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Economic and Political Aspects of Sugar from an International Perspective

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SUGAR AND ITS HISTORY

"Sugar crops provide the world's most abundant organic chemical available in purified form (96–99.9 per cent pure)" (1). A carbohydrate, sugar is formed through photosynthesis. The energy of sunlight, transformed into chemical energy by the chlorophyll in green plants, acts on water and atmospheric carbon dioxide to form plant sugars in many foods both in the tropics and in temperate zones.

Only one substance is by common usage called *sugar*, and that is the natural sweetener sucrose, a product obtained, usually commercially, in crystalline form from sugar cane or sugar beets. *Sucrose* is a disaccharide of the carbohydrate family: disaccharide because it is a chemical union of two monosaccharides, glucose (dextrose) and fructose (levulose); and carbohydrate because it is a chemical compound in which hydrogen and oxygen, in the proportion of 2:1, as in water, are combined with carbon, $C_{12}H_{22}O_{11}$.

Whether *sugar cane* was originally a native to New Guinea (where wild species are still to be found) or the Bengal Coast is uncertain. Hindu literature refers to cane growing in India 3000 years ago, one of Alexander's generals refers in 325 BC to cane growing in Western India, and Pliny (23–79 AD) referred to Indian sugar. The development of a world sugar industry had its foundations in the spread of Islam in the Old World and Christianity in the New World. Sugar cane was carried by Arab traders to Persia in the sixth century and to China in the eighth. Islam's Holy Wars hastened the spread of sugar cane throughout the Littoral and the Mediterranean, including Egypt. Sugar was a scarce European product in this period, developing from the pharmacopoeia of the Salerno School in the tenth century to a luxury item imported by Venetian traders. By 1300, Venice was the sugar capital of the world. From Spain, sugar cane reached Madeira in 1420, whence it was carried to the Canary Islands and the Azores.

Sugar cane reached the New World in 1493 in the hands of a son-in-law of a Madeiran cane planter, Christopher Columbus. Portuguese enterprise spread sugar cane to the west coast of Africa and Brazil. There was then a rapid spread of sugar

cane in the Caribbean. By the early seventeenth century, England and France had established refineries to handle raw sugar from the West Indies (2,3).

Credit for the recognition of the presence of sugar in beets is given to a German chemist, A. S. Margraff, who published in 1747 experiments that established that sugar from cane and from the white beet *Beta vulgaris saccherifera* were the same. His pupil, F. C. Achard, developed practical methods for extracting sugar from beet and presented a sample of sugar thus produced to the King of Prussia in 1799. Beet factories were established in Austria and Salesia from 1800. These developments were capitalized on by Napoleon, whose struggle with England had resulted in the cutting off of sugar shipments from the Caribbean. By 1813, 334 factories had been established and 35,000 tonnes produced.

Sugar has been causal to the great and relatively recent social upheavals in world history. A colonial and plantation crop, sugar was developed by western enterprise and capital to produce raw materials in return for manufactured goods. This two-way trade was extended because of the high demand for cheap labor to the slave trade. The abolition of slavery was succeeded by a gradual increase in the barriers to trade to protect a more highly capitalized agriculture in metropolitan countries. To meet the shortage of labor created by emancipation, indentured labor was imported, especially from India, creating in turn, racial problems in a postcolonial era.

POLITICS AND CONSUMERS

The world sugar economy rarely provides a good fit for economic theories, since not only is it subject to massive government intervention but also it is influenced by powerful political idealism and consumer forces.

The major influence, of course, has been war, which has directed national sugar policies and the desire for self-sufficiency since the Napoleonic Wars. More recently, the injection of economic liberalism into centralized systems has led to demands not only for political freedom but also for greater economic choice, as seen in the emergence of USSR and China as major sugar consumers and importers over the last two decades. Those two countries now import one third of all sugar traded annually.

Expansion in the trade demand for white sugar in the 1970s derived from the emergence of new markets in countries that had achieved rapid wealth from the export of oil, such as Saudi Arabia, Nigeria, Iran, Iraq, Indonesia, Mexico, and the Arabian Gulf. These countries were generally without sugar refineries, and their growth in consumption was aided by growing export availabilities from the European Community (EC). This demand slackened in the early 1980s with world recession, which included a fall in crude oil prices, following which certain countries, including Mexico, Indonesia, and Venezuela, took steps to increase domestic production (4).

In Brazil, the ethanol industry, which has been supported by the government for strategic and trade reasons, absorbs about 60% of Brazil's massive cane crop. This

year, it appears likely that the Brazilian government may have to divert additional cane from sugar to alcohol in order to maintain strategic stocks.

