure 11a.

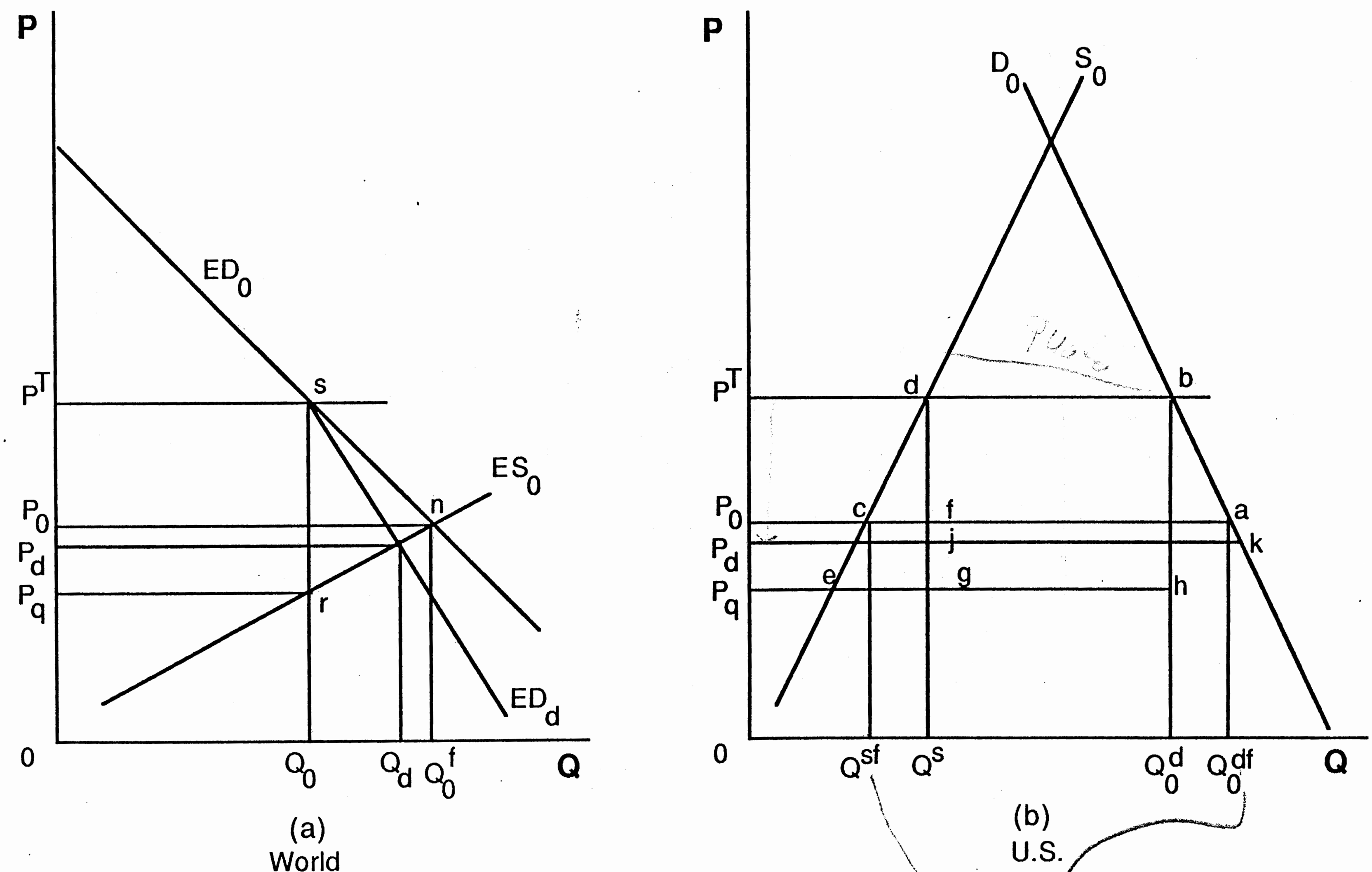


Figure 11. Sugar Markets

Source: Leu, Schmitz and Knutson

The U.S. quota is db, which equals Q^s-Qd0 and also 0-Qo in Figure 11a. World price is P_q, and the price premium between the U.S. and world prices is P^TP_q.

The quota would cost domestic consumers P_oabP^T and benefit domestic producers P_ocdP^T. Quota holders would benefit by receiving quota rents of ghbd, which equals P_qrsP^T. There is a net loss to the U.S., measured by the gain to producers minus the loss to consumers, P_ocdP^T - P_oabPt. The rest of the world can either gain or lose, since their gain of P_qrsP^T is offset by a loss of P_qrnP_o.

Equivalent Tariff

If the U.S. replaced the quota with an equivalent tariff, domestic producers and consumers would not be affected. However, the U.S. government would collect tariff revenue of ghbd, which previously would have gone to foreign sugar suppliers as quota rents. The net loss to the U.S. would be cabd - ghbd, which could be a positive or negative amount. The welfare loss under a tariff is significantly less than the loss, cabd, under the quota.

Deficiency Payment

Under a deficiency payment scheme, the government would guarantee the price P^T to producers, but let consumers face the market price. Assuming that the price P^T is the supply-inducing price, the domestic supply curve would be vertical at Q^S up to P^T, and follow S_o above P^T. The excess demand curve would be EDd below P^T and ED_o above P^T. World price would fall below P_o to P_d. Consumers would benefit by $P_d$kaP_o, as they would face the lower world price and consume a larger quantity. Producers would benefit by $P_o$cdP^T, as before. Taxpayers would lose $P_d$jdP^T. The net gain of the deficiency payment compared to a free market situation would be jkaf - cfd.

Comparing the deficiency payment with the quota, it is clear that the quota is the most expensive program. To benefit producers by the amount $P_o$cdP^T under the quota, the country loses the amount cabd. To give producers the same benefit with a deficiency payment, the country loses cfd - jkaf.

Welfare Effects With Corn Sweetener Substitution

Using the concept of equilibrium demand curves described in the first section it is possible to investigate the welfare implications of the substitution of corn sweeteners for sugar. In Figure 12, the demand curve D1 is the sugar demand curve given that corn sweetener substitution has occurred. D^* is the one-year general equilibrium demand curve for the n+1-year length of run of the analysis, during which time the (administratively determined) sugar price of P^T has induced corn sweetener substitution and thus shifted the demand for sugar inward.

The quota must now be reduced to db', or Q^s-Qd1, which equals OQ1 in Figure 12a. World price falls to P1w. The

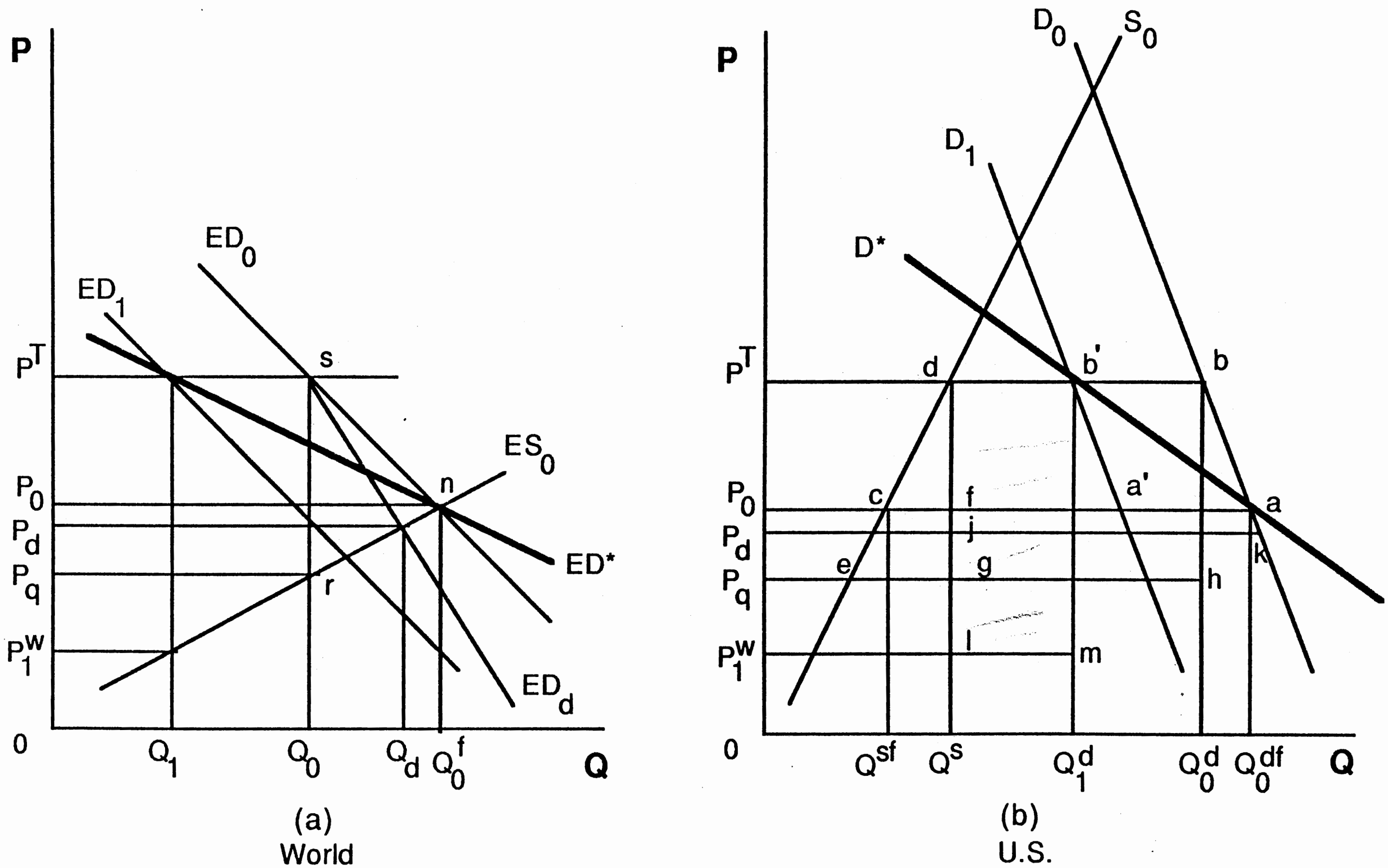


Figure 12. Sugar Markets, Large Country Assumption

Source: Leu, Schmitz & Knutson

welfare loss of the related industries can be measured in the sugar market diagram using the assumptions underlying D^*. Therefore, the consumer surplus loss is $P_oab'P^T$, compared to P_oabP^T had there been no corn sweetener substitution. Producer gain is still P_ocdP^T. Quota rent to foreign suppliers is lmb'd. The net cost of a quota is cab'd. An equivalent tariff would transfer the quota rent, lmb'd, to the U.S. government, leave producers and consumers unaffected, and result in a net loss to the U.S. of cab'd - lmb'd, which again could be positive or negative.

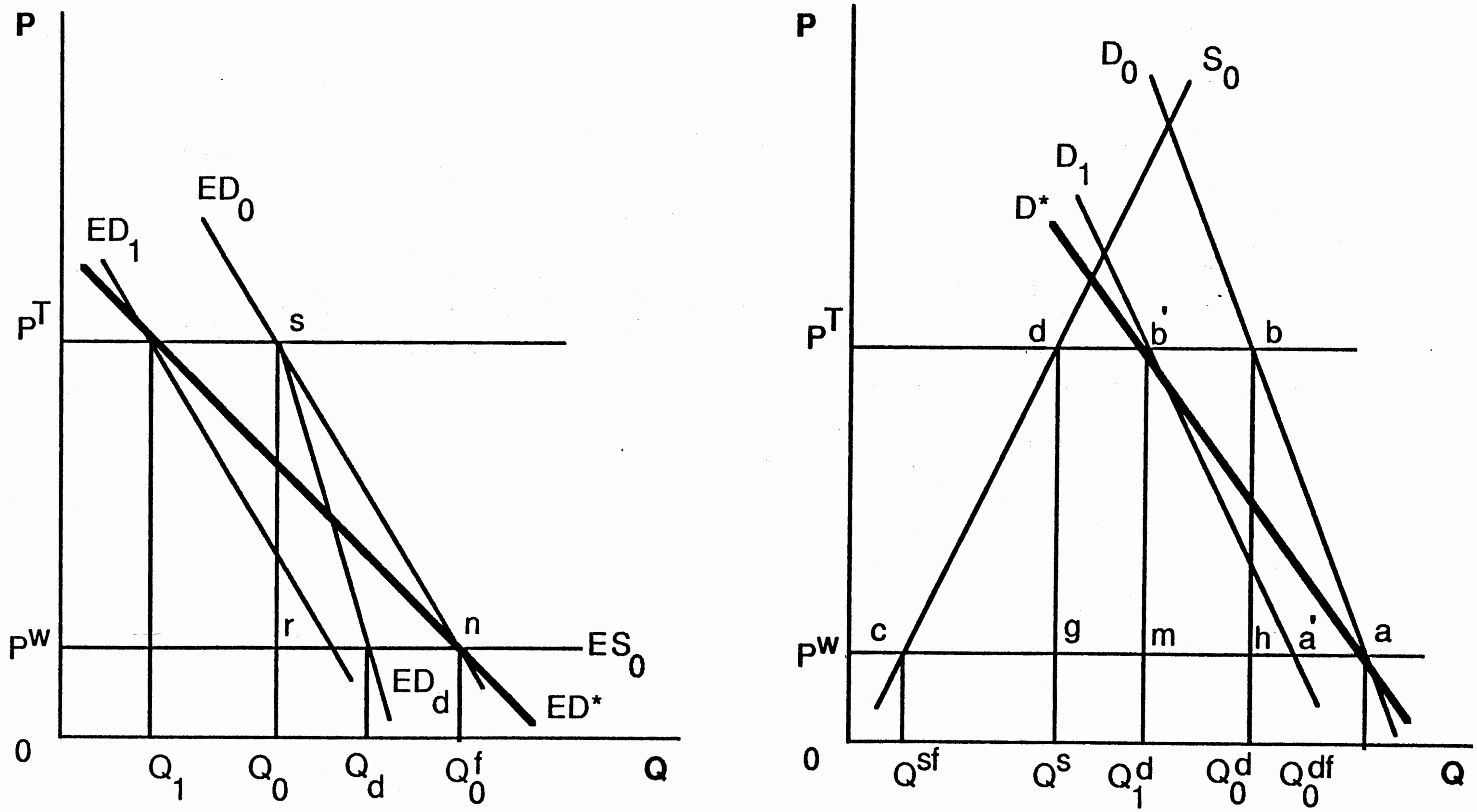
Small Country Assumption

Given uncertainty about the elasticity of world sugar excess supply facing the U.S., the case of an infinitely elastic world excess supply curve is also analyzed. A constant world price facing the U.S. for sugar imports is particularly relevant for short-run analysis. Figure 13 shows the world and U.S. sugar markets for the case of a constant world price.

Assuming HFCS substitution, a quota of db would result in consumer loss of $Pwab'P^T$, producer gain of $PwcdP^T$, and net U.S. loss of cab'd. Quota rent would be gmb'd, and quota premium would be P^TPw.

An equivalent tariff would not change the results for producers and consumers but would yield tariff revenue ghbd to the government. Net social loss would be cabd - ghbd.

Under a deficiency payment program the U.S. sugar price



(a)
World

(b)
U.S.

Figure 13. Sugar Markets, Small Country Assumption

Source: Leu, Schmitz & Knutson

would be the same as the world price, and it is likely that HFCS substitution would not have occurred. A deficiency payment program to give producers price P^T would cost taxpayers $PwgdP^T$. Producers would benefit $PwcdP^T$. Consumers would be unaffected, as they would continue to buy at the unchanged world price. Imports, ga, are greater than under a quota. Net welfare loss the U.S. would be cgd.

