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砂糖政策



OCCASIONAL PAPER 104

JAPANESE SUGAR POLICY: ITS EFFECTS ON THE WORLD MARKET

AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS

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PAPER 104

JAPANESE
SUGAR POLICY:
ITS EFFECTS ON
THE WORLD
MARKET

PROJECT 42300c

ROBERT STURGISS,
PETER TOBLER AND
PETER CONNELL

AUSTRALIAN
BUREAU OF AGRICULTURAL
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Australian Bureau of Agricultural and Resource Economics
GPO Box 1563 Canberra 2601

Telephone (062) 469111 Facsimile (062) 469699 Telex AGEC AA61667

Foreword

The focus of the current round of GATT multilateral trade negotiations is on problems in world agricultural trade. This emphasis reflects recognition by developed countries of the damage done to world agricultural markets by restrictive agricultural policies. The United States and the Cairns Group have both identified free trade in agriculture as a goal of the negotiations. If progress is to be made toward this goal, objective analysis documenting the economic effects of protectionist policies needs to be presented. The Bureau has recently published analyses of the effects of Japanese, European Community and United States policies.

Concerning sugar in particular, the Bureau has recently published two papers, one on the effects of government intervention on the world market generally and the other on US sugar policies. In this paper the sweetener policies of Japan are analysed. The way the policy operates is explained in detail, and the economic effects of the policy on the domestic Japanese market and on world markets are analysed.

The Bureau intends to continue its study on the effects of government intervention on world primary produce markets. The focus of future work will be mainly on the effects of various multilateral trade reforms.

ROBERT BAIN

Director

Australian Bureau of
Agricultural and Resource Economics

Canberra

February 1988

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日本の砂糖政策：その世界市場への影響

序文

日本は世界第2の砂糖輸入国であり、その甘味政策は、砂糖の世界市場に多大な影響を及ぼしている。オーストラリアは、世界市場に砂糖の80%を輸出しており、日本はオーストラリアにとって最大の単一輸出市場となっている。そのために、日本市場とその世界市場への影響は、オーストラリアにとって非常に重要である。この報告書は、日本の甘味政策が日豪両国及び世界市場に及ぼす重要な影響を、両国民により良く理解していただくために準備されたものである。

今回のガット多角的貿易交渉においては、世界農業貿易問題が焦点となっている。これは先進諸国が、制限的な農業政策の世界農産物市場にもたらす損害について、認識を深めていることを反映していると言える。合衆国およびケアンズグループは共に、交渉の目標が農業における自由貿易であることを確認している。この目標に向かって交渉を前進させるためには、保護政策の経済的影響を実証した客観的な分析を提示する必要がある。弊局は最近、日本、ヨーロッパ共同体および合衆国の政策の影響に関する分析を公表した。

とりわけ砂糖に関しては、弊局は最近2冊の報告書を出版している。1冊は世界市場一般への政府介入の影響に関するもので、他方は合衆国の砂糖政策についてのものである。本報告においては、日本の甘味資源政策について分析がなされている。政策の運営方法の詳細な説明と、日本国内市場および世界市場への政策の影響についての分析が行われている。

弊局は、一次産品世界市場への政府介入の影響に関する研究を、今後も継続する意向である。将来の研究の焦点は、主として、多様な多角的貿易改革の影響に関するものとなる。

ロバート ベイン (局長)

オーストラリア農業資源経済局
キャンベラ 首都特別地域

1988年2月

要約

日本は、世界第2の砂糖輸入国である。そのため、日本の甘味資源市場における政府の規制は、国際価格に多大な影響を及ぼす。本報告においては、日本の砂糖政策の世界市場に及ぼす経済的な影響と、日本および各輸出・入国の経済的厚生についての分析を行った。