PROTECTION

Trade in sugar is distorted by an almost unimaginable array of regulations, levies, subsidies, and quotas for the protection of domestic producers or to insulate them from market realities. For the few countries with open markets and no export subsidies, such as Australia, an export position is earned and retained through successful competition and an ability to survive in the trough of the price cycle. Of most concern are developed countries: USA, EC, and Japan. The policies of Japan and the USA, which guarantee high returns to domestic producers and encourage the production of alternate sweeteners based on starch, have added to the instability of world price, over the longer term, lowered world prices, reduced domestic consumption, and cost consumers billions of US dollars a year (5,6).

The sugar regime in the EC, based on assured prices and a self-sufficiency of 135%, has turned the EC from being a net importer of sugar in the early 1970s to becoming the world's largest exporter of sugar to the world free market by the early 1980s.

Fortunately, there is some small hope for rationality in world trade in agriculture being negotiated in the GATT Uruguay Round, even if driven only by the unfavorable prospect of a trade war between major powers.

WORLD PRODUCTION AND CONSUMPTION

Sugar is one of the most widely spread of all major agricultural commodities, being cultivated in almost every country of the world and consumed as a basic or staple food. *Consumption* is a function of a number of factors, including real income per person, retail prices, influenced by both world prices and government intervention, nonprice rationing in centralized economies, and availability of substitutes, such as high fructose corn syrup (HFCS) and primitive sugars.

Growth in world consumption has been strong over the last four decades, rising from 30 million tonnes in 1950 to a projected 110 million tonnes in 1990. Although the rate of growth in world sugar consumption may be declining on an annual basis, actual consumption growth is increasing, as shown in Table 1 (7).

> Since the boom prices in the world market in 1974–75, four major changes have affected sugar demand. There has been rapid development of high fructose corn syrup (HFCS) production and consumption, first in the United States and then Japan. There has also been rapid expansion in the consumption of high intensity sweeteners, mainly aspartame. There has been stagnation of demand growth for caloric sweeteners in some important developed countries due to dietary changes, and the proportion of world sugar consumption by developing countries has increased from around 45 per cent in 1974–75 to about 65 per cent in 1987–88. (8)

TABLE 1. *Annual growth of world sugar consumption*

	Million tonnes	%
1951–1959	1.99	5.2
1960–1969	2.01	3.6
1970–1979	2.11	2.7
1980–1987	2.15	2.2

Adapted from Borrell B (7).

World Bank projections in 1988 indicate that per person incomes will grow more strongly into the first half of the 1990s than they did in the first 7 years of the 1980s. Population increase also is expected to continue strongly in Asia. On this basis, world sugar consumption should continue to grow at the rate of about 2.5 million tonnes annually up until 1993–1994 (8).

World production, with the exception of brief periods during major world wars, has demonstrated a continuing growth from less than 1 million tonnes in 1839 to 5.67 million tonnes a century ago to 30.51 million tonnes in 1939 (9) and in excess of 100 million tonnes in 1989.

A number of factors influence the responses of countries to production opportunities reflected in the demand price cycle. These include domestic policies that insulate producers from changes in world prices, currency fluctuations, differences in cost structure, relative attraction of alternative crops, and time lag, which, from past experience, is about 18 months (10). Figures 1 and 2 (11) show the trend in world production and consumption over the last 15 years.

WORLD SUGAR TRADE

> Sugar is one of the world's most important agricultural commodities. Despite the fact that a substantial part of production is consumed domestically, it remains a major traded item. Not only is it a leading, and in some cases crucial, source of foreign exchange for exporting countries, but its cultivation is a substantial source of employment, particularly in the developing world. The fortunes of the sugar industry thus have a crucial bearing upon the broader economic, social and political issues in many of the producing countries. (12)

World trade in sugar is essentially residual. Although annual production approaches 110 million tonnes, only about 26% is exported, and after exclusion of special arrangements and trade within blocs, the quantity of sugar traded on the free market is only about 15% of annual production. White sugar from both beets and cane now occupies about 40% of world trade in sugar, a trend that has increased over the last decade (4).

On the supply side, there have been three major changes in the world sugar market in the 1970s and 1980s: a decline in the size of the world free market, the trend in

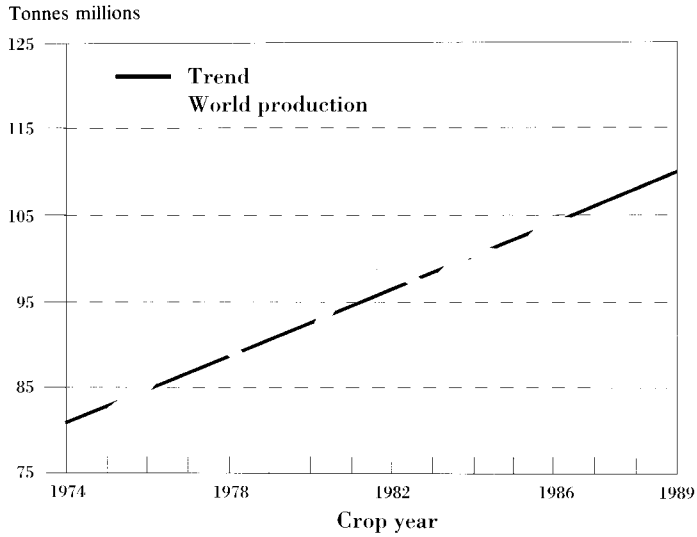

FIG. 1. World sugar production trend. From USDA (11).