Random Coefficients Model Estimation

The assumptions underlying analysis of time series data, particularly the assumption that the coefficients are fixed or stable over the entire time period, has been a topic of considerable debate. For example, are consumers equally responsive to a change in the price of sugar in 1988 as they were in 1980 or 1960? And are producers of sugar equally responsive to a change in the price of sugar at different times?

It is quite likely that a consumer's response to a price change will be affected by many other factors. When major events affect large numbers of people, the aggregate markets are affected. Dummy variables are often included to account for war, recessions, and other major shocks. On the supply side, technological change could result in sharply differing supply responses, by individual producers or by an entire sector. Institutional changes such as changing government price support policies will also condition the supply response. Again, techniques such as dummy variables or switching regressions (see for example Judge et.al. 1985, p. 529) have been used to account for these shocks.

Alternative methods for accounting for changes in parameters have been evaluated. Random coefficient models have been proposed and estimated. Swamy, Conway and LeBlanc (1988a) (hereafter SCL) cite the following six reasons why random coefficient models may be theoretically and empirically superior to traditional fixed coefficient models.

First, the underlying process which generates the coefficients could be a time-varying or non-stationary random process. This is in contrast to most models in the physical sciences. For example, the physicist who attempts to measure the gravitational constant or the speed of light is searching for a parameter which is assumed to have a "true" value which does not vary over time. The economist who attempts to measure the elasticity of demand has more reason to suspect that the parameter is random and time-varying than that it is a fundamental constant of nature.

Second, SCL point out that "omitted variables that exhibit nonstationary behaviour and that are not orthogonal to the included variables can induce variability in the coefficients of the included variables."(page 3).

Third, the use of proxy variables could introduce non-stationarity. Even if the true model was stationary, it would be possible for the relationship between the proxy variable and the true variable to change over time. Most economic models contain proxy variables.

Fourth, aggregation could induce non-stationarity. "It is highly restrictive to assume the aggregation weights of microunits will not change over time...(and) There are surely few observed events that are not already the outcome of some aggregation."(page 3). Swamy et. al. give a proof that with aggregation in a regression model with a disturbance term, the conditions for the stochastic convergence of the disturbance term to zero are less stringent if the model allows for random coefficients than if it does not. If the stochastic coefficients model could exist under a broader set of conditions than the fixed coefficients model, it should be included in the economist's tool kit. "For any practical work, the existence conditions are important because a model that does not exist could not have generated our data and should not be used for empirical analysis." (page 4).

Fifth, incorrect functional form may justify a stochastic coefficients specification, as already alluded to above. Since economists usually do not know the 'true' functional forms of their models, a more flexible form could allow for more accurate estimation. Swamy et. al. quote Rausser, Mundlak and Johnson(1983); " The approximation of highly nonlinear 'true' relationships by simpler functional forms, along with observations outside the narrow sample range, provides perhaps the strongest motivation for a varying parameter structure."

Sixth, the rational expectations literature has raised questions about economic models which forces consideration of stochastic parameters. Economic theory is built upon a framework of optimizing behaviour by agents, whose decisions are conditioned by their environment. If some change in policy or an institution occurs, agents may adopt new decision rules, which may in turn lead to a new micro or macro economic structure.

Several random coefficient and time-varying parameter models were considered. The Hildreth-Houck model, widely used in the agricultural economics literature, does not allow for any permanent trend in parameter variation and is better suited to cross-sectional analysis than time series analysis. One of the widely used random coefficients models is the Cooley-Prescott model, described in detail in Appendix A. It allows for coefficient variation to be either permanent or transitory. It is a flexible model which includes other random coefficient models as special cases, including the traditional random coefficient model and the adaptive regression model.

CHAPTER IV

EMPIRICAL ESTIMATION OF U.S. SUGAR DEMAND AND SUPPLY

> I do not know if coffee and sugar are essential to the happiness of Europe, but I know well that these two products have accounted for the unhappiness of two great regions of the world: America has been depopulated so as to have land on which to plant them; Africa has been depopulated so as to have the people to cultivate them.

From Vol. 1 of J.H. Bernadin ed Saint Pierre's _Voyage to Isle de France, Isle de Bourbon, The Cape of Good Hope...With New Observations on Nature and mankind by an Officer of the King(1773)._ Quoted in Mintz(1985, p. 29).

The above quotation emphasizes the importance that has been placed upon access to sugar throughout recent history. Little has changed from colonial times up to the present, in the sense that governments still intervene in a major way in the determination of sugar demand and supply. This fact complicates and perhaps makes more challenging economic analysis of sugar markets.

In this chapter a review of recent U.S. sugar supply and demand studies will be made, followed by an empirical estimate of 1987 U.S. supply and demand.

U.S. Sugar Demand

Previous Studies

A recent estimate of U.S. sugar demand was made by Leu et. al. (1987). Using annual data from 1963-83, the estimated equation, after adjusting for autocorrelation, is:

$$
\begin{aligned}
Q = \underset{(15.18)}{111.84} - \underset{(-4.76)}{0.3288}\ Pt - \underset{(-6.15)}{0.4192}\ Pt\text{-}1 \\
+ \underset{(2.92)}{0.4759}\ MIXPt\text{-}1 \ \underset{(-2.39)}{-1.1638}\ T
\end{aligned}
\qquad (4.1)
$$

$$R^2 = .98$$

where Qt is per capita consumption for refined sugar, Pt is wholesale list price of refined sugar in the northeastern United States deflated by the consumer price index (1967=100), Pt-1 is price lagged one year, MIXPt-1 is the arithmetic mean of prices of HFCS, glucose and dextrose weighted by their consumption quantities and lagged one year, and T is a trend variable. The numbers in parenthesis are t-statistics.

Estimation of U.S. Sugar Demand

USDA personnel have indicated that the Northeast wholesale price is not as accurate as the Chicago-West wholesale refined beet sugar price, which was thus chosen as the best single representative price for the U.S. market. Sugar is purchased in refined form mostly by manufacturers who put it in various food products, and so the producer price index was used to adjust for inflation.

Since data on HFCS are only available back to 1970 it is tempting to utilize data on glucose and dextrose in order to extend the analysis further back in time, as done by Leu et. al. However, glucose and dextrose are not equivalent to HFCS as sugar substitutes, and since one purpose of this study is to capture the effects of HFCS substitution for sugar, only the time period since HFCS became available (1970 to present) is utilized.

Attempting to use the price of HFCS as a regressor resulted in an equation whose parameters were not stable with respect to alternative time periods. USDA officials who have worked with HFCS price series (Langley and Barry, personal communication) have concluded that the HFCS industry structure is such that the price of HFCS is determined largely by producers who set it at a discount to the sugar price, rather than by competitive market forces. A study by Ives and Hurley (1988) found the price of HFCS to be closely correlated with the price of sugar. And the correlation coefficient between the price of HFCS-42 and Chicago-West wholesale sugar price from 1975 to 1987 is 0.87. Thus the price of HFCS was not included. The per capita consumption of HFCS was found to be the best shifter for the sugar demand equation.

An income variable is often used in demand estimation. However, the income elasticity of demand for sugar has been estimated by others (de Vries, FOA) to be very close to zero for the United States. Therefore, no income variable was included.

For theoretical reasons, the demand for sugar was estimated on a per capita basis. Annual data are used due to the lack of consumption data series reported in other frequencies. The price used is lagged due to the fact that most sugar is purchased far in advance by large firms using it as an input in some production process.

Ordinary Least Squares Estimation. Using data from 1970 to 1987, the results were:

$$Q = 106.98 \quad -.525\ P(-1) \quad -.92\ HFCS \qquad (4.2)$$
$$(2.13) \qquad (.16) \qquad\qquad (.035)$$

Durbin Watson Statistic = 1.8

Adjusted R^2 = .98

where Q is U.S. per capita consumption of refined sugar per year, P(-1) is the Chicago-West price of beet sugar lagged one year, and HFCS is the U.S. annual per capita consumption of HFCS-42 and HFCS-55. Standard errors are in parentheses. The estimated elasticity of demand at the means was -0.06, which is quite low.

Cooley-Prescott Model Estimation. The Cooley-Prescott model was run using the same data set as above for OLS. This model will hereafter be referred to as the TVP (Time Varying Parameters) model. The estimated value of γ, the parameter which indicates the fraction of temporary and permanent variation (see Appendix A) was zero. The parameter values and standard errors derived from OLS and Cooley-Prescott are almost identical so that the Cooley-Prescott results are not reported. The coefficient on the price variable indicates that for each increase in sugar price of 1 cent per pound, per capita consumption falls by about half a pound per year. The coefficient on the HFCS variable in equation (4.7) indicates that for each one pound increase in HFCS consumption, sugar consumption falls by .92 pounds, which means that each increase of one pound in per capita consumption of HFCS displaces almost a pound of sugar. The demand equation was very stable with respect to extending or reducing the sample period.

U.S. Sugar Supply

Previous Studies

Sugar supply theoretically depends upon the price of sugar, costs of production, and other variables . A great deal of aggregation is necessary in any estimation of such an equation. Leong (1985) estimated an aggregate U.S. sugar supply function using annual data for 1955 through 1981:

$$QS = 3000.8 + 158.19\ P(t-2) - 28.12\ FERT(-2) + 183.94\ T + 50.14\ Z*FERT(-2) \quad (4.4)$$

where QS is U.S. raw sugar supply in thousand short tons, P(t-

2) is retail sugar price lagged two periods, FERT(-2) is fertilizer price lagged two periods, T is technology (sic), Z is a zero-one dummy variable which is equal to one for the "free market" period of 1974-81, and Z*FERT is a slope shifter on the fertilizer price parameter. The estimated supply elasticity is .4805.

Leong also reported a double logarithm supply function estimated over the same time period with lagged supply as a predetermined variable:

$$\begin{aligned} LNQS = 3.8664 &+ .4907\ LNQSLAG + .1636\ LNRETLG \\ &- .1224\ LNFERL2 - .1527\ LNPWAGE + .2667\ LT \\ &- .0157\ ZLRETLG \end{aligned} \qquad (4.5)$$

where the LN prefix signifies the natural log of the variable. QS is U.S raw sugar supply in thousand short tons, QSLAG is QS lagged one period, RETLG is the retail sugar price lagged two periods, FERL2 is the fertilizer price lagged two periods, PWAGE is the wage rate lagged two periods, LT is the natural log of the technology variable, and ZLRETLG is the natural log of the slope shifter variable, as in equation (4.2). The partial adjustment specification allows calculation of short-run and long-run price elasticities, which were reported as .1636 and .3213, respectively. Leong concluded on the basis of low t-statistics that the coefficients on the LNFERL2 and ZLRETLG variables were not different from zero at the 5 percent significance level.

Leu. et. al. (1987) reported a U.S. sugar supply function derived from the work of Gemmill (1976). Gemmill had estimated separate sugar supply equations for four cane producing areas (Hawaii, Florida, Louisiana and Texas) and for continental beet production. These five equations were aggregated by Leu et. al. into a single U.S. sugar supply equation. The price elasticity of supply estimated by Gemmill was approximately 2.0.

Estimated supply (and demand) elasticities often vary widely in economics, depending upon the time period selected and the estimation technique used. The range from Leong's estimate of .4805 to Gemmill's estimate of 2.0 is wide enough to result in significantly different policy conclusions, depending on which elasticity is used. For the purposes of this study differing supply elasticities would affect the magnitude, but not the direction of the calculated welfare transfers to sugar producers and users, if the extremes of zero and infinite elasticity of supply are excluded.

Estimation of U.S. Sugar Supply

From economic theory the best determinants of sugar supply are the supply price perceived by producers and the cost of production. The Chicago-West price of refined beet sugar was chosen as the single price series which reflects most closely the actual price faced by producers (after discussions with USDA personnel knowledgeable about the sugar industry). It is necessary to keep the price used in supply and demand estimation consistent in order to perform the welfare analysis of Chapter V.

Fertilizer expense constitutes the single largest variable cost item for both cane and beet sugar producers. The particular blends of nitrogen, phosphorus and potassium are so varied among regions and producers that the overall fertilizer price index published by the USDA was selected as the best proxy for the cost of inputs in sugar production.

Determining the appropriate lag on supply price was necessarily a compromise, due to the nature of aggregation in the supply function. Cane producers must commit to production by planting the "ratoon" about eighteen months before the first harvest, and the cane field will be harvested several times over a further period of several years before it is plowed up. Beet producers can adjust their acreage and planting decisions in the spring, with harvest coming in the fall, so that a much shorter production response to price is possible. A one year lag on price was selected as the best specification to capture the behaviour of aggregate sugar supply response. Annual data are used to keep the supply and demand specifications consistent.

There is no problem of joint determination of quantity and price in this market, because the price of sugar was set exogenously as a policy variable during most of the years of the sample. Even during 1975-81, which was a period of nominally "free market" U.S. sugar policy, there was always the threat of policy intervention in the event of a world price drop. When world prices fell in 1981, U.S. quotas were quickly reinstated.

Ordinary Least Squares. Using data from 1970 to 1987, initial OLS equation results were (standard errors in parentheses):

$$QS = -310227.8 + 131.75\ P(-1) - 7.88\ PF + 159.81\ TR \quad (4.6)$$

$$(54585.9) \quad (22.1) \quad (1.57) \quad (27.77)$$

Adjusted R^2 = .71

Durbin Watson Statistic = 2.65

where QS is U.S. domestic sugar production in thousand metric tons, refined basis, P(-1) is the Chicago-West wholesale beet sugar price divided by the Producer Price Index and lagged one period, PF is the Fertilizer Price Index, and TR is a trend variable set to the value of the year (1971, 1972, etc.). All t-statistics are above 5. The adjusted R^2 is .71, indicating that about 71 percent of the variation in annual sugar supply is explained by the included regressors. The Durbin-Watson statistic provides a way of testing for autocorrelation in the residuals. Under the null hypothesis of negative autocorrelation, the calculated Durbin-Watson statistic of 2.65 leads to a rejection of the null hypothesis at the 5 percent significance level.

The coefficients in (4.4) indicate that for each one cent increase in the real price of sugar, producers increase production by about 131 thousand metric tons, while for each one point increase in the fertilizer price index, producers decrease production by about 7.88 thousand metric tons. The trend variable is clearly picking up influences of other variables not included as regressors in the equation, which are estimated to be increasing sugar production at the rate of about 159 thousand metric tons per year.

Cooley-Prescott Model. The Cooley-Prescott model was estimated with the same variables and data as above, except that the trend variable was not included. Results are shown in Table 10. The estimated value of γ, which is a parameter ranging between zero and one which estimates the allocation of the permanent and transitory components of parameter variation, is 0.78. This indicates that a substantial fraction of parameter variation is permanent over time. Figures 14, 15 and 16 show the estimated permanent components of the parameters.