現在の政策が、日本国内及び海外双方にもたらす負担は、日本の生産者が得る利益に比較して多大であることが判明した。こうした費用は、仮に日本の消費者が砂糖に支払っている価格が、世界市場価格をより反映するようになれば、かなり削減することができる。生産者に対する援助は、直接的な所得支持支払いによって維持できるであろう。

こうした援助の日本経済にとっての負担は、この援助が直接に目標を定めることができるものであるため、軽減されたものとなるだろう。また日本の砂糖を使用する産業の資源利用の効率性も、改善されるだろう。政策の変更は、国際価格を最高4.9%まで引き上げるとともに、価格変動の幅の縮小にも役立つであろう。

日本市場の特徴

日本における甘味料の消費は増加しているが、砂糖価格が政府介入により非常に高く維持されているため、砂糖の消費は抑制され、代替甘味料の消費が促進されている。この結果、代替甘味料の消費が急速に増加し、砂糖の消費は減退している。主な代替甘味料は、ハイ・フラクトースコーンシロップ（異性化糖）であるが、この消費量は1974-75年にはほぼ皆無であったのに、1986-87年には甘味資源市場の20%にまで増加している。全体として、高価格が甘味料の消費を抑制しており、日本人1人当たりの甘味料の消費量は先進国中最低となっている。

砂糖消費の減退は、砂糖輸入の減少を伴っている。1975-76年に日本の砂糖需要の84%を占めていた輸入は、1986-87年には67%になっている。この砂糖輸入需要の減退は、国際価格を低下させがちであり、それゆえ全ての砂糖輸出国の厚生を減少させている。

日本の政策の特徴

日本の農業政策の広義の目標は、価格安定化、自給をめざした食料生産の選択的拡大、非農業生産者の所得とほぼ均衡した農家所得の維持などである。これら全ての目的は、日本の砂糖政策の形成に影響を与えてきたようである。さらに砂糖産業の地域的集中化ゆえに、砂糖政策は地域政策としての目的をも持っていると言えよう。

日本の糖価安定事業団（蚕糸・糖類価格安定事業団の前身）は、1965年に砂糖政策実施のために創設された。輸入砂糖に対する課徴金制度が政策の中心で、この課徴金は以下の点において重要である。

- 国際価格に影響されない水準、通常はかなり高いレベルに市場価格を維持すること；
（1985-86年には、国際価格の7倍）
- この市場価格の安定化；
- 生産者および粗糖製造業者に対する財政補助のための財源の調達；

日本の砂糖政策は、生産者価格の引き上げと安定化には成功した。粗糖価格は、1985-86年には国際価格の13倍であった。しかし、この産業の生産者にもたらされるはずであった便益の一部は、土地、労働力及び機械類のような生産の投入財価格の上昇により、損なわれてしまったようである。しかも、高い消費者価格は、日本の消費者および日

本経済全般に多大なコストを生じた。砂糖の自給は、日本にとって達成できそうもない目標のようである。

この政策が主にもたらしたものは、砂糖貿易の縮小である。非常に高い砂糖の消費者価格は、砂糖需要を減少させるだけでなく、砂糖より安いハイ・フラクトースコーンシロップ（異性化糖）の存在を許容している。異性化糖の消費には、若干の税金が課せられているが、主原料であるトウモロコシは無税で輸入できる。こうした砂糖とコーンシロップに対する不平等な取り扱い、砂糖の代わりにシロップの生産と使用を促進している。

高位安定化している砂糖生産者価格によって、砂糖生産は着実に増加を辿っている。消費減と生産増は、砂糖輸入の減退をもたらしている。しかし砂糖輸入の減少は、トウモロコシ輸入の増加によってもたらされたものである。

輸入需要は、日本の砂糖政策により抑えられているため、砂糖の国際価格はそうでない場合に比較して低くなっている。さらに日本市場は国際価格の変動から隔離されているので、日本の砂糖生産者及び消費者は、世界の需給状況の変化に反応を示さない。この硬直性は、国際価格の変動に拍車をかける結果になっている。