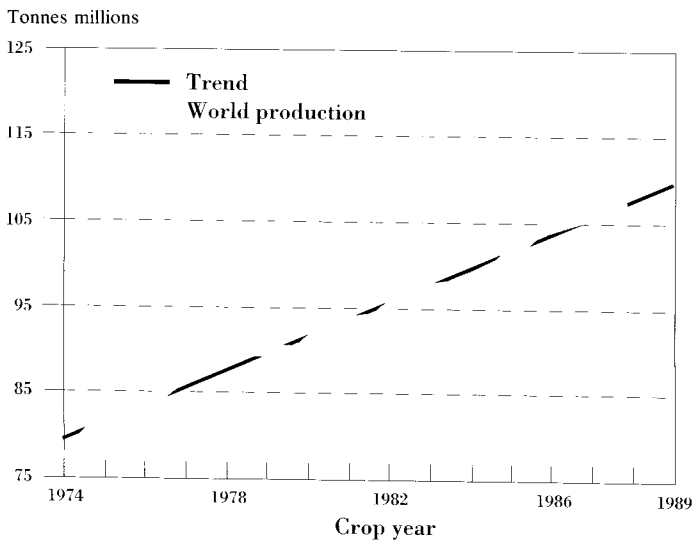

FIG. 2. World sugar production trend. From USDA (11).

TABLE 2. *World free market—expanding during the 1970s, contracting during the 1980s*

Year	Million tonnes	Year	Million tonnes
1970	13.7	1980	19.4
1971	14.3	1981	20.6
1972	16.0	1982	21.7
1973	16.6	1983	20.6
1974	15.7	1984	19.2
1975	13.5	1985	19.0
1976	14.9	1986	18.2
1977	19.6	1987	18.5
1978	17.4	1988 (est)	17.2
1979	17.7		

Adapted from Australian Raw Sugar Industry (13).

trade to white sugar, and the concentration of sugar exports from a few major countries.

Table 2 (13) and Fig. 3 (13) set out the expansion of the world free market in the 1970s, followed by a decline in the size of the world market, a factor in the low levels of sugar prices during the 1980s. Growth in trade is expected to be only marginal and to be increasingly concentrated.

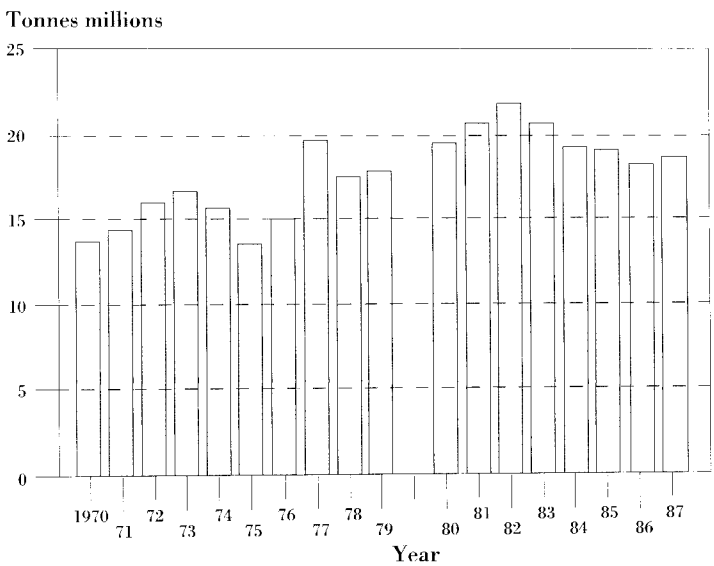

FIG. 3. World free market size. From Australian Raw Sugar Industry (13).

WORLD PRICE

Economic predictability for sugar is not readily applicable to the price equilibrium one expects from economic theory. In practice, the relationship between sugar stocks and price is nonlinear, for example, accelerating with a deepening stock draw down but moving at a decelerating rate as stocks accumulate. The price response of the market will vary to supply–demand disruptions at different price levels. For example, in a depressed market, a substantial production deficit (e.g., cyclone) will have little price response, but in a rising market, prices may respond to little more than rumor of production setbacks. Producers respond more quickly to price strength in the form of increased production than to price weakness in the form of production cuts, partially due to government intervention and partially to asset fixity. The speculative element, although generally healthy and giving depth to futures' trading, also stimulates short-term movements within the market.