The permanent component of the intercept increases almost continuously over the sample period, as shown in Figure 14. The intercept in 1971 is 4.4 million metric tons, refined basis, and rises to almost 5.5 million metric tons in 1987. The coefficient on sugar price is seen in Figure 15, and shows substantial movement up and down. There is a downward trend from 1971 to 1983, when a dramatic upward trend begins. In Figure 16 the coefficient on the fertilizer price index is shown. Since this coefficient is negative, its upward trend is moving it closer to zero. It changes from about -2.5 in

TABLE 10

SUPPLY COEFFICIENTS AND ELASTICITY,
COOLEY-PRESCOTT MODEL

Year	Coefficient: Intercept	Coefficient: Sugar Price	Coefficient: Fertilizer Price Index	Supply Elasticity
1971	4497.872	95.461	-2.534	0.199
1972	4599.751	99.235	-2.437	0.207
1973	4414.952	92.243	-2.621	0.192
1974	4410.953	91.952	-2.612	0.192
1975	4525.143	95.878	-2.398	0.200
1976	4586.262	95.553	-2.304	0.199
1977	4618.379	93.405	-2.266	0.195
1978	4709.591	93.412	-2.116	0.195
1979	4639.030	88.471	-2.270	0.184
1980	4777.762	90.962	-1.999	0.190
1981	4759.158	88.212	-2.125	0.184
1982	4788.591	88.204	-2.121	0.184
1983	4791.059	87.155	-2.190	0.182
1984	4913.651	90.454	-1.950	0.188
1985	5014.807	93.030	-1.767	0.194
1986	5262.722	100.376	-1.212	0.209
1987	5472.161	106.602	-0.747	0.222

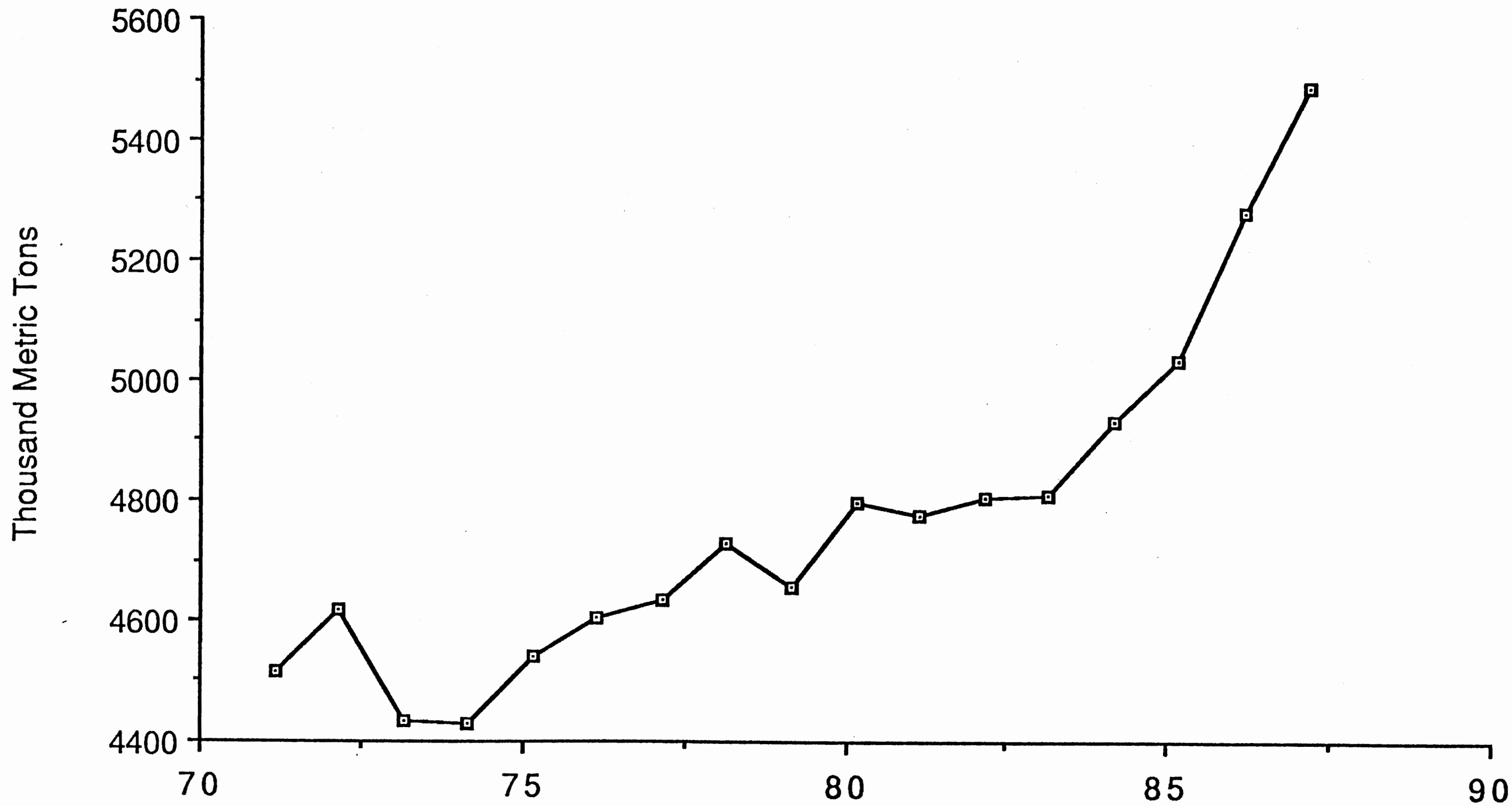


Figure 14. Intercept From TVP Supply Estimation, 1971-87

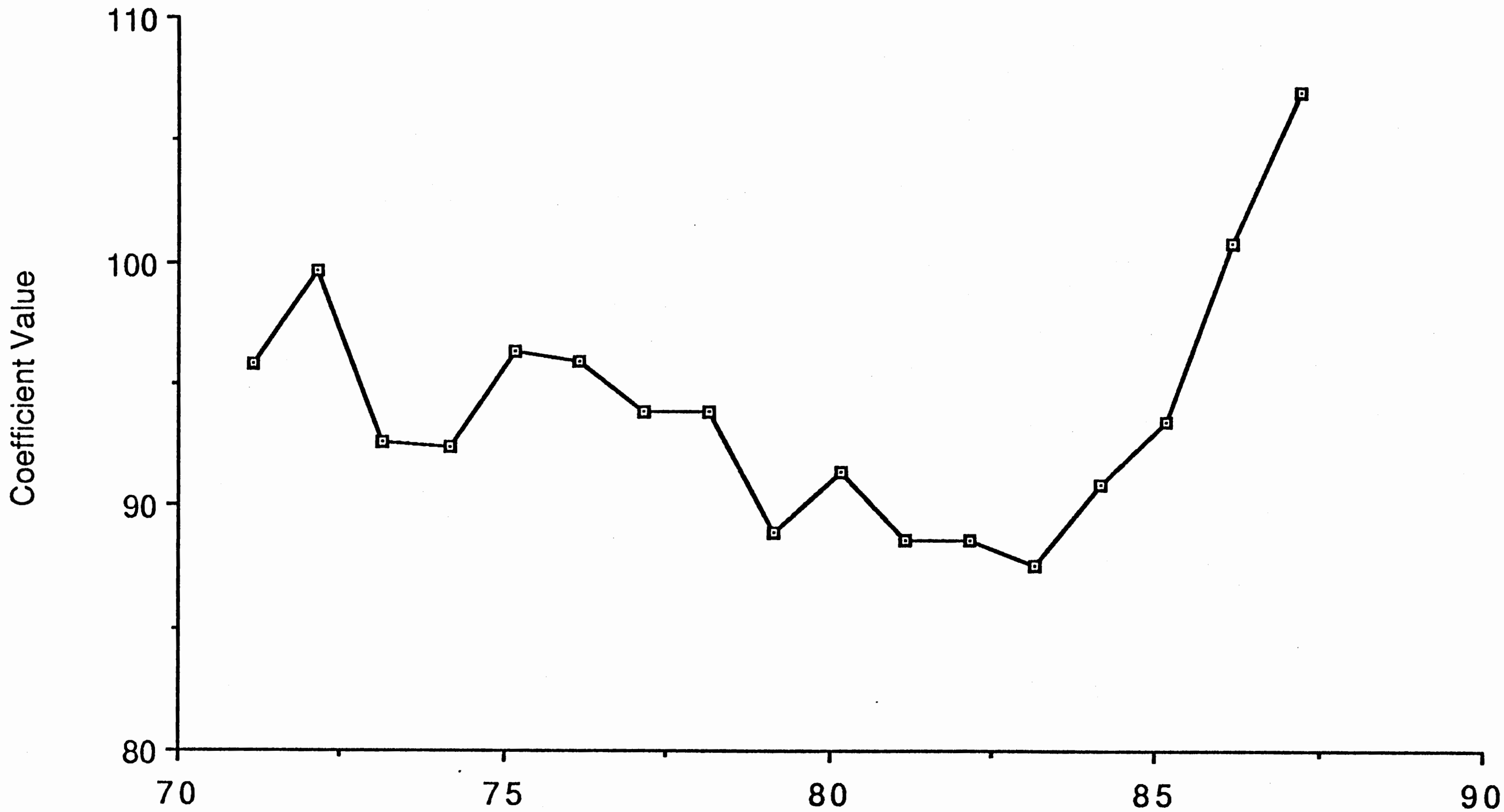


Figure 15. TVP Sugar Price Coefficient From TVP Supply Estimation, 1971-87

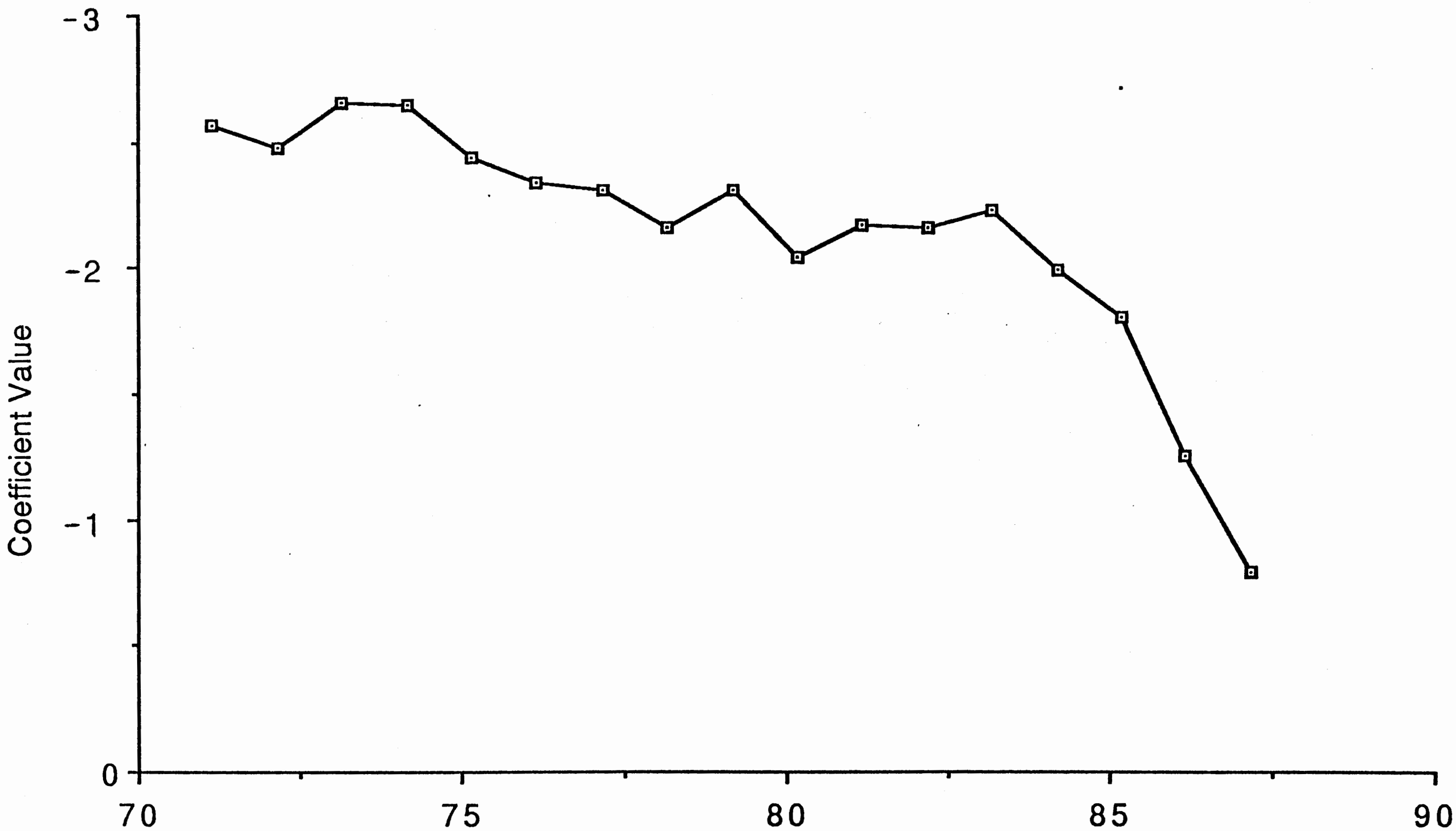


Figure 16. Fertilizer Price Index Coefficient From TVP Supply Estimation, 1971-87

1971 to -0.7 in 1987.

In Figure 17 the coefficients for sugar price and the fertilizer price index are shown on a normalized scale, to illustrate their variation relative to their means. The largest deviation for both series is in the period since 1983, when supply has become more responsive to sugar price and less responsive to the fertilizer price index.

The elasticity of supply is given in Table 10. Calculated at the means of price and quantity, it averages about .20, and is relatively constant. The low value is .181 in 1983, and the high is .222 for 1987.

A trend variable, such as in the initial OLS supply equation, is a proxy for a number of variables influencing the market over time. In the TVP model, these factors are reflected in the intercept. As Figure 14 shows, the intercept is not stable over the sample period. From 1971 to 1983, the intercept trended upward, but irregularly and not dramatically. The percentage increase in the intercept from 1971 to 1983 is about 6.5 percent, or only 0.5 percent per year. However, in the four years from 1983 to 1987 the intercept increased by 14.2 percent, or about 3.5 percent per year.

The year 1983 is also a turning point for the other coefficients. From 1971 to 1983 the sugar price coefficient falls 8.7 percent, or about .7 percent per year, while from 1983 to 1987 it rises 22.2 percent, or 5.6 percent per year. The fertilizer index coefficient declines 13.6 percent from

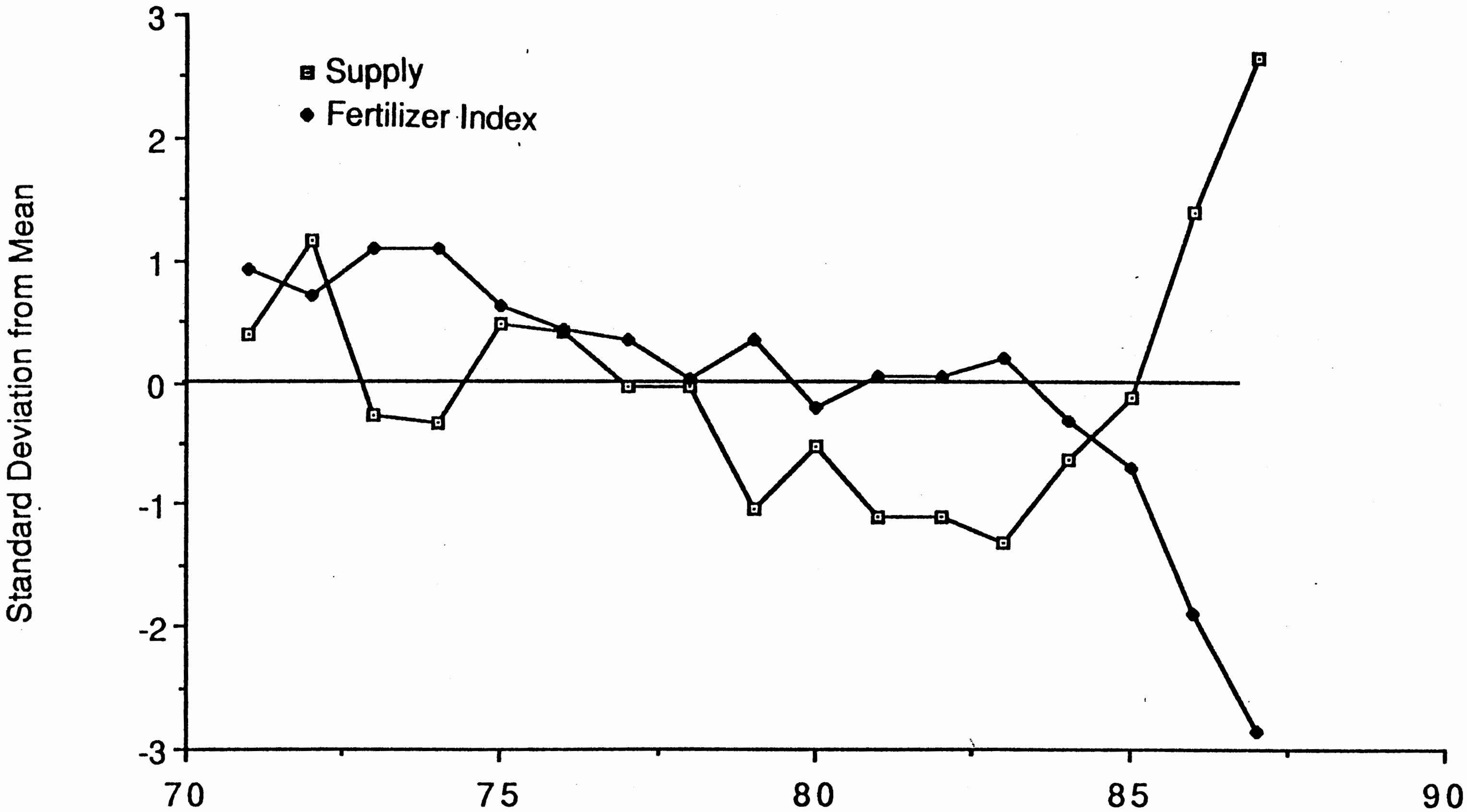


Figure 17. Normalized TVP Supply Equation Sugar Price, Fertilizer Index Coefficients, 1971-87

1971 to 1983, which is a rate of about 1.1 percent per year. But from 1983 to 1987 it declines 66 percent, or about 16 percent per year. These coefficient shifts indicate that the U.S. sugar supply function is shifting outward, becoming more responsive to sugar price, and less responsive to fertilizer price.