国際価格の低下は、輸出諸国、特に世界市場に依存している国の所得を減少させる。このことは、結局その国の日本を含めた他国からの購買能力を減少させることになる。同様に輸出国における砂糖以外への資源移転を生じさせる。資源配分の誤りは、多くの国の多数の産業に互って起こるであろうし、それは世界的規模での貿易、所得及び雇用の減退を引き起こすことになるかもしれない。

一般に農業に対する高い保護は、価格を上昇させる要素価格を生じさせる。とりわけ土地市場のような供給の制限されている市場では、そうである。この高要素価格は、日本経済のその他の部門、特に住宅やリクリエーション（例えばゴルフ）のような土地集約型産業の競争力を減少させる。このように農業に対する保護は、間接的にその他の部門における成長、所得及び雇用の減退させることになる。

円の価値が高まっている時に、農産物の消費者は、輸入価格の低下による利益を享受することができない。消費者価格は円高にもかかわらず一定に維持されており、農業に対する保護は増大している。日本における所得配分は、消費者から甘味料生産者への大規模な移転をともなうこのような価格介入によって変更されている。世界市場では、典型的な低所得の開発途上国である世界輸出諸国から、世界輸入国への移転が行われている。

日本の政策の影響についての測定

日本の政策の影響を、正確に測定するのは困難であるが、影響の規模についてのおおよその測定はできる。こうした測定は、世界の砂糖生産者と消費者の厚生に対する日本の政策の影響に焦点を当てるには有効である。この研究に当たり、2部門間の計量経済学的な貿易モデルを開発した。1つの部門は日本の甘味資源市場を、他方はその他の世界を表している。全体にわたる費用推定は、日本とその他の世界の間の貿易が現在の政策下で行われている場合と、自由貿易を想定した場合の両方についてシミュレーションによって求めた。このモデルから得られた推定は、過小評価されたものである。なぜならば、こうした複雑な政策を実行するための行政費用や利益集団のロビー活動費、生産者の費用効率の減退、あるいは経済の他部門の成長に対する輸入制限の間接的な負の効果を無視しているからである。

世界市場への影響

日本の砂糖輸入需要は、政府による介入がなかった場合に比べ5.4%低くなっている。

現在の日本の政策によって、国際価格は1985年～2004年の間で平均では2～5%、砂糖の国際価格の低落時には最高14%低められる。

国際価格の変動は、現在の日本の政策が採用されない場合よりも、された方が大幅になると予測された。変動を予測する1つの方法は、変動係数を求めることであるが、これによると日本の政策によって11%大きくなると予測された。

日本国内への影響

異性化糖生産者は、1985年～87年の3年間に7億米 D_{11} 以上の事実上の補助金を受け取った。

製糖業者、加工業者、生産者は共に、同時期に20億米 D_{11} 以上の補助金を受けた。

日本の粗糖、精製糖の消費者に対する政策費用は、同時期に70億米 D_{11} 以上であった。

1987年において、日本の粗糖生産者に1米 D_{11} 移転されるごとに、砂糖の消費者にかかる負担は2.27米 D_{11} であった。

世界の生産者への影響

1986年に日本の砂糖政策によって引き起こされた国際価格の低落が、主な輸出国に以下のような輸出収入の損失をもたらしたと推定される。オーストラリア、4千百万米 D_{11} から5千万米 D_{11} ；ブラジル、3千8百万米 D_{11} から4千6百万米 D_{11} ；タイ、フィリピン、3千3百万米 D_{11} から4千万米 D_{11} である。

1987年において、日本の砂糖生産者に1 D_{11} 移転されるごとに、1987年に世界の生産者に課せられた負担は、2.50米 D_{11} から3.40米 D_{11} と推定された。

政策の意味するもの

日本の消費者と砂糖の輸出諸国に賦課される政策費用の合計額は、その政策が日本の甘味料生産者に与える利得をはるかに超えている。日本の砂糖政策の重荷を負っている集団は、共同して改革を促進しようとする強い動機を持っている。