The world sugar economy is very concentrated. For example, five countries consume 43% of world total consumption (USSR, India, China, USA, Brazil), produce 40% of total sugar (India, USSR, Cuba, Brazil, USA), and account for 70% of the world exports (Cuba, EC, Australia, Thailand, Brazil). Consequently, changes of a political or structural nature in those economies may be reflected quickly in world price fluctuations.

Because of the residual nature of sugar trade, prices quoted on world markets are volatile, since even small movements in world production or consumption have a significant impact on the quantities available for trade or on the depletion–accretion of residual or buffer stocks. Periodic price surges result in production increases and oversupply, which take some years to correct. The result is relatively long periods of depressed prices interspersed with relatively short periods of price buoyancy, as shown in Table 3 and Fig. 4 (14). Future world price cycles are expected to be flatter than in the past.

INTERNATIONAL AGREEMENTS

There has been a long history of international cooperation in sugar. Burdensome subsidization of beet sugar exports at the end of the nineteenth century led to continental producers signing the Brussels Sugar Convention of 1902, and low world prices in the 1920s induced most free market exporters to participate in the Chadbourne Agreement of 1931, which was designed to work off surplus stocks. Worldwide interest in commodity agreements and stabilization measures after World War II began with attempts to regulate markets for wheat and sugar. That these attempts have all but failed does not deny that for short periods at least they were successful and that participation in negotiations on trade produced a level of international understanding unobtainable diplomatically.

The 1937 International Sugar Agreement (ISA), suspended during the war, set the pattern for the future: a price objective, basic export tonnages, annual quotas, the

TABLE 3. *World sugar prices: annual average NY No. 11 spot*

Year	US cents/pound	Year	US cents/pound
1970	3.68	1980	28.69
1971	4.52	1981	16.85
1972	7.27	1982	8.39
1973	9.45	1983	8.52
1974	29.66	1984	5.18
1975	20.37	1985	4.03
1976	11.51	1986	6.06
1977	8.10	1987	6.72
1978	7.81	1988	10.16
1979	9.65	1989 (6 months)	11.40

Adapted from Licht FO (4).

exclusion of special arrangements, exporters to maintain minimum reserve stocks, and voting rights of importers and exporters. The first postwar ISA was negotiated in 1953 and was followed by one in 1958. This failed when Cuba demanded an excessive quota after being excluded from the USA market in 1961. A new agreement was negotiated in 1968, but it was weakened by the refusal of USA and the EC to join. At the 1973 conference, it proved impossible to renegotiate an agreement, again largely because the EC was not prepared to make concessions on its new sugar regime. A new ISA eventually evolved in 1977 during a difficult period for world

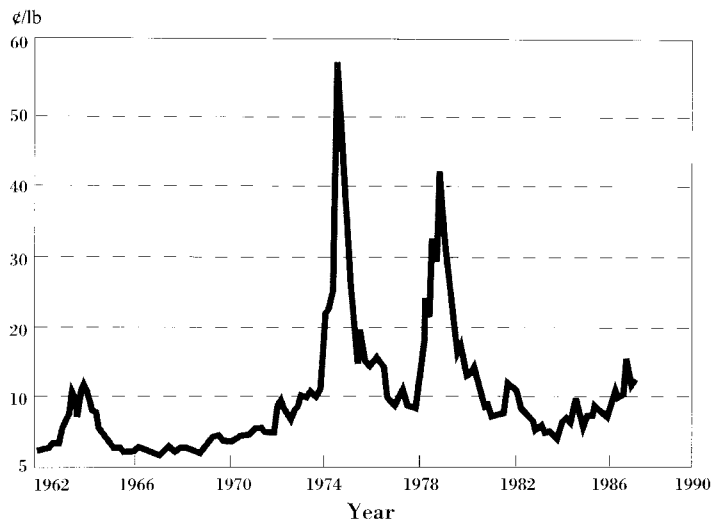

FIG. 4. World sugar price NY No. 11 spot, monthly average price 1962–1988. From Australian Raw Sugar Industry (14).

sugar exporters. Its effectiveness was short-lived, and three UNCTAD-sponsored conferences in Geneva in 1983 and 1984 failed in efforts to negotiate a new agreement.

Given the dominance in world sugar trade of five exporting nations, whose economies and political establishments are quite diverse, it is unlikely that an economic agreement to regulate world sugar trade could be achieved in the near future.

SUGAR SUBSTITUTES

Products available as partial substitutes for sugar under two broad categories are *caloric sweeteners*, such as glucose syrup or HFCS, derived from starch, and *non-caloric*, or artificial, *sweeteners*, such as saccharin, cyclamate, and aspartame. Such sweeteners are relatively recent in a trade context but are significant in world consumption. They occupy over 12% of world sweetener consumption and are particularly prominent in developed economies, such as North America and Japan. Although alternate sweeteners have in part substituted for sucrose, artificial sweeteners have contributed to a new market segment. For example, with the inroads of HFCS in the United States, total per capita caloric sweetener consumption has remained relatively static. At the same time, consumption of *low caloric* foods and especially soft drinks has risen. Table 4 (15) sets out the world production of HFCS in the 1980s.