An increase in sugar output is not by itself an indication of a supply shift, since it is possible for the supply response to lag many years behind the price stimulus. Economic theory indicates that the effect of a change in own price are manifested by a change in quantity supplied along a stable supply curve. Thus, theory would seem to rule out the price of sugar being a cause of a shift in sugar supply.

But in Chapter III it was shown how a policy-controlled change in the price of a good could, under certain conditions, result in a shift of the demand curve. It is useful to test an application of this same theory on the supply side of sugar.

The discussion of Chapter III illustrated horizontally related goods, but a similar result is possible with vertically related goods (Just, Hueth and Schmitz, Chapter 9) and is illustrated in Figure 18. Figure 18a shows the sugar market, and Figure 18b shows the market for some input used by the sugar industry. The following conditions are necessary in order for welfare consequences of a policy-induced price change to be calculated:

1) The sugar industry is competitive and the demand for

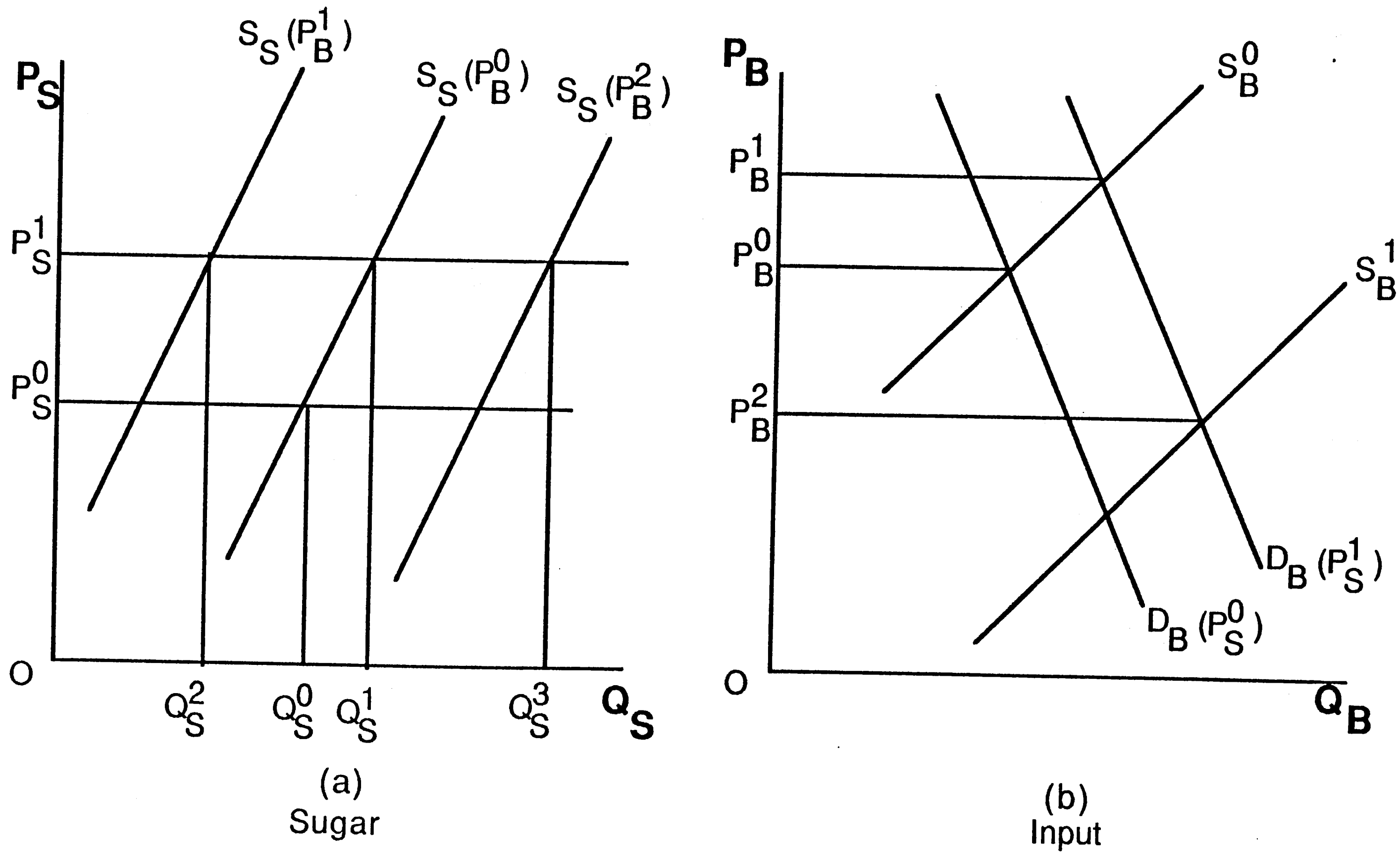


Figure 18. Vertically Related Markets

sugar is perfectly elastic

2) Input B is the only input the sugar industry uses

3) Industry B is competitive and faces perfectly elastic supply of its inputs

These assumptions effectively isolate the markets for sugar and its input from the rest of the economy and allow the effect of a policy-set price change to be precisely calculated.

Initially the price of sugar is P_0, which is raised by policy to P_1. Sugar suppliers attempt to raise output from Q_0 to Q_1. But the demand for the input, initially $D_B(P_0)$, increases to $D_B(P_1)$ due to the dependence of the derived demand for the input on sugar output. The resulting price increase in the input market from P_0 to P_1 shifts the sugar supply curve from $S_A(P_0)$ to $S_A(P_1)$, and after these effects have worked through the system, sugar output falls to Q_2 instead of increasing to Q_1.

This analysis would indicate that the most obvious theoretical result of the high sugar support price of the 1980s should be an <u>inward</u> shift of sugar supply, which is the opposite of the TVP model results.

If the supply of the input were to shift, as from S_0 to S_1 in Figure 18, then the resulting decrease in input price from P_0 to P_2 could result in an outward movement of sugar supply from $S_A(P_0)$ to $S_A(P_2)$. However, this violates assumption (3) above; the price of the inputs used by the sugar input industry must not change.

Thus the equilibrium model, which is useful in demonstrating welfare effects of sugar policy on the demand side, cannot be used on the supply side. No equilibrium supply curve such as S* in Figure 18 can be calculated. However, for any year of interest, a unique supply curve is given by the TVP model.

Changes in costs can be a cause of shifts in supply functions. Production and processing costs for refined beet sugar fell between 1982 and 1985 from 25.518 to 21.034 cents per pound (USDA Sugar and Sweetener Report). For raw cane sugar, the corresponding costs were 21.533 and 20.55 cents per pound (however, when costs of refining raw sugar of 4-6 cents per pound are included, the estimated cost of production for cane sugar exceeds that of refined beet sugar). But the parameter on the fertilizer price index appears to capture these production cost movements fairly well.

It is of some interest to note parallels between the sugar market and other agricultural markets of the early 1980s. Trends in the sugar market are paralleled to some extent in other agricultural markets such as corn and wheat. Many researchers have argued that high, guaranteed price supports of the 1981 legislation caused "overproduction" of grains, leading to excessive stockpiling by the CCC. In the 1985 farm legislation, discretionary power to lower the loan rates and support prices for corn and wheat was given to the Secretary of Agriculture, and this power was utilized in an attempt to regain export market share. Since the U.S has a deficit of sugar and has never been a net exporter of sugar, there was no lobbying in 1985 for lower sugar loan rates as a way of regaining export market share. The 1985 farm bill, far from decreasing sugar loan rates, requires that if the Secretary of Agriculture determines that the support price for any crop year from 1986-90 should not be increased, he must submit a report justifying his determination to the Committee on Agriculture of the U.S. House of Representatives and the Senate Committee on Agriculture, Nutrition and Forestry (USDA, Sugar and Sweetener Report, March 1988).

The above considerations lead to the conclusion that although no definite cause of shifts in sugar supply can be identified, there is at least suggestive evidence from the TVP model that shifts have occurred, especially since 1983.

In the next chapter, welfare consequences of the indicated shifts in supply and demand will be calculated.

CHAPTER V

WELFARE COMPARISONS OF ALTERNATIVE U.S. SUGAR POLICIES

This chapter will utilize the conceptual framework of Chapter III and the empirical results of Chapter IV to assess the welfare consequences of the current U.S. sugar quotas, and to compare the current policy with an equivalent tariff and a deficiency payment program. A spreadsheet model is used to calculate measures of producer and consumer surplus resulting from alternative policies. A forecast of some consequences of continuation of current policy for the next two years will be made, with particular reference to trade consequences.

Methodology and Assumptions

In order to estimate the welfare effects of the U.S. sugar program, a border price for imported sugar must be assumed. There is no consensus on an appropriate world sugar rice. Most analysts agree that the world raw sugar price quoted on the New York exchange is not a representative "free market" price, since virtually every government subsidizes its sugar industry and dumps excess supplies on the world market. In recent years the quoted world price has ranged from 29 cents in 1980 to 4 cents in 1985. The 29 cent 1980 price was a short-run "shortage" price, and not likely a possible long-run equilibrium price. The low prices since 1985 are considered by many to also be disequilibrium prices, but chronic excess supply at government-set prices in most countries has in the past led to extended periods of low world prices. In 8 of the last 10 years, the world price has been below 10 cents. Many analysts suggest a world free trade price would be between 10 and 15 cents (Hoff et. al., 1987). This study will demonstrate welfare impacts under three alternative world price levels, rather than taking a point estimate of a true world price.

The current Market Stabilization Price for sugar is about 22 cents, 4 cents above the loan rate of 18 cents. The domestic raw sugar price (New York No. 14, c.i.f. duty-paid) has in recent years been very close to the MSP, between 21 and 22 cents. Taking the U.S. target price for raw sugar as 22 cents, and using comparisons on a raw sugar basis as is usually done in the world markets, alternative hypothetical world prices of 17, 12, and 7 cents would correspond to U.S. raw sugar price premia of 5, 10 and 15 cents, respectively. There is no need to consider transportation charges since the relevant world price is a landed U.S. price for world sugar.

To translate the price premium between U.S. and world raw sugar prices into a wholesale refined measure, the raw price premia of 5, 10, and 15 cents are multiplied by 1.07 to convert to refined sugar premia of 5.35, 10.7 and 16.05 cents, respectively. These represent the gap between U.S. and world refined wholesale prices. In recent years a New York raw price of 22 cents would correspond approximately to a 24 cent Chicago wholesale refined price. Alternative world prices are calculated by subtracting the refined premia from 24 cents, which yields estimates of 18.65, 13.3 and 7.95 cents.

Current sugar policy includes a small tariff, the effect of which is subsumed in the analysis of the quota system which follows since the tariff effects are negligible compared to the quota effects. In the analysis of an equivalent tariff, it is assumed that the equivalent tariff replaces the current system of quota and small tariff.

The "consumer" in the estimated demand curve for this analysis is the wholesale sugar user. Estimates of sugar user and total social welfare losses would be higher if retail prices were used in the estimation. However, welfare measures based on profit-maximizing firm behaviour are more theoretically sound than consumer welfare measures which are based on utility maximization assumptions. Also, retail prices are not as appropriate as wholesale prices for sugar as explained in Chapter IV.

Two estimates of the world excess supply elasticity facing the U.S. will be used. If the analysis is short run, or the U.S. is considered to be a small country with respect to world sugar trade, an infinite elasticity is appropriate. If U.S. sugar trade is presumed to affect world price, as is more likely in the long run or when the U.S. is a major trader of sugar, then some positive elasticity is appropriate, and the world sugar excess supply elasticity estimate of 2.37 from Leu et. al. is used.

Using the estimated OLS demand function (4.2), per capita sugar demand functions for 1971 and 1987 were found by including the appropriate values of the non-price variable, HFCS consumption, in the intercept:

$$1971: \quad Q = 106.152 - 0.525\ P(-1) \tag{5.1}$$

$$1987: \quad Q = 63.464 - 0.525\ P(-1) \tag{5.2}$$

Multiplying by population and converting to metric tons gives estimated total sugar demands:

$$1971: \quad QT = 9995.897 - 49.437\ P(-1) \tag{5.3}$$

$$1987: \quad QT = 7015.348 - 58.034\ P(-1) \tag{5.4}$$

The intercept shifted to the left by about 2.98 million metric tons between 1971 and 1987. If the 1971 equation is adjusted for 1987 population, it becomes:

$$1987A: \quad QT = 11734.105 - 58.034\ P(-1) \tag{5.5}$$

This gives an estimated decrease of the intercept from 1971 to 1987 of about 4.719 million metric tons. Equation (5.5) can be used to estimate 1987 sugar demand, had no HFCS substitution occurred.

The supply equation for 1987 calculated from Table 10 is:

$$1987: \quad Qs = 5238 + 106.60\ P(-1) \qquad (5.6)$$

where Qs is U.S. sugar production in thousand metric tons, refined basis, and P(-1) is as above.

Empirical Measures of Welfare Impacts of Alternative U.S. Sugar Policies, 1987

The Current Quota

Table 11 gives estimates for the costs and benefits of the sugar quota in 1987. With a world excess supply elasticity of 2.37 and a premium of 5.35 cents, the quota caused losses to sugar users of $970 million, with HFCS substitution. This loss corresponds to area $P_oa'b'P^T$ in Figure 12. Without HFCS substitution, the quota would have cost sugar users $1226 million, corresponding to area P_oabP^T in Figure 12. Substitution of HFCS for sugar between 1971 and 1987 reduced the cost of the quota for sugar users by $256, corresponding to area a'ab' in Figure 12.