前述したように、粗糖に対する輸入課徴金は、日本の甘味資源政策の中心的な手段となっており、これこそが直接、間接に負の経済効果を生んでいるものである。例えば、国際価格に日本の政策が及ぼす影響の90%が、輸入課徴金によるものである。

関税と貿易に関する一般協定のもとで行われている今回の多角的貿易交渉は、輸出国にとって貿易改革を促進するための理想的な機会となっている。改革を促進するための輸出国によるどんな戦略においても、その目標は日本の消費者価格が国際価格に連動するように、輸入課徴金を確実に変更することである。

こうした改革は、日本の消費者や輸出諸国に多大な利益をもたらすであろう。たとえ日本の生産者に対してその他の手段、すなわち日本政府による直接的支払いといった形での保護が継続されたとしても、そう言えるであろう。所得補填の形で支払われる農民に対する直接的な援助は、生産者価格への補助金の支払いよりも、より効率的、公正な援助の形であろう。そしてこの援助は、非効率的な農民のこの部門からの転換を助け、残った農民による効率的な砂糖生産を促進し、影響を受ける地域において長期的な展望の描ける代替産業を誘致することを目標にしたものである。

SUMMARY

Japan is the world's second largest importer of sugar. Government regulation in the Japanese sweetener market could therefore have a large influence on the world price. This paper analyses the economic effects of Japanese sugar policy on the world market and on the economic welfare of Japan and of individual exporting and importing nations.

The costs of the current policy, both within Japan and elsewhere, are found to be large relative to the benefits obtained by Japanese producers. These costs could be largely eliminated if the prices Japanese consumers pay for sugar more closely reflected world market prices. Assistance to producers could be maintained through direct income support payments.

The costs to the Japanese economy of the assistance could be reduced because it could be targeted directly. Efficiency of resource use in the Japanese sugar using industries would also be improved. The change in policy would raise world prices by up to 4 per cent and would help to reduce their variability.

Features of the Japanese market

Sweetener consumption is increasing in Japan, but very high sugar prices maintained by government intervention discourage consumption of sugar and encourage the consumption of alternative sweeteners. In consequence, consumption of sugar is declining while consumption of alternative sweeteners is increasing rapidly. The main alternative sweetener is high fructose corn syrup, consumption of which has risen from virtually nil in 1974-75 to 20 per cent of the sweetener market in 1986-87. Overall, high prices constrain the consumption of sweeteners, and Japan's consumption of sweeteners per person is the lowest of all developed nations.

The decline in sugar consumption has been accompanied by a decline in sugar imports. In 1975-76 imports accounted for 84 per cent of Japan's sugar requirements; in 1986-87, for only 67 per cent. This decline in import demand tends to lower the world price and therefore reduce the welfare of all sugar exporting countries.

Features of Japanese policy

The broad aims of Japanese agricultural policy include price stability, selective expansion of food production toward self-sufficiency and the maintenance of rural incomes at levels broadly comparable to those of non-agricultural workers. All of these objectives are likely to have influenced the development of Japan's sugar policy. Furthermore, because of the regional concentration of the industry, sugar policy may also have regional objectives.

The Japanese Sugar Price Stabilisation Agency (now the Raw Silk and Sugar Price Stabilisation Corporation) was established in 1965 to implement the sugar policy.

The key instrument used is a system of levies on imported sugar. The levies are crucial in:

- maintaining the market price at a level unrelated to, and usually well above, the world price (seven times as high in 1985-86);
- stabilising this market price; and
- raising revenue for financing subsidies to growers and raw sugar producers.

Japanese sugar policy has been successful in raising and stabilising prices received by producers. Raw sugar prices paid to producers were thirteen times the world price in 1985-86. However, some of the benefits intended for producers in the industry are likely to have been eroded by cost increases as the prices of inputs to production — such as land, labour and machinery — have been bid up. Further, the high consumer prices have created large costs for Japanese consumers and the Japanese economy generally. Self-sufficiency in sugar is probably an unattainable goal for Japan.