The development of starch-based sweeteners in the USA and Japan, to the detriment of world trade in sugar, is a consequence of direct government intervention. In the USA, the returns to domestic producers of both cane and beet sugar have been kept so high (two to three times the world price) in the 1980s that producers of corn syrup have been able to supply the market with a cheaper alternative for most uses. There has been a growth in glucose and high fructose syrup production in Japan. Not only has the domestic sugar price been kept at artificially high levels in that country, but also concessional incentives have been given to the domestic (potato) starch industry.

TABLE 4. *World production of HFCS*

Year	1000 tonnes dry basis
1980	2,636
1981	3,362
1982	3,919
1983	4,526
1984	5,313
1985	6,304
1986	6,480
1987	6,847
1988	7,125

Adapted from Landell Mills Commodities Studies Ltd. (15).

Although they are important as a basic food, this article does not address the production of *noncentrifugal sugars*, such as gur and khandsari. For example, in India, the world's largest producer of sugar cane, estimated at 180 million tonnes annually, about 45% is directed to noncentrifugal sugar. *Gur* is produced by farmers who concentrate cane juice in open pans and solidify the syrup in molds with a final sugar content of 65 to 75%. This basic food is produced as *muscavado* in the Philippines, *rapadura* in Brazil, and *panela* in Colombia, Ecuador, Bolivia, and Peru. *Khandsari* is produced by allowing concentrated cane juice to form crystals, which are then separated from the mother liquor to produce a domestic sugar of up to 98% sucrose.

ALTERNATIVE USES

In a world increasingly concerned about the greenhouse effect, sugar cane and sugar beet must be favorably regarded as plants for the conversion of sunlight, water, and carbon dioxide into a basic carbohydrate. Sugar cane provides *fiber*, which is generally consumed as the *fuel* in sugar mill boilers, minimizing the demand for fossil fuels. That fiber is used to a limited extent in some countries in *paper* manufacture. Beet pulp is useful as a *stock feed*. Both beet and cane factories produce *molasses* as a by-product of manufacture for use as potable and nonpotable *alcohol* as well as for *stock feed*.

Considerable research has been invested into alternative uses for sugar, and there have been a number of technical successes but few of them economic (to date). Achievements are notable in the areas of biodegradable *detergents*, biodegradable *plastics*, *ascorbic acid*, *citric acid*, *mannitol*, and *penicillin*. Even if these developments gain economic importance in their own right, however, it is not likely that their use would have an impact on the total world demand for sugar.

So far, only alcohol production, as *ethanol* in automotive fuel, has provided a new market for sugar cane. Ethanol can be used as an octane booster, 10 to 15% can be added to petrol without modification to ordinary cars, it has a benefit on cleanliness of emission, and especially modified vehicles can accept 100% ethanol for efficient operation. However, its introduction as an automotive fuel is dependent on a number of interlocking economic factors, such as energy self-sufficiency, balance of payments, excise, and strategic factors. In Australia, it is simply not an economic proposition to convert sugar cane into ethanol at current oil prices. This may not always be so. In the USA, the development of the infrastructure of an alcohol industry appears to have been subsidized for social and political aspirations. However, in Brazil, to achieve economic and strategic goals, ethanol has been developed on a massive scale to the extent that more sugar cane is now used for fuel alcohol than for sugar production. By way of comparison, in 1988 the USA produced 3.18 billion liters of ethanol from 340 million bushels of grain, and in Brazil, anhydrous alcohol production from 11,570 distilleries was 1.71 billion liters from sugar cane (16).

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DISCUSSION

Dr. Kretchmer: Can you expand on the reasons for the large fluctuations in price around 1976 and 1980?

Mr. Desmarchelier: The first step is to recognize that we are dealing with a residual market, so that where you have a variation in world production or world consumption of only 1 or 2% (i.e., 1 or 2 million tons of sugar), that could be transposed into the residual traded market, being a multiple of five or six times that. A 2% variation in world production can lead to a 10 or 12% variation in world trade. Around 1974, in particular, there was a very rapid rundown in world sugar stocks because of some natural disasters and a rise in world sugar consumption related to wealth generated in the OPEC countries. Then there is one additional element that is very hard to measure—that is, when speculators are involved.

Dr. Zimmet: You mentioned the trend was a 2% per annum increase in sugar consumption throughout the world, and it was not clear to me from your slide whether these figures are adjusted to changes in the world population. Similarly, the question of trends in artificial sweeteners. Even though there appears to be a tailing off in growth, what is the average percentage per annum increase in consumption of those over the last decade?