With infinitely elastic world excess supply of sugar and a premium of 5.35 cents, the quota costs sugar users $1055 million. Losses are larger than the $970 million with the positively sloped world excess supply, since the gap between U.S. target price and world price (P^T-P_o in Figure 12) is less than the price premium (P^T-P_q in Figure 12); with a horizontal

TABLE 11

COSTS AND BENEFITS OF THE SUGAR QUOTA PROGRAM, 1987

Quota Price Premium	Elasticity of World Excess Supply	Sugar User Cost: HFCS Substitution Without	Sugar User Cost: HFCS Substitution With	Net Social Gain From HFCS Substitution	Producer Gain	Net Social Cost (with HFCS Substitution)
c/lb		$million				
5.35	2.37	1226	970	256	654	316
	infinite	1334	1055	278	710	345
10.70	2.37	2522	1998	524	1318	679
	infinite	2680	2123	557	1397	726
16.05	2.37	3892	3087	805	1991	1096
	infinite	4039	3204	835	2061	1143

how?

world price the two gaps are the same, as in Figure 13.

In the case of world excess supply elasticity of 2.37 and a premium of 5.35 cents, producer gains due to the quota are $654 million. The loss to sugar buyers minus the gain to producers is net social cost, which is $316 million. With infinite world excess supply elasticity, net social cost would be $345 million.

With a 16.05 cent premium and infinite world excess supply elasticity, the quota would cost sugar users $3204 million, benefit producers $2061 million, and result in net social losses of $1143. The gain from HFCS in this case would be $835 million.

Figure 19 reproduces sugar user losses and producer gains from Table 11 for the small country case. The gains to sugar producers are clearly smaller than the losses to sugar users. The cost of transferring benefits to sugar producers is demonstrated in Figure 20. With a 5.35 cent premium, it costs society $348 million to transfer $708 million to producers. Regardless of the premium, it costs society about half of the value of the gain to producers to effect the transfer with quotas.

An Equivalent Tariff

Gains and losses of a tariff equivalent to the current quota are shown in Table 12. The losses to sugar users and gains to sugar producers are the same as in Table 11. With a premium of 5.35 cents and the large country assumption,

TABLE 12

COSTS AND BENEFITS OF AN EQUIVALENT TARIFF, 1987

Quota Price Premium	Elasticity of World Excess Supply	Sugar User Cost — Substitution: Without	Sugar User Cost — Substitution: With	Net Social Gain From HFCS Substitution	Producer Gain	Government Revenue — Substitution: Without	Government Revenue — Substitution: With	Net Social Cost (With HFCS Substitution)
c/lb		$million						
5.35	2.37	1226	970	256	654	605	49	267
	infinite	1334	1055	278	710	605	49	296
10.70	2.37	2522	1998	524	1318	1211	98	582
	infinite	2680	2123	557	1397	1211	98	628
16.05	2.37	3892	3087	805	1991	1816	146	950
	infinite	4039	3204	835	2061	1816	146	996

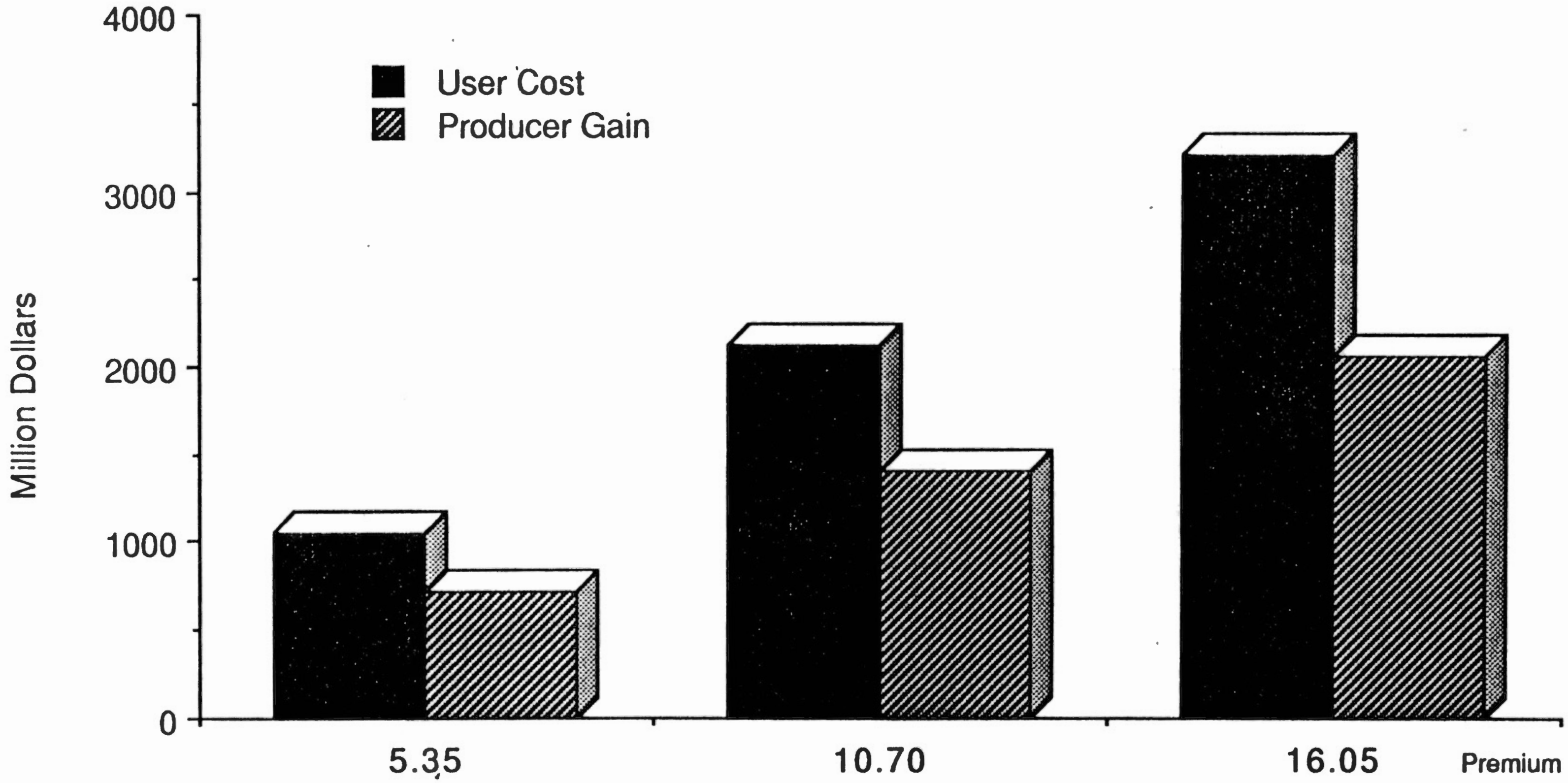


Figure 19. Sugar User Losses and Producer Gains from Quota, 1987

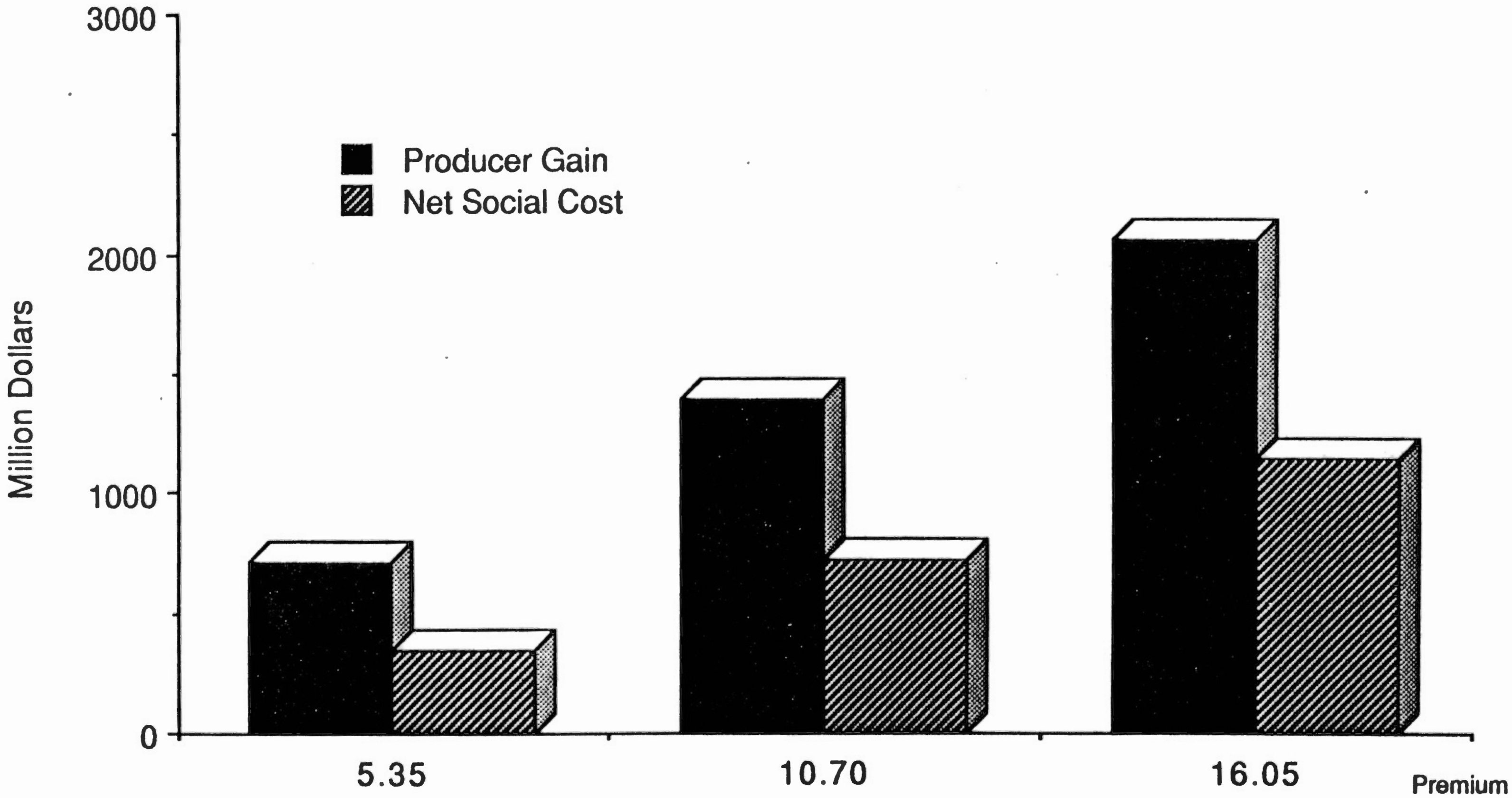


Figure 20. Producer Gains and Net Social Cost
From Quota, 1987

government revenue from the tariff is $49 million with HFCS substitution, corresponding to area lmb'd in Figure 12. Tariff revenue without substitution would have been $605 million. There is no difference in tariff revenue between the large and small country cases, since revenue depends on the premium which, is the same in either case.

If the premium were 16.05 cents, the government would collect $146 million from the tariff. The range of net social costs under a tariff is from $267 million to $996.

Figure 21 compares the net social cost of the tariff and quota. Regardless of the premium, the quota is a more expensive policy to achieve the same transfer to producers.

Deficiency Payment

Table 13 shows the difference between a deficiency payment program and the current quota program. Under the small country assumption, with a 5.35 cent premium, sugar users would gain $1334 million, exactly equal to their losses under the quota or tariff. With world price constant the deficiency payment program would be equivalent to the free trade situation for sugar users.

Under the large country assumption, consumers gain relative to a free trade situation, since world price falls below the free trade price and consumption rises above free trade quantity. The consumer gain over the free trade situation corresponds to area P_akaP_o in Figure 12. With a 5.35 cent premium the sugar user gain compared to the quota,

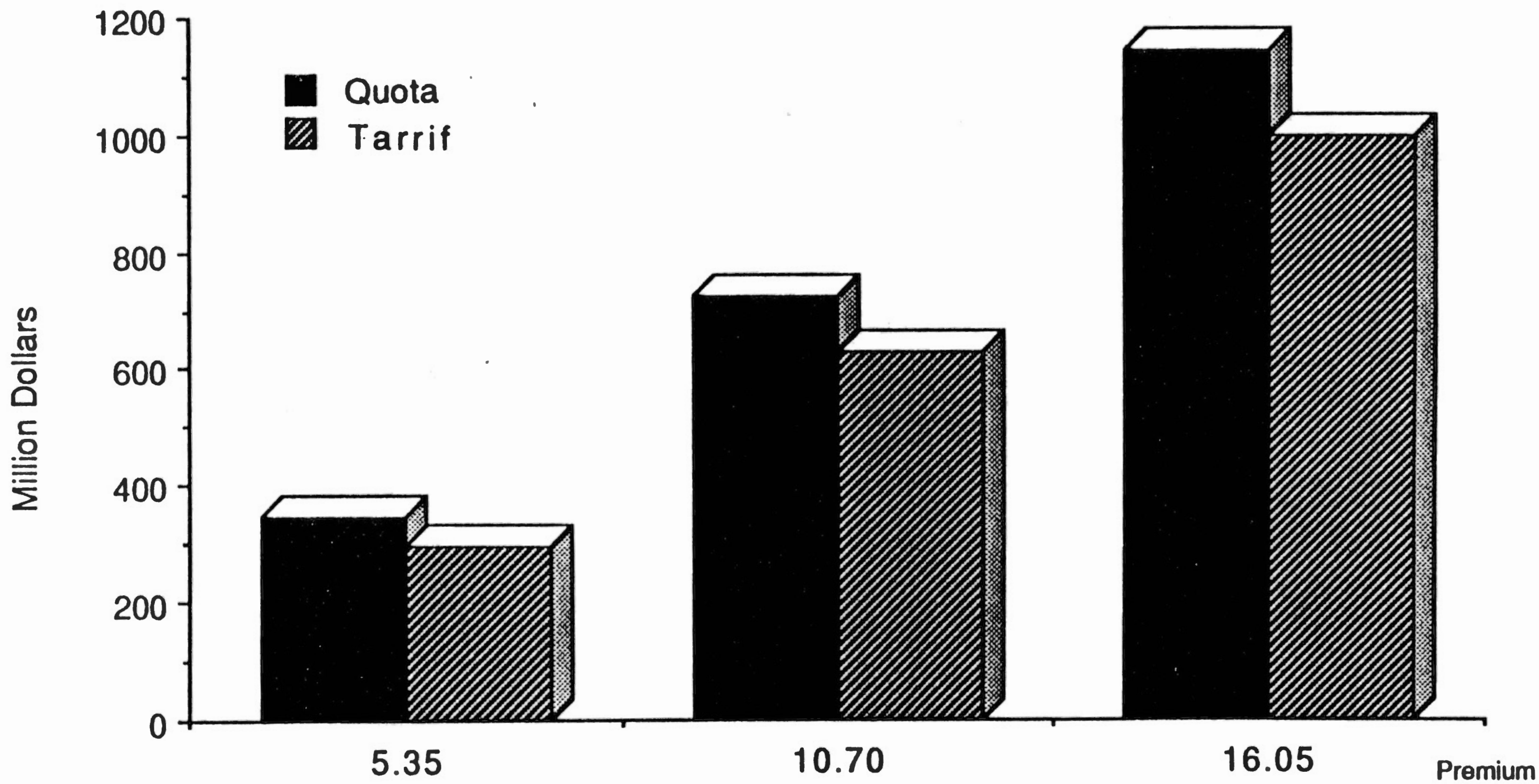


Figure 21. Comparison of Net Social Losses from Quota and Equivalent Tariff, 1987

TABLE 13

COSTS AND BENEFITS OF DEFICIENCY PAYMENT PROGRAM
COMPARED TO QUOTA, 1987

Quota Price Premium	Elasticity of World Excess Supply Curve	Sugar User Gain: Substitution Without	Sugar User Gain: Substitution With	Producer Effect	Treasury Expenditure	Net Social Gain (With HFCS Substitution)	Gain in Sugar Exporter Earnings
c/lb		------------------- $ million					-------------------
5.35	2.37	1294	1038	0	700	337	2032
	infinite	1334	1055	0	722	333	2016
10.70	2.37	2622	2098	0	1413	685	1489
	infinite	2680	2123	0	1444	679	1464
16.05	2.37	3986	3181	0	2138	1043	866
	infinite	4039	3204	0	2166	1038	841

$1038 million, exceeds the sugar user losses under the quota, $970 million, by $68 million.