A major consequence of the policy is a reduction in sugar trade. The very high consumer price for sugar not only reduces sugar demand but allows high fructose corn syrup to be priced below sugar. Consumption of high fructose corn syrup is subject to a small tax, but maize, its major raw material, can be imported duty free. This unequal treatment of sugar and corn syrup has encouraged production and use of the syrup in place of sugar.

The high, stable sugar producer prices have induced a steady increase in sugar production. Decreased consumption and increased production have increased self-sufficiency by reducing sugar imports. But the reduction in sugar imports has been achieved largely at the expense of increases in maize imports.

Because import demand is lowered by the Japanese sugar policy, the world sugar price is lower than it would otherwise be. Moreover, because Japanese market prices are insulated from world price fluctuations, Japanese sugar producers and consumers do not respond to changes in world supply and demand conditions. A consequence of that inflexibility is a more volatile world price.

The reduction in the world price lowers the incomes of exporting countries, especially those dependent on the world market, which in turn reduces their ability to buy from other countries, including Japan. As well, exporting countries are induced to shift resources out of sugar. A misallocation of resources may occur across a large number of industries in many countries, diminishing trade, income

and employment worldwide.

High protection to agriculture generally causes factor prices to be bid up, particularly in markets having limited supply such as the land market. The higher factor prices reduce the competitiveness of other sectors of the Japanese economy, especially land intensive industries like housing and recreation (for instance, golfing). In this way, protection to agriculture can indirectly reduce growth, income and employment in other sectors.

As the value of the yen increases, consumers of agricultural products cannot benefit from lower import prices. Consumer prices are maintained despite the high value of the yen, and protection to agriculture increases. In Japan, income distribution is changed by such price intervention, with large transfers from consumers to sweetener producers. On the world market there is a transfer from world exporters, which are typically lower income developing countries, to world importers.

Measuring the effects of Japanese policy

Accurate measurement of the effects of Japanese policy is difficult. However, good approximations of the size of the effects can be obtained. Such measures are useful in highlighting the influence of Japanese policy on the welfare of the world's sugar producers and consumers. For this study a two-sector econometric trade model was developed, in which one sector represents the Japanese sweetener market and the other represents the rest of the world. Overall cost estimates were obtained by simulation, running the model both with current policies in force and under the assumption of free trade between Japan and the rest of the world.

The estimates obtained from the model are underestimates, because they ignore the administrative costs of operating such a complex policy, the lobbying costs of interest groups, the reduced cost efficiency of producers and the adverse indirect effects of import restrictions on the growth of other sectors of the economy.

Effects on the world market

Japanese sugar import demand may be as much as 54 per cent lower than it would be in the absence of government intervention.

Due to current Japanese policy, the world price is on average lower by 2–5 per cent over the period 1985–2004, and by up to 14 per cent in the depressed phase of the world sugar price cycle.

The world price is estimated to fluctuate more widely with current Japanese policies in force than in their absence. One measure of variability is the coefficient of variation, which is estimated to be 11 per cent higher because of Japanese policy.

Effects within Japan

High fructose corn syrup producers have received an effective subsidy of over US\$700m in the three-year period 1985–87.

Sugar millers, processors and growers have together received a subsidy of about US\$2000m over the same period.

The cost of the policy to Japanese consumers of raw and refined sugar was over US\$7000m in this period.

For every dollar transferred to Japanese producers of raw sugar in 1987, the cost to consumers of sweeteners was about US\$2.27.

Effects on world producers

In 1986, the lowering of world price caused by Japanese sugar policy is estimated to have imposed the following costs on major exporters in terms of lost export revenue: to Australia, between US\$41m and US\$50m; to Brazil, between US\$38m and US\$46m; and to Thailand and the Philippines, between US\$33m and US\$40m.