Mr. Desmarchelier: To the first question, it is a straight unadjusted chart—that is, world sugar consumption is rising by about 2 million tonnes or 2½ million tonnes, or roughly about 2%, each year. That trend has been in evidence for some decades, and according to the World Bank, does not show signs of tailing off. With respect to artificial sweeteners, it is difficult to ascertain exactly the size of the market, but we believe that artificial sweeteners and alternate sweeteners, that is, the starch-based ones as well, occupy about 12% of world sugar consumption, or the equivalent of about 12% in sweetener value. There is evidence

from America and from Australia that some of the artificial sweeteners are creating a new market segment. Indeed, the total consumption of caloric sweeteners in Australia and the total consumption of caloric sweeteners in the USA is not declining despite the fact that there are more and more products using artificial sweeteners, particularly in soft drinks.

Dr. Shafrir: As you have indicated, there is rise in the use of high fructose corn syrup and a concomitant decrease in sugar production. Because the corn syrup is cheaper, contains mainly fructose, which is sweeter, and contains less calories per unit of sweetness, will its use replace a large portion of sugar production in the future?

Mr. Desmarchelier: The production of high-fructose corn syrup depends on one very important factor: the availability of a cheap starch. That is true in the USA and in Canada, to a certain extent. It is also true in Japan because of their very high tariff structures on certain imported products, such as sugar, and relatively low tariffs on imported starches, as well as the development of the potato starch industry in Japan. The second factor that will inhibit the development of high fructose corn syrup is that it is not consumable on the table in a crystallized form. It is in a liquid form, and it is sensitive to temperature. So it does not lend itself easily to export because of its high liquid content and, therefore, weight and its sensitivity to temperature. There is one very great danger facing the sugar industry, that is, the work being done by Staley and others in the USA in the commercial crystallization of high fructose corn syrup.

Dr. Guesry: When you see the very dramatic variation of the price of sugar from 5 to 50 cents a pound, you think that large stocks of sugar could avoid this dramatic change. Since sugar is a strategic raw material, I suspect that many governments would have ordered the industry to keep certain stocks of sugar. What are the stocks of sugar related to the world consumption, and what should be the price of sugar and the price of a barrel of oil for ethanol in order to be competitive with gasoline?

Mr. Desmarchelier: World sugar stocks are measured by an international statistician in Germany, F. O. Licht, and are produced on a regular basis as a percentage of consumption. When international sugar prices were extremely depressed in 1983 to 1986, world sugar stocks as a percentage of consumption were of the order of 36% to 40%. In the past 5 years, world sugar consumption has been higher than has world sugar production. As a result, stocks have declined. The most recent estimate is that the world sugar stocks, as a percentage of consumption, are now down to 28%, which puts the market poised for speculation or bullish factors or exogenous shocks to a very rapid upward movement in prices again. With respect to the comment on strategic stocks, the answer to that is probably "No," except in centralized economies.

Ethanol has to be looked at as a strategic matter, not an economic one. The reason Brazil is in ethanol has to do with balance of payments, lack of oil, and a very high dependence on road transport. They made a deliberate move into ethanol at a time when sugar prices were lower. They now can't get out of it because they are producing cars that consume 100% alcohol. Total ethanol production from cane in Brazil is 12 billion liters a year.

Dr. Bhandari: India is one of the big sugar-producing countries, and our sugar industry and sugar lobby are quite strong. Our consumption is greater than production, and this is partly responsible for the steep rise in the price of sugar that we are experiencing because we export a lot of sugar.

Mr. Desmarchelier: India is in the "top five" categories in terms of world consumption (about 10 million tons of sugar each year) and production (above 9 million tons of sugar each year). Could I make a comment on the political aspect? India is very finely balanced between imports and exports of sugar. Recently, as India moved toward an election and a religious

festive season, consumption of sugar rose rapidly, and prices doubled in a period of 1 to 2 months. Some of the sugar statisticians and political observers suggested that one of the reasons for the downfall of the previous prime minister was the very high price for sugar during the festival and the government's slowness to react to import sugar to bring the prices down.

Dr. Wahlqvist: Could you comment on how economically marginal the industry actually is despite progressive increases in production? Second, the increasing interest and concern about environmental issues may play a decisive role in future nutritional choices. Would you comment on what kind of land currently is being recruited for the 2% annual increment in sugar production and whether that in itself might not have some implication for sweetener choices in the future?

Mr. Desmarchelier: The first question can be answered in terms of technological development. Those countries that previously were prominent in sugar and are now moving out of the industry, such as the West Indies, have relied heavily on cheap labor. As individual countries and their economies get more political freedom and demands for higher living standards, two things can happen: you either have to pay full wages or move into some alternatives. For these reasons, the West Indies is no longer a major producer of sugar. In countries like Australia, I should mention two major developments. The first was the move from manual cane cutting to total mechanical harvesting between about 1960 and 1968. Even in Cuba, where there is a very high need to employ people, they have moved to 67% mechanical harvesting. The second big development in Australia was bulk handling. Loading is now completely automatic, and the raw sugar is not touched by human hands and it is not packaged in any form. The third factor relates to the environment and technology. There actually has been very little increase in land use recently to achieve the additional sugar production. Throughout Europe, yields are increasing continually each year. The area under beet was reduced by about 15% in the last 5 years, yet they are producing more sugar. In Australia, our increase in area has been of the order of about 5% in 10 years, yet we are producing about 2 to 3% more sugar each year. This indicates an increase in yields.