Sugar producers experience no difference between the quota and the deficiency payment program, except that some producer revenue now comes from the government. Treasury expenditures range from $700 million to $2166 million, compared to no Treasury expenditures under the quota. The net social gains of a deficiency payment program over a quota range from $337 million to $1038 million.

Comparison of Net Social Costs of Quota, Tariff and Deficiency Payment

Table 14 presents a summary of the net social costs of the three programs. The deficiency payment program numbers are based on the assumption that, had the U.S. sugar price been at world price levels, no HFCS substitution would have occurred, since the world price level was below the estimated cost of production of HFCS. Table 14 shows that the quota and tariff policies are far more expensive than the deficiency payment program. Negative numbers (net social gains) under the deficiency payment program show the theoretical possibility of a large country gaining from trade interference.

Tables 13 and 15 show effects of alternative policies on the volume and value of trade. In Table 13, the last column shows the gains in exporter earnings from a deficiency payment program compared to the quota, and the range of estimates is

TABLE 14

NET SOCIAL COST COMPARISONS: QUOTA, TARIFF, DEFICIENCY PAYMENT, 1987

Policy Option	Elasticity of World Excess Supply	Quota or Tariff Price Premium		
		5.35	10.70	16.05
		(cents per pound)		
		$million		
Current Quota Policy	2.37	316	679	1096
	infinite	345	726	1143
Tariff	2.37	267	582	950
	infinite	296	628	996
Deficiency Payment	2.37	-21	-6	53
	infinite	12	46	104

TABLE 15

U.S. SUGAR IMPORT VOLUME, VALUE AND QUOTA RENT UNDER ALTERNATIVE PROGRAMS, 1987

US Import	Unit	Elasticity of World Excess Supply	Quota Price Premium ------ cents/lb --------- 5.35	10.70	16.05
Volume					
Quota	1000mt	2.37	413	413	413
		infinite	413	413	413
Free Trade	1000mt	2.37	5412	5705	6012
		infinite	5436	5740	6044
Value					
Quota	$million	2.37	219	219	219
		infinite	219	219	219
Free trade	$million	2.37	2276	1751	1130
		infinite	2235	1683	1059
Quota rent	$million	2.37	49	98	146
		infinite	49	98	146

from $841 to $2032 million. In Table 15, the volume and value of U.S. sugar imports under the quota is compared to a free trade scenario.

The quota necessary to achieve the target price of 22 cents for raw sugar is 413 thousand metric tons. Under free trade conditions the estimated imports of sugar would range from 5412 to 6044 thousand metric tons. The value of the quota imports evaluated at the target price is $219 million, compared to values of imports ranging from $1059 to $2276 million under free trade. The value of the quota rent is shown to range from $49 to $146 million. Exporters who obtain quotas realize the U.S. price of 22 cents instead of the lower world price, as the U.S. does not auction its quotas. In the past, it is possible that quota holders gained sufficient benefits from the quota rent to offset the lower volume of trade which resulted from the higher U.S. price. This table shows that this is not likely to be the case at present. The restrictions of sugar import volume necessary to achieve U.S. support price levels have reduced quota rents to a small fraction of the earnings which exporters would realize if there were no quotas.

Forecast of Welfare Impacts for 1988 and 1989

Validation of Equations

In this section the demand and supply equations will be used to forecast U.S. supply, demand and imports. The supply equation and forecasts for 1988 and 1989 are shown in Table 16, and the demand equation and forecasts for 1988 and 1989 are shown in Table 17. An import equation was constructed by subtracting the supply from the demand equation, and results are presented in Table 18. The numbers used for actual imports are derived by subtracting U.S. demand from U.S. production, rather than using the figures for imports listed in the USDA Sugar and Sweetener Reports, since the latter number includes some sugar destined for reexport.

Validation statistics over the sample period, 1971-87, are presented in Table 19. The root mean square simulation error of the demand equation is 200.211 thousand metric tons, where the mean value of demand over the sample period is 8462.047 thousand metric tons. The root mean square percent error is .025, and Theil's inequality coefficient is .012. The forecast and actual demand are visually represented in Figure 22.

The supply equation has a better fit than the demand equation over the sample period, which is a result of the Cooley-Prescott specification. The root mean square simulation error is 70.859 thousand metric tons, where the mean of the supply variable is 5180.18 thousand metric tons. The root mean square percent error is .014, and Theil's inequality coefficient is .007.

The import equation has a less precise fit than the supply and demand equations. The root mean square simulation error is 207.88 thousand metric tons, where the mean value of

TABLE 16

SUGAR SUPPLY: ESTIMATED, ACTUAL AND FORECAST

	Year	Intercept (1)	Slope (2)	Forecast Supply	Actual Supply (3)	Error
				---thousand metric tons---		
	1971	4158	95.46	5118.99	5076.9	-42.10
	1972	4263	99.23	5275.81	5395.7	119.88
	1973	4022	92.24	4950.59	4874.3	-76.32
	1974	3768	91.95	4659.86	4602.1	-57.76
	1975	3758	95.88	5844.37	5895.1	50.70
	1976	3960	95.55	5591.14	5611.9	20.74
	1977	4016	93.41	4941.03	4910.7	-30.31
	1978	4149	93.41	4925.10	5003.1	78.03
	1979	3988	88.47	4841.13	4730.1	-111.00
	1980	4064	90.96	4887.31	4982.8	95.48
	1981	3945	88.21	5313.12	5274.4	-38.68
	1982	3974	88.20	4899.32	4917.5	18.18
	1983	3992	87.16	4848.57	4772.5	-76.05
	1984	4171	90.45	4998.67	5012.5	13.79
	1985	4382	93.03	5203.73	5115.0	-88.68
	1986	4864	100.38	5656.87	5678.0	21.15
	1987	5238	106.60	6098.68	6210.5	111.79
(4)	1988	5447	110.20	6326.22	NA	NA
(4)	1989	5744	115.00	6649.60	NA	NA

Calculated from TVP supply equation.
NA = Not Available
(1) Includes non-price term
(2) Based on lagged price
(3) Source: USDA Sugar and Sweeteners Reports
(4) Forecast

TABLE 17

SUGAR DEMAND: ESTIMATED, ACTUAL AND FORECAST

Year	Intercept (1)	Slope	Estimated Demand (2)	Actual Demand (3)	Error
			--thousand	metric	tons---
1971	9995.90	-49.44	9498.39	9614.3	-115.95
1972	10071.60	-49.98	9561.65	9739.9	-178.25
1973	10096.83	-50.46	9588.77	9688.5	-99.75
1974	10111.79	-50.94	9617.95	9285.2	332.80
1975	10030.79	-51.44	8911.37	8739.5	171.91
1976	9923.53	-51.91	9037.12	9235.7	-198.58
1977	9812.33	-52.44	9292.87	9408.8	-115.94
1978	9677.75	-53.01	9237.22	9228.6	8.59
1979	9519.19	-53.58	9002.26	9113.8	-111.56
1980	9234.34	-54.22	8743.66	8634.5	109.19
1981	8934.09	-54.77	8084.80	8283.5	-198.71
1982	8684.14	-55.32	8103.89	7765.7	338.15
1983	8374.95	-55.84	7825.88	7562.7	263.14
1984	7910.39	-56.44	7393.90	7245.6	148.30
1985	7118.37	-56.99	6615.26	6838.3	-223.06
1986	7123.34	-57.51	6669.06	6594.5	74.59
1987	7015.35	-58.03	6546.59	6875.6	-329.03
(4)1988	6816.03	-58.59	6348.71	NA	NA
(4)1989	6700.87	-59.12	6235.34	NA	NA

Calculated from demand equation
NA = Not Available
(1) Includes non-price term
(2) Based on lagged price
(3) Source: USDA Sugar and Sweeteners Reports
(4) Forecast

TABLE 18

SUGAR IMPORTS: ESTIMATED, ACTUAL AND FORECAST

Year	Demand Minus Supply (Imports)		Error
	Projected	Actual	
	----Thousand metric tons---		
1971	4379	4537	-158
1972	4286	4344	-58
1973	4638	4814	-176
1974	4958	4683	275
1975	3067	2844	223
1976	3446	3624	-178
1977	4352	4498	-146
1978	4312	4226	87
1979	4161	4384	-223
1980	3856	3652	205
1981	2772	3009	-237
1982	3205	2848	356
1983	2977	2790	187
1984	2395	2233	162
1985	1412	1723	-312
1986	1012	916	96
1987	448	665	-217
(1)1988	22	NA	NA
(1)1989	-414	NA	NA

NA = Not Available
(1) Forecast. Figures for 1987-89 are not exactly the same as in Tables 11-15 and 22-31 since these are based on actual price, and the other Tables are based on the target price

TABLE 19

VALIDATION MEASURES OF SUPPLY, DEMAND, IMPORT EQUATIONS

	--------Equation-----------		
Measure	Supply	Demand	Import
Root Mean Square Simulation Error (thousand metric tons)	70.859	200.211	207.884
Root Mean Square Percent Error	0.014	0.025	0.110
Mean Simulation Error	8.849	-7.304	-6.784
Mean Percent Error	-0.001	-0.001	-0.013
Theil's Inequality Coefficient	0.007	0.012	0.030
Mean of Variable	5180.183	8462.047	3281.863

For formulas see Pindyck and Rubenfeld, Chapter 12

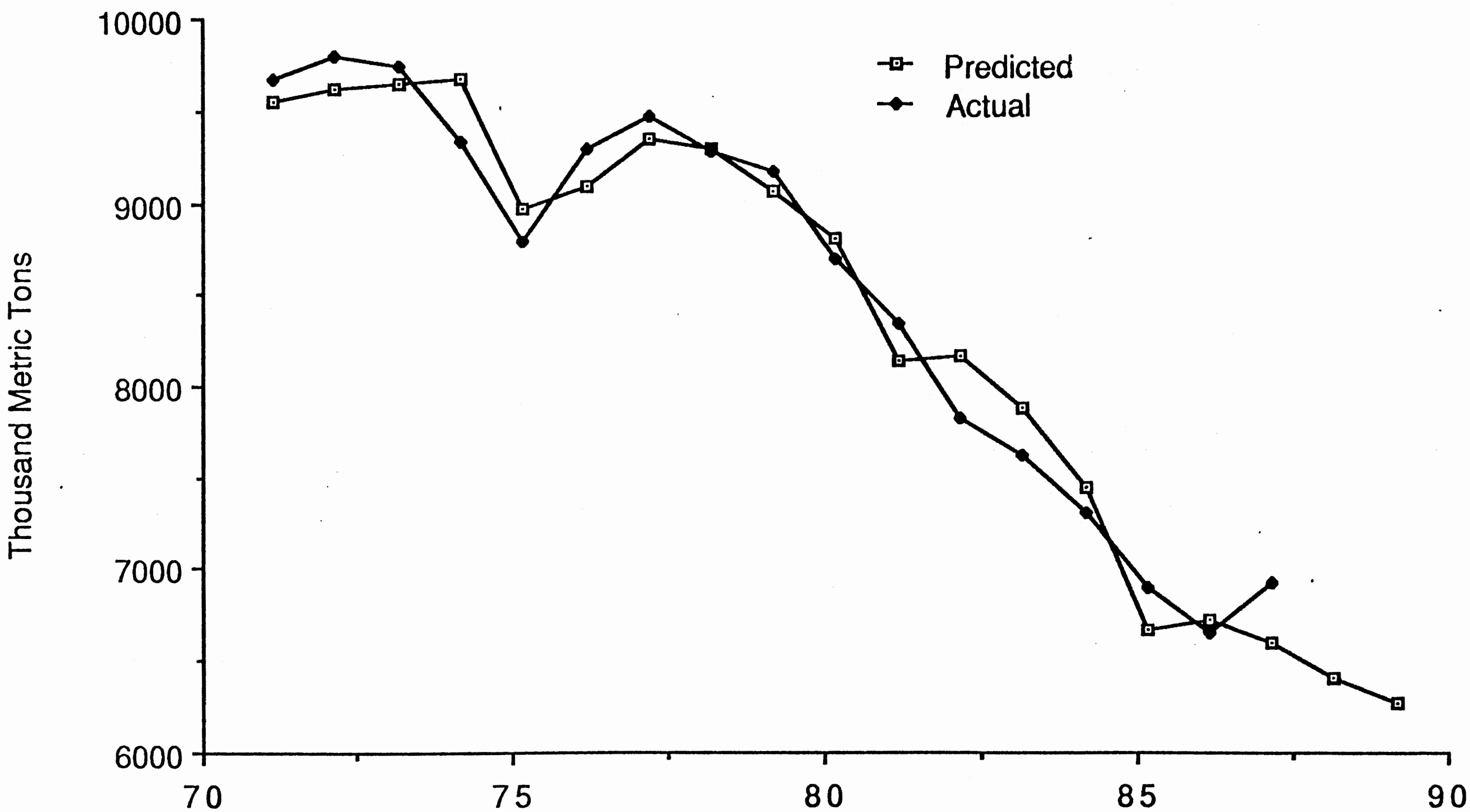


Figure 22. U.S. Sugar Demand, Predicted and Actual, 1971-89

imports is 3281.86. The root mean square percent error is .110, and Theil's inequality coefficient is .03.

To create a U.S. demand equation for 1988 and 1989, a forecast of per capita consumption of HFCS was used from Lin and Novick (1988). They forecast 1988 and 1989 levels of per capita HFCS consumption at 49.9 and 51.6 pounds per capita, respectively. The Chicago-West price of sugar was forecast to be 24 cents (nominal) in 1987 and 1988, which is approximately the same as the 1987 price. The producer price index was assumed to rise at 3 percent annually and is used to arrive at a real price. Adjusted for the median projected U.S. population estimates for 1988 and 1989 (U.S. Department of Commerce, 1988) the forecasted U.S. total sugar demand equations are:

(1988a) $$Q_d = 11847.257 - 58.593\ P(-1) \qquad (5.7)$$

(1988b) $$Q^d = 6838.373 - 58.593\ P(-1) \qquad (5.8)$$

(1989a) $$Q^d = 11953.186 - 59.117\ P(-1) \qquad (5.9)$$

(1989b) $$Q^d = 6724.618 - 59.117\ P(-1) \qquad (5.10)$$

where the "a" equations are the forecast equations, and the "b" equations will be used for estimates of the effect of HFCS substitution for sugar from 1971 to 1987.

A forecast of the supply curve requires assumptions about how the time-varying parameters will vary in the future as well as a forecast of the exogenous variables. Whatever the source of parameter variation, it is hypothesized to continue with the same influence on the permanent trend in the parameters that they have exhibited since 1983. A linear extrapolation based on 1983-87 values was computed for each supply parameter. The fertilizer price index was forecast to stay constant at the 1987 level for the next two years. Table 16 shows the estimated values of the supply parameters for 1971-87 and projected supply for 1988-89, which is also shown in Figure 23.