Dr. Gracey: Is the Ord River Irrigation area in the north of Western Australia likely to become a sugar producer in this country in the foreseeable future?

Mr. Desmarchelier: When the world sugar price peaks, the Western Australian Government becomes interested in producing sugar. The yields of cane in the Ord would be among the best in the world. The Ord River region is an extraordinarily prolific area to grow cane because it has flat land, cheap water, and abundant sunshine. However, the economics that are associated with setting up the infrastructure, the transport to the nearest port (70 kilometers away), and then the transport from that port force the economic of "No." There will be interest in the Ord in terms of renewable resources for the production of ethanol should the price of oil change in the next decade or so.

Dr. Schiffman: One of the major advantages of sucrose is its bulking power. When an artificial sweetener, such as aspartame is used, only $\frac{1}{200}$ of the weight of sucrose may be required to obtain the same sweetness. Bulking agents and fat substitutes are now being developed to give sugarlike textural properties to a chocolate candy bar or food made with an artificial sweetener.

Mr. Desmarchelier: The United States has shown that some users of sugar (soft drinks, especially) are prepared to move from crystal sugar to corn syrup in a liquid form. There are others who are using a combination of artificial sweeteners and sugars, and there are experiments going on all the time into "neo-sugars" and l-shaped sugars. The answer is one

of economics. World sugar consumption is essentially of a basic food that is reasonably cheap in countries like Brazil, Mexico, the rest of Latin America, India, and China.

Dr. Diamond: I am fascinated by that steep rise in Thailand's importance as an importer, and I have four related questions. First, did the land to produce Thai sugar come from chopping down rain forests or reallocating previous agricultural land? Second, what were the motives of the Thais in switching to sugar? Third, was it an indigenous decision, or did it depend on foreign advice? Finally, what was the lead time between the Thais deciding to go into sugar and how many years later it took to achieve that foreign export?

Mr. Desmarchelier: Thailand always had been a modest producer of sugar to the extent of about 1½ million tonnes in the early 1980s. It was about 1983 when the entrepreneurs in that country decided that the world sugar price, which was then extremely depressed, would not remain so, and it was a deliberate movement by individuals without government support to move in a countercyclical way to raise the sugar price. At a time when other countries were reducing inputs of fertilizer, fuel, and labor costs because of the low prices, they actually started building new sugar factories and encouraging farmers to move away from established crops, such as rice and cassava. In a period of something like 6 years, they increased their production of sugar from 1.7 million tonnes to 4.1 million tonnes, and they moved from exporting about 1 million tonnes to exporting 3 million tonnes. They now rank with Australia as the third largest exporter of sugar in the world.

I would like to make an observation on Dr. Kretchmer's article in relation to how sugar got underway in Australia. There was some sugar cane that came to Australia with the first fleet in 1788 from South Africa, but the reason that sugar cane developed in Australia was related to the American Civil War. This has not been well recognized in history. Queensland became a substantial producer of cotton in the early 1860s. Then, when slavery was abolished and the USA's domestic market started to recover in 1863–1864, the cotton market collapsed, and Queensland had arable land, particularly around the city of Brisbane. The Queensland government then offered inducements for production of the first crystallized sugar. Sugar cane spread very rapidly from the availability of indentured Kanaka labor that had been brought in to manage the cotton fields.

Dr. Truswell: Have the negative comments that some nutritionists were making about sugar in the early 1970s had any effect on the consumption of sugar?

Mr. Desmarchelier: There was an attitude developed in Australia, as part of the fairly loose discussion on nutrition in the early 1970s, that led to negative attitudes toward sugar. We determined as an industry to turn around this attitude through advertising. We have spent something like $10 million a year on attitudinal advertising in Australia. We talk about "sugar as a part of life," "sugar is natural," "sugar is part of a balanced diet." As a consequence, we have turned attitudes around. We have developed a positive attitude toward sugar in Australia and have turned around the consumption of sugar both per capita and in total. This is a very fine example of what can be achieved in attitudinal change and if you tell the truth and stay with the facts backed by professionals, nutritionists, and the media.

The discussion continued after the projection of the film, "Some Aspects of the Sugar Industry in the USA."

Dr. Holdsworth: It would appear that sugar beet production is almost entirely dependent on artificial subsidies. Beet production appears to be a rotational crop, and there are alternatives. Are there alternatives, particularly in the USA, for cane sugar production that would make it feasible for farms to survive? What could they grow, in Florida for example, instead of sugar cane? There are crops in Europe that can be grown instead of beets.