Forecast of Domestic Impacts

The welfare results of the 1988 and 1989 forecasts from the model for the policy alternatives of a quota, tariff and deficiency payment are presented in Appendix Tables 22-31. A summary of the forecasted welfare effects of the quota and tariff for 1988 and 1989 is presented in Table 20. Using the median price premium of 10.70 cents and the infinite world excess supply assumption, producer gain is seen to increase from $1397 million in 1987 to $1521 million in 1989. Sugar user losses are $2123 million in 1987, and decline to $2115 in 1989.

The forecast shows that producer gains increase by $124 million from 1987 to 1989, and sugar user losses decrease by $8 million. Political pressure by producers to maintain current policy should remain high or perhaps even increase, even though the industry as a whole may shrink as a result of current policy. If sugar user incentives to eliminate the quotas are affected by their welfare losses, these results

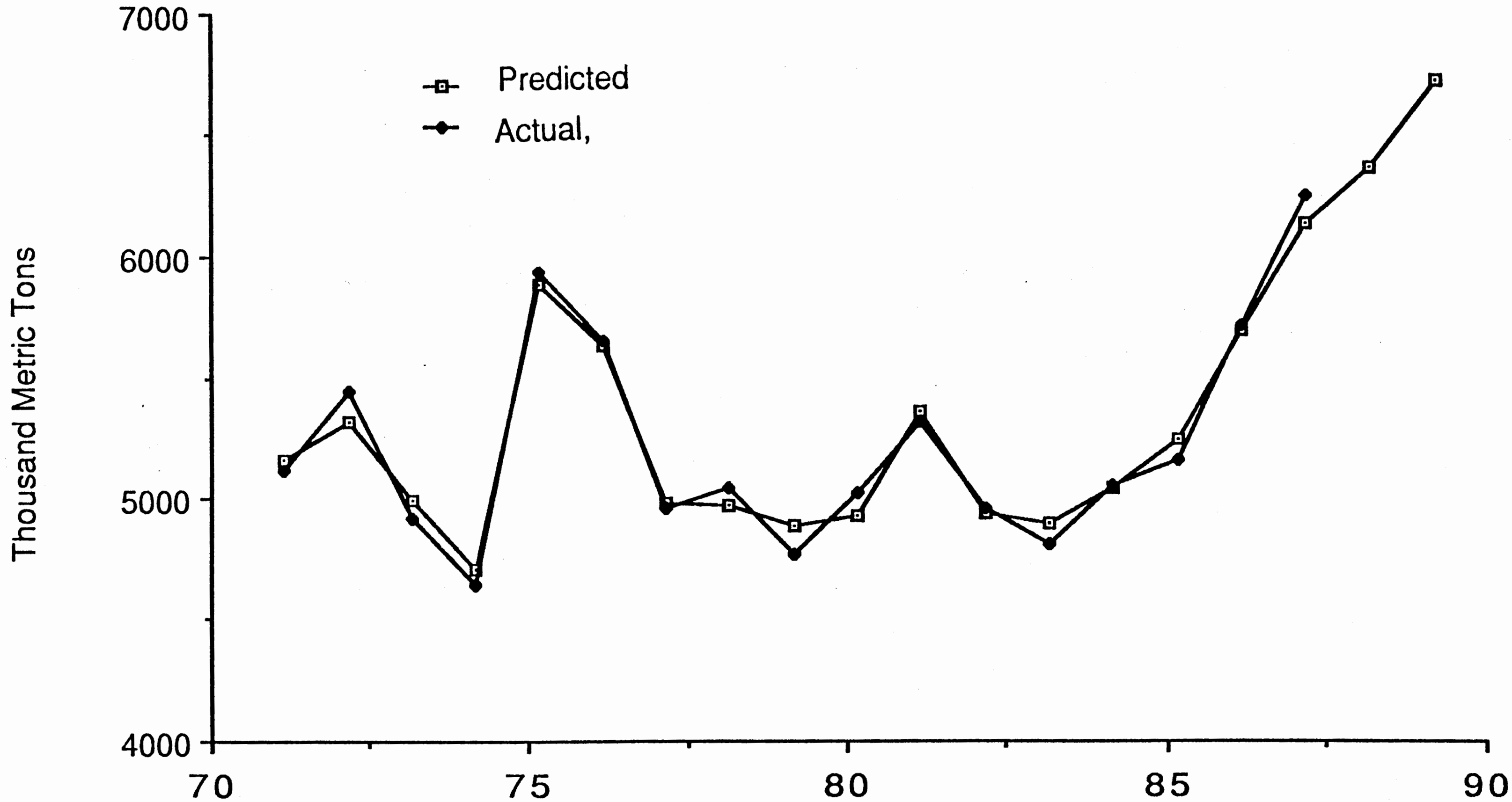


Figure 23. U.S. Sugar Supply, Predicted and Actual, 1971-89

TABLE 20

COMPARISON OF QUOTA AND TARIFF, 1987-89

Category	1987	1988	1989
	Year		
	$million		
QUOTA			
Net Social Cost	726	665	594
Producer Gain	1397	1449	1521
Sugar User Loss	2123	2114	2115
TARIFF			
Net Social Cost	628	665	692
Government Revenue	98	0	-98

All calculations based on assumption of infinite world excess supply elasticity, premium of 10.70, and with HFCS substitution indicate such incentives should decrease over the next two years.

Forecast of Trade Impacts

Table 21 shows that imports decline from 413 thousand metric tons in 1987 to zero in 1988, and then become negative, i.e. exports of 414 thousand metric tons in 1989. Figure 24 shows predicted and forecast imports for 1971-89. While it seems unlikely that the U.S. would ever become a net sugar exporter, it is sobering to realize that the European Community was until the mid-1970s one of the world's largest sugar importers and now exports about 6 million tons per year, second only to Cuba.

The value of the quota rent to exporters is lost as U.S. imports end, and under the 1989 projection the U.S. would be competing for export markets. Under an alternative free trade policy, Table 20 shows U.S. sugar imports would be 5642 and 5449 thousand metric tons in 1988 and 1989, respectively.

The reduction of sugar imports has had a large impact on some countries. For the Dominican Republic, for example, the reduction in the value of their annual U.S. quota from 1982/83 to 1987 was $126.4 million, while U.S. foreign aid to the Dominican Republic in fiscal year 1987 was $69.2 million (Ives and Hurley p. 75). Thirteen Caribbean countries have faced reduced sugar earnings from declining U.S. quotas in recent years, eleven of them countries to which the U.S. gives substantial foreign aid. The reduction of sugar export

TABLE 21

US IMPORT VOLUME, VALUE AND QUOTA RENT, 1987-89

	Unit	1987	1988	1989
		---------- Year	----------	----------
Quota Volume	1000mt	413	0(1)	-414
Quota Value	$million	219	0	-219
Quota rent (2)	$million	98	0	-98
Free Trade Volume (2)	1000mt	5740	5642	5449
Free Trade Value	$million	1683	1654	1598

(1) Actual value from model was 0.02 thousand metric tons, which rounds to zero
(2) All calculations made under assumption of infinite world excess supply elasticity and 10.70 cent premium.

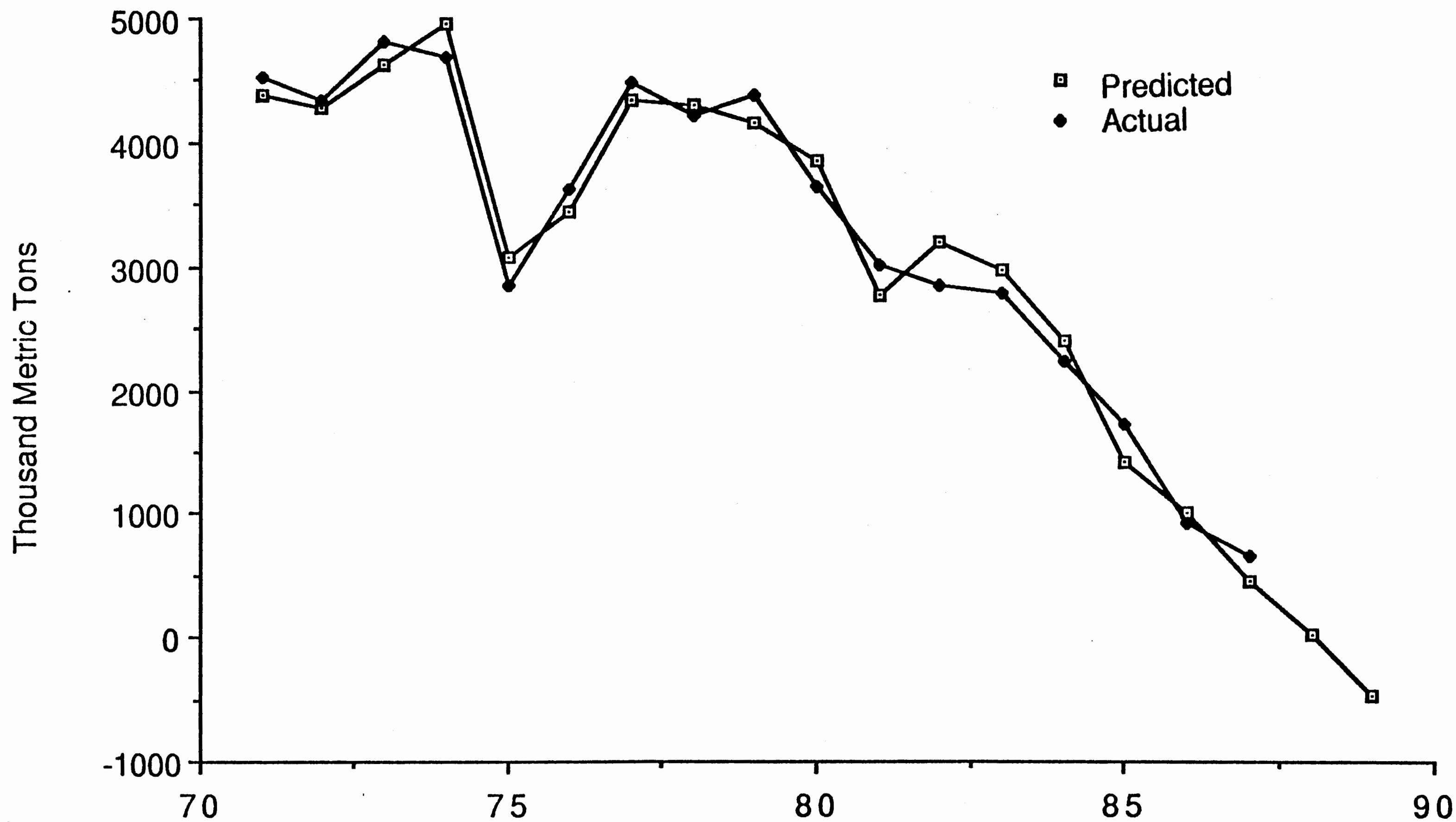


Figure 24. U.S. Sugar Imports, Predicted and Actual, 1971-89

earnings is not directly comparable to foreign aid dollars, since the earnings are not all profit.

The U.S. might want to maintain, for political reasons, a certain level of imports over the next few years. Suppose it was decided that a level of 500 thousand metric tons (refined basis) of sugar would be imported. The model shows that in order to attain this level of imports, the Chicago-West sugar price would need to be 15.23 cents in 1988, and 8.0 cents in 1989. Currently, the MSP for raw sugar is about 2 cents below the Chicago-West price, so approximate levels of the MSP needed to maintain the import target of 500 thousand metric tons would be 13.23 cents in 1988 and 6 cents in 1989. It must be kept in mind that these forecasts are only indicative, and based on the many assumptions used to create the forecasts. Many possible events, such as a world sugar price spike or a major drought, could cause the forecasts to be off.

The U.S. has proposed at the negotiations currently occurring under the Uruguay round of the General Agreements on Tariffs and Trade (GATT) that all agricultural subsidies and trade-interfering policies be eliminated over the next ten years. Current sugar policy is clearly inconsistent with the U.S. position at the GATT, and could jeopardize the progress of the talks if it contributes to a sense among other countries that the U.S. is hypocritical about its free trade position. If the above short-run forecasts of sugar imports are even of the correct sign, the U.S. "free trade" bargaining position at the GATT will be weakened. It would be difficult to argue that Japan, for example, should open up their rice, beef, and other agricultural markets to U.S. exports when we are protecting sugar in much the same way that Japan is protecting its domestic agriculture.

triggered

CHAPTER VI

CONCLUSIONS

U.S. sugar policy has successfully protected U.S. sugar producers, but has triggered trends in sugar supply and demand and related markets which may force a reevaluation of the policy in the near future. The declining imports of sugar due to lower quotas has harmed many politically friendly less developed countries. The HFCS industry, which now uses about six percent of the U.S. corn crop, is a major unintended beneficiary of the policy. U.S. corn farmers are also unintended beneficiaries to the extent that HFCS provides an additional demand for about 500 million bushels of corn.

The procedures used in this study were as follows. U.S. supply and demand for sugar were estimated with annual data from 1971-87 using both Ordinary Least Squares and the Cooley-Prescott random coefficients model. An equilibrium demand curve model was used to capture welfare effects of the substitution of HFCS for sugar. A classical welfare analysis, using the concepts of consumer and producer surplus, was used to estimate the welfare losses to the U.S. of current sugar policy under various assumptions about the world price and excess supply elasticity facing the U.S.. Forecasts of U.S. sugar demand, supply and imports were made.

The specific objectives of this study were to:

1) measure the effects of U.S. sugar quotas on producers, consumers, taxpayers, and foreign suppliers

2) measure the welfare effects of the recent trend of substitution of HFCS for sugar

3) evaluate the welfare effects of the alternative policies of an equivalent tariff and a deficiency payment program

4) forecast the welfare effects of continuation of the current quota policy for the next two years.

In the light of these objective, the principle conclusions are:

1) The U.S. quota policy imposes significant costs on the U.S. economy, ranging from $654 to $2061 million in 1987, depending on assumptions about the world price of sugar and the elasticity of world excess sugar supply facing the U.S. Producers gain from $256 to $835 million, and sugar users suffer losses of $970 to $3204. The quota was shown to cost about 50 cents for each dollar transferred to producers. The welfare measures are conservative in the sense that they do not capture effects on the final consumer, which if included would result in larger estimates of all net social losses.

U.S. sugar quota imports are below projected free trade import levels by almost 5 million metric tons, which translates into large revenue losses for sugar exporters. The gains to exporters from the quota rent are from $49 to $146 million in 1987, far below projected revenue under free trade of from $1059 to $2276 million. For the U.S. to decide to maintain sugar imports of 500 thousand metric tons in 1989 in order to assist low income sugar exporting countries, the model predicts that the domestic price would have to be lowered to about 6 cents (raw sugar).

2) The substitution of HFCS for sugar, which was induced largely due to the fact that the U.S. sugar price was far above the world price, has significantly reduced the net social cost of U.S. sugar policy. For 1987 the net social gain due the HFCS substitution is estimated to range from $256 to $835 million. This is a large gain, and is a <u>net</u> gain, over and above the benefits to the corn sweetener industry. Such substitutions, made by cost-minimizing agents, serve not only to benefit the agents and frustrate the policy which causes them to arise, but also benefit society, a point made by Adam Smith in 1776 in <u>The Wealth of Nations.</u>

3) The quota is found to be a less efficient policy than the alternatives of an equivalent tariff or a deficiency payment program. For 1987 an equivalent

tariff would have reduced the net social loss of sugar policy by $49 to $146 million, compared to the quota. A deficiency payment program would have saved the U.S. $333 to $1038 million compared to the quota. The conclusion that a quota is less efficient than a tariff or deficiency payment program is generally supported by economic theory.