Dr. Kretchmer: Florida has a semitropical environment that grows citrus fruits, sugar cane, and other tropical agriculture. Beets are grown in the temperate climates in the USA, and I don't know what crop could be grown to replace the production of sugar cane. A recent book titled *Big Sugar* by Wilkinson was reviewed in *The New York Times* recently and discusses in detail this point. There isn't an apparent alternative crop. I should add that the labor in the sugar fields in Florida is not US labor but is imported on a contract basis primarily from the Caribbean, from Jamaica, Barbados, and Haiti. Labor in the mills is US labor.

Mr. Desmarchelier: Sugar beet in Europe is subsidized by governments but, more particularly, by the consumer. The European sugar regime aims for 135% self-sufficiency, and within that 135%, there is an assured price and a protection against imports, so there are no imports of sugar into Europe apart from under the Lomé Convention. This 135% self-sufficiency has, of course, led to surpluses. Between 1974 and 1984, the EEC moved from being a net importer of sugar to becoming—not only a net exporter of sugar—but the largest net exporter of sugar to the world free market. It was that additional sugar that caused the depression on the world prices.

Dr. Wahlqvist: Would you please comment a little further on Australia in the context of subsidies. You produced some figures for the USA and for the EEC. I would also like to know what information we have about non-EEC European countries.

Mr. Desmarchelier: The chart I showed was produced by the OECD on producers' subsidy equivalents (PSEs) that was done for GATT. It shows that Japan is the most highly subsidized. If you think in terms of ratios, Japan was about 80, the European Community close to 50, the USA closer to about 30, and Australia about 10 with respect to overall agricultural subsidies. With respect to sugar specifically, what I am about to say is quite categorical. There is no government support for sugar in Australia. There was at one stage an embargo on the importation of sugar, that is, the domestic industry had a protection against imports. That embargo has now been lifted, and Australia and Canada are the only two producing countries in the world that are completely free markets for sugar.

Dr. Guesry: I have a theoretical question for John Desmarchelier. If everything could be equal, could we compare the efficiency of producing cane sugar versus beet sugar versus high fructose corn sweeteners with regard to the surface of land that is necessary for producing 1 tonne of sweetener or a certain amount of dietary energy and the manpower and the energy involved to produce these equivalents?

Mr. Desmarchelier: The problems with beet are transport and fuel. Beet must be grown in rotation, so you need an area two to three times as large as that for cane, and transport costs are higher. Second, with sugar cane one uses the fiber in fueling boilers. In Australia, the sugar mills are self-sufficient in fuel, whereas the beet factory has to import and use coal or furnace oil or electricity. In those ways, the cane industry is more efficient in the use of resources. I believe that the labor would be higher in cane than in beet. The mechanization is higher in beet, but there is little doubt that in terms of cost, an efficient cane industry will be lower in cost than an efficient beet industry. Also, the cane industry is probably lower in use of energy resources, but there must be exceptions to this rule.

Dr. Guesry: And with regard to high fructose corn syrup?

Mr. Desmarchelier: I understand that corn is produced at an extremely low cost in the USA. As a consequence, the production of high fructose corn syrup to a sweetener equivalent can be carried out for about 12 cents a pound in the USA as compared with the sugar price guarantee of about 18 cents a pound.

Dr. Kretchmer: The last point was very important. Corn is a major crop in the USA, which is the world's largest corn producer. The corn industry is almost completely mechanized,

and corn growers have been looking for by-products for the grain. This HCFS was a wonderful by-product at approximately 12 or 15 cents a pound, incredibly expensive when you look at the production of corn, but as was pointed out in the film, the subsidy for sugar was propping up corn syrup sweeteners, which form a major basis for sweeteners in the beverage industry.

Dr. Cowett: I am fascinated by Mr. Desmarchelier's talk and Adam Smith's film, both which considered the European Community as kind of a unified whole. As we all know, it is not until 1992 that the European Community is going to become like a United States of Europe, economically and in other ways. Might you postulate on what effect breaking down of the tariff barriers between the European countries is going to have, internationally.

Mr. Desmarchelier: It is important to realize that there has been a sugar regime that is part of the Common Agricultural Policy in Europe since 1974, and as additional countries have joined the European Community, they have become part of that sugar regime. A sugar regime is established by way of national quotas, and within the national quotas are factory quotas and farm quotas. This is, therefore, a quota system that is based on 135% self-sufficiency, as mentioned earlier. It appears that there will be very little change in 1992. Many countries regard this quota as part of their national patrimony, and it would be extremely difficult for the smaller countries to support transferability of quotas across borders, even though there would be a logic in increased efficiency, say, going to France and West Germany. The Treaty of Rome was drawn up by groups of people who had faced difficulties in maintaining food supplies during wartime. However, the arrangements that exist really are excessive and highly protective.