4) If current policy and trends continues, the U.S. sugar deficit is forecast to become a surplus in two years. This would harm other sugar exporting countries. Domestic welfare effects would depend heavily upon how the U.S. responded to its new surplus sugar position. Export subsidies or Commodity Credit Corporation purchases would require Federal expenditures, which current legislation prohibits. The evidence in this study supports a conclusion that a welfare transfer from sugar exporting countries to U.S. sugar producers, HFCS producers and corn growers has occurred. This transfer, which harms the relatively poorer sugar exporters, may not be acceptable in the light of U.S. foreign policy, especially the Caribbean Basin Initiative which seeks to strengthen the private sectors and economic performance of Caribbean countries.

It should be noted that as in almost all cases, the welfare transfers found in this study may be uneven; for example, raw sugar refiners have traditionally depended heavily upon raw sugar imports, and they have suffered under the quota policy even though they would be classified in the sugar producing industry.

Suggestions for Further Research

This study has suggested that U.S. HFCS producers and corn growers have benefitted from sugar policy. Further research could be done to quantify that transfer, as well as the transfer from foreign producers to U.S. sweetener producers. This study has focused on the impact that sugar policy has had on the allocation of resources, but research on the distributional effects of sugar policy would be necessary before any comprehensive evaluation of sugar policy could be attempted.

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APPENDIX A

THE COOLEY-PRESCOTT MODEL

The following is a brief description of the Cooley-Prescott model. The derivations are from Cooley and Prescott (1976) and Judge et. al. (1985), where more detail is given.

The process to be modelled is:

$$y_t = x_t \beta_t \qquad \text{(A.1)}$$

where y_t is the t^{th} observation of the dependent variable, x_t is the observation vector on k explanatory variables and β_t is the parameter vector, which is stochastic. There are considered to be two types of variation possible in the parameter vector, permanent and transient. The parameter vector is modeled as:

$$\beta_t = \beta_t^p + u_t \qquad \text{(A.2)}$$

$$\beta_t^p = \beta_{t-1}^p + v_t \qquad \text{(A.3)}$$

where β_t^p is the permanent component of the parameter vector. The u_t and v_t are identically and independently distributed normal variates with mean vectors zero and covariance structures known up to scale factors. They can be parameterized as follows:

$$\text{cov}(u_t) = (1-\gamma)\sigma^2\Sigma_u \tag{A.4}$$

$$\text{cov}(v_t) = \gamma\sigma^2\Sigma_v \tag{A.5}$$

where again, Σ_u and Σ_v are known up to scale factors. The transitory change in the intercept will correspond to the additive disturbance term in a conventional regression model, when an intercept is present and a normalization setting σ_u^{11} and σ_v^{11} equal to one. The unknowns are the β_t, and the unchanging σ^2 and γ which specify the covariance structure. The objective is to estimate these unknowns.

The process generating the parameters is non-stationary and it is thus impossible to specify the likelihood function. However, the likelihood function conditional on the value of the parameter process at a particular point in time is defined, and specific realizations of the parameter process can be treated as random parameters to be estimated. Choosing period T+1, one period past the sample,

$$\beta^R_{T+1} = \beta^R_T + v_{T+1} = \beta^R_t + \sum_{s=t+1}^{T+1} v_s \tag{A.6}$$

$$\beta_t = \beta^{p}_{T+1} - \sum_{s=t+1}^{T+1} v_s + u_t \qquad \text{(A.7)}$$

Now we can rewrite equation (A.1):

$$y_t = x'_t\beta + \mu_t \qquad \text{(A.8)}$$

where

$$\beta = \beta^{p}_{T+1} \qquad \text{(A.9)}$$

and

$$\mu = x'_t u_t - x'_t \sum_{s=t+1}^{T+1} v_s \qquad \text{(A.10)}$$

The error term of equation (A.8), μ, is distributed normally with mean zero and covariance matrix:

$$\text{cov}(\mu) = \sigma^2[(1-\gamma)R + \gamma Q] = \sigma^2\Omega(\gamma) \qquad \text{(A.11)}$$

where R is a diagonal matrix with

$$r_{ii} = (x'i\Sigma_u xi) \qquad \text{(A.12)}$$

and Q is a matrix such that

$$q_{ij} = \min(T-i+1,\ T-j+1)x'_i\Sigma_v x_j \qquad \text{(A.13)}$$

To estimate the permanent component of the parameter vector in some period t, β^{p}_{t}, the appropriate formulae for the q_{ij}

are:

$$q_{ij} = \min(|t-i|,\ |t-j|)x'_i\Sigma_v x_j, \tag{A.14}$$

if both i and j exceed or are less than t. Otherwise, q_{ij} = 0. Compiling the equations, a full model can be written

$$Y = X\beta + \mu \tag{A.15}$$

where β is the k-component vector for period T+1, Y is the T component vector of the y_t, and X is the Txk matrix of observations on the independent variables. Y is distributed as:

$$Y \sim N[\ X\beta,\ \sigma^2\Omega(\gamma)] \tag{A.16}$$

The unknown parameter γ indicates how the β's are adapting to structural change; if γ is large (close to one) then permanent changes are large relative to transitory changes; is γ is close to zero, then permanent changes are small relative to transitory changes.

The log likelihood function of the observations is the multivariate normal form:

$$L(Y;\beta,\sigma^2,\gamma,X) = -\frac{T}{2}\ln 2\pi - \frac{T}{2}\ln\sigma^2 - \frac{1}{2}\ln|\Omega(\gamma)|$$

$$-\frac{1}{2\sigma^2}(y-X\beta)'\Omega(\gamma)^{-1}(y-X\beta) \tag{A.17}$$

The above likelihood function can be maximized partially with respect to β and σ^2 to obtain estimators conditional on γ;

$$B(\gamma) = [X'\Omega(\gamma)^{-1} X] \quad X'\Omega(\gamma)^{-1} Y \tag{A.18}$$

$$s^2(\gamma) = \frac{1}{T} [(Y-X\beta(\gamma))'\Omega(\gamma)^{-1} (Y-X\beta(\gamma))] \tag{A.19}$$

These two equations are substituted into (A.17) to determine a concentrated log likelihood function:

$$Lc(Y;\gamma) = -\frac{T}{2}\ln 2\pi - \frac{T}{2}\ln s^2(\gamma) - \frac{1}{2}\ln|\Omega(\gamma)| - \frac{T}{2}$$

$$= -\frac{T}{2}(\ln 2\pi+1) - \frac{T}{2}\ln s^2(\gamma) - \frac{1}{2}\ln|\Omega(\gamma)| \tag{A.20}$$

Estimation proceeds by maximizing (A.20) with respect to γ. Since γ is restricted to the range $0 \leq \gamma \leq 1$, this can be done iteratively with small computational cost. Once an estimate of γ, say g, is obtained, B(g) and $s^2(g)$ can be obtained.

Cooley and Prescott show that g is consistent for γ and that $B(\gamma)$ is asymptotically efficient and asymptotically yields optimal predictions. Due to the non-stationarity, however, there is no consistent estimator for β_{T+1}.

The relative variability of the parameters is not often known empirically, requiring an estimate of the matrices Σ_u and Σ_v. In the absence of other information, the covariance matrix of the coefficient vector from ordinary least squares is used as an estimator for both Σ_u and Σ_v. If there is no covariance between elements of the β vector, then Σ_u and Σ_v will be diagonal matrices, and in this paper it is assumed that the matrices are diagonal.

Cooley and Prescott found the model to be robust with respect to variation in Σ_u and Σ_v.

APPENDIX B

TABLES OF FORECASTED WELFARE MEASURES OF ALTERNATIVE U.S. SUGAR POLICIES FOR 1988 AND 1989

TABLE 22

COSTS AND BENEFITS OF THE SUGAR QUOTA, 1988

Quota Price Premium	Elasticity of World Excess Supply	Sugar User Cost, HFCS Substitution: Without	Sugar User Cost, HFCS Substitution: With	Net Social Gain From HFCS Substitution	Producer Gain	Net Social Cost (with HFCS Substitution)
c/lb		$million				
5.35	2.37	1237	964	272	677	288
	infinite	1348	1051	297	736	315
10.70	2.37	2544	1986	558	1365	622
	infinite	2708	2114	593	1449	665
16.05	2.37	3929	3071	858	2063	1008
	infinite	4080	3190	890	2138	1052

TABLE 23

COSTS AND BENEFITS OF AN EQUIVALENT TARIFF, 1988

Quota Price Premium	Elasticity of World Excess Supply	Sugar User Cost Substitution Without	Sugar User Cost Substitution With	Net Social Gain From HFCS Substitution	Producer Gain	Government Revenue Substitution Without	Government Revenue Substitution With	Net Social Cost (With HFCS Substitution)
c/lb		$million						
5.35	2.37	1237	964	272	677	593	0	288
	infinite	1348	1051	297	736	593	0	315
10.70	2.37	2544	1986	558	1365	1187	0	622
	infinite	2708	2114	593	1449	1187	0	665
16.05	2.37	3929	3071	858	2063	1780	0	1008
	infinite	4080	3190	890	2138	1780	0	1052

TABLE 24

COSTS AND BENEFITS OF DEFICIENCY PAYMENT PROGRAM
COMPARED TO QUOTA, 1988

Quota Price Premium	Elasticity of World Excess Supply Curve	Sugar User Gain Substitution Without	Sugar User Gain Substitution With	Producer Effect	Treasury Expenditure	Net Social Gain (With HFCS Substitution)	Gain in Sugar Exporter Earnings
c/lb		$million					
5.35	2.37	1307	1034	0	725	309	2209
	infinite	1348	1051	0	748	303	2194
10.70	2.37	2649	2091	0	1463	627	1679
	infinite	2708	2114	0	1496	618	1654
16.05	2.37	4026	3169	0	2214	954	1068
	infinite	4080	3190	0	2244	946	1042

TABLE 25

NET SOCIAL COST COMPARISONS: QUOTA,TARIFF, DEFICIENCY PAYMENTS, 1988

Policy Option	Elasticity of World Excess Supply	Quota or Tariff Price Premium (cents per pound)		
		5.35	10.70	16.05
		$million		
Current Quota Policy	2.37	288	622	1008
	infinite	315	665	1052
Tariff	2.37	288	622	1008
	infinite	315	665	1052
Deficiency Payment	2.37	-21	-6	54
	infinite	12	47	106

TABLE 26

U.S. SUGAR IMPORT VOLUME, VALUE AND QUOTA RENT
UNDER ALTERNATIVE PROGRAMS,1988

US Import		Unit	Elasticity of World Excess Supply	Quota Price Premium ------ cents/lb --------- 5.35	10.70	16.05
Volume						
	Quota	1000mt	2.37	0	0	0
			infinite	0	0	0
	Free Trade	1000mt	2.37	5311	5605	5913
			infinite	5336	5642	5947
Value						
	Quota	$million	2.37	0	0	0
			infinite	0	0	0
	Free trade	$million	2.37	2235	1723	1113
			infinite	2194	1654	1042
	Quota rent	$million	2.37	0	0	0
			infinite	0	0	0

TABLE 27

COSTS AND BENEFITS OF THE SUGAR QUOTA PROGRAM, 1989

Quota Price Premium	Elasticity of World Excess Supply	Sugar User Cost: HFCS Substitution Without	Sugar User Cost: HFCS Substitution With	Net Social Gain From HFCS Substitution	Producer Gain	Net Social Cost (with HFCS Substitution)
c/lb		$million				
5.35	2.37	1245	961	283	708	254
	infinite	1361	1051	310	772	279
10.70	2.37	2563	1982	581	1429	553
	infinite	2734	2115	619	1521	594
16.05	2.37	3961	3067	894	2164	903
	infinite	4120	3191	929	2246	945

TABLE 28

COSTS AND BENEFITS OF AN EQUIVALENT TARIFF, 1989

Quota Price Premium	Elasticity of World Excess Supply	Sugar User Cost: Substitution Without	Sugar User Cost: Substitution With	Net Social Gain From HFCS Substitution	Producer Gain	Government Revenue: Substitution Without	Government Revenue: Substitution With	Net Social Cost (With HFCS Substitution)
c/lb		$million						
5.35	2.37	1245	961	283	708	571	-49	303
	infinite	1361	1051	310	772	571	-49	328
10.70	2.37	2563	1982	581	1429	1141	-98	650
	infinite	2734	2115	619	1521	1141	-98	692
16.05	2.37	3961	3067	894	2164	1712	-147	1050
	infinite	4120	3191	929	2246	1712	-147	1091

TABLE 29

COSTS AND BENEFITS OF DEFICIENCY PAYMENT PROGRAM COMPARED TO QUOTA, 1989

Quota Price Premium	Elasticity of World Excess Supply Curve	Sugar User Gain: Substitution Without	Sugar User Gain: Substitution With	Producer Effect	Treasury Expenditure	Net Social Gain (With HFCS Substitution)	Gain in Sugar Exporter Earnings
c/lb		$million					
5.35	2.37	1319	1036	0	760	276	2349
	infinite	1361	1051	0	784	267	2334
10.70	2.37	2674	2093	0	1534	559	1841
	infinite	2734	2115	0	1569	546	1817
16.05	2.37	4065	3171	0	2322	849	1253
	infinite	4120	3191	0	2353	838	1228

TABLE 30

NET SOCIAL COST COMPARISONS: QUOTA, TARIFF, DEFICIENCY PAYMENTS, 1989

Policy Option	Elasticity of World Excess Supply	Quota or Tariff Price Premium		
		5.35	10.70	16.05
		(cents per pound)		
		$million		
Current Quota Policy	2.37	254	553	903
	infinite	279	594	945
Tariff	2.37	303	650	1050
	infinite	328	692	1091
Deficiency Payment	2.37	-22	-6	54
	infinite	12	48	107

TABLE 31

U.S. SUGAR IMPORT VOLUME, VALUE AND QUOTA RENT
UNDER ALTERNATIVE PROGRAMS, 1989

US Import		Unit	Elasticity of World Excess Supply	Quota Price Premium ------ cents/lb ---------		
				5.35	10.70	16.05
Volume						
	Quota	1000mt	2.37	-414	-414	-414
			infinite	-414	-414	-414
	Free Trade	1000mt	2.37	5118	5411	5720
			infinite	5144	5449	5755
Value						
	Quota	$million	2.37	-219	-219	-219
			infinite	-219	-219	-219
	Free trade	$million	2.37	2156	1666	1080
			infinite	2115	1598	1009
	Quota rent	$million	2.37	-49	-98	-147
			infinite	-49	-98	-147

2

VITA

Ronald Canby Lord

Candidate for the Degree of

Doctor of Philosophy

Thesis: ESTIMATION OF WELFARE EFFECTS OF U.S. SUGAR POLICY WITH TIME-VARYING PARAMETERS

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Grinnell, Iowa, March 22, 1952, the son of Charles R. and Josephine S. Lord. Married to Jenny L. Tarpley on May 2, 1981.

Education: Graduated from Westtown School, Westtown, Pennsylvania, in June 1969; received Bachelor of Arts Degree in Biology from Earlham College in June 1976; received Master of Arts Degree in Agricultural Economics from the University of Wisconsin-Madison in August, 1981; completed the requirements for the degree of Doctor of Philosophy at Oklahoma State University in December, 1988.

Professional Experience: Research Assistant, Department of Agricultural Economics, University of Wisconsin-Madison, 1979-81; Adjunct Assistant Professor, Department of Economics, Lakeland College, Sheboygan, Wisconsin, January - June 1982; Lecturer in Economics, University of Wisconsin-Richland Center, August 1982-May 1983; Lecturer in Economics, University of Wisconsin-Stout, Menomonie, Wisconsin, August 1983-August 1985; Research Fellow, Department of Agricultural Economics, Oklahoma State University, August, 1985 to present.