For every dollar transferred to Japanese sugar producers in 1987, the estimated cost to world producers in 1987 was between US\$2.50 and US\$3.40.

Policy implications

The combined costs of the policy to Japanese consumers and sugar exporting countries far exceed the gains it confers on Japanese sweetener producers.

Collectively the groups carrying the burden of Japanese sugar policy have a strong incentive to encourage reforms.

As has been noted, levies on imports of raw sugar are a key instrument in Japanese sweetener policy, and it is the levies that directly and indirectly cause adverse economic effects. For instance, 90 per cent of the effect of Japanese policy on the world price is due to the levies on imports.

The current multilateral trade negotiations under the auspices of the General Agreement on Tariffs and Trade provide an ideal opportunity for exporters to promote trade reform. In any strategy by exporters to promote reform, the objective should be to ensure that levies on imports be changed so that Japanese consumer prices follow world prices.

Such a reform would provide major benefits to Japanese consumers and to exporting nations, even if protection to Japanese producers were continued by an alternative means, namely by direct payments from the Japanese government. Direct support to farmers, paid in the form of income supplements, would be a more efficient and equitable way of providing assistance than paying price subsidies on production. Assistance could then be targeted so as to help inefficient farmers to leave the industry, promote efficient sugar production by those remaining and provide incentives for establishing alternative industries with better long term prospects in the affected areas.

1. Introduction

Japan is the world's second largest importer of sugar, with estimated imports of 1.8 Mt (raw value) in 1986-87, equal to 66 per cent of total sugar supply (production plus imports) to the Japanese market. However, the importance of sugar imports relative to domestic production has declined. In 1975-76 Japanese imports were 2.4 Mt, around 84 per cent of total supply (see table 1). Rising sugar production and falling sugar consumption have both contributed to the decline in imports.

Japan's consumption of sugar per person is the lowest of all developed countries. It has generally been declining since 1975-76, when corn syrup began to make inroads into the sugar market. By 1986-87 corn syrup accounted for approximately 20 per cent of the Japanese sweetener market (see figure A). Growth in corn syrup consumption does appear to be

levelling off, perhaps due to the already high level of penetration into suitable markets such as the soft drinks sector. The low consumption of sweeteners generally, and the switch to high fructose corn syrup in particular, can be directly attributed to Japan's complex protective policy governing the sugar and corn syrup industries. Protection of Japan's sugar industry is such that both consumer and producer prices of sugar are maintained at levels that are usually many times the world price. The corn syrup industry is also highly protected, but is less rigidly controlled than the sugar industry and thus has a competitive edge in the sweetener market.

The nature of Japanese sugar import restrictions, the marked appreciation of the yen and the fall in the world sugar price since 1980 have all contributed to a large increase in the level of protection of

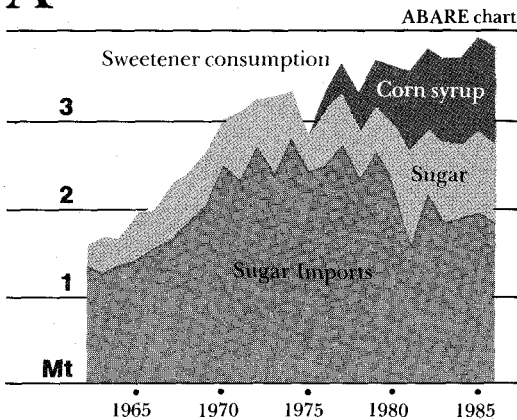
1 Japanese consumption, production and imports of sugar and production of high fructose corn syrup

Sugar ^a

Crop year ^b	Production kt	Imports kt	Share of	Consumption kt	High fructose corn syrup production kt
			production in production and imports %		
1975-76	467	2 401	16.3	3 092	
1976-77	567	2 596	17.9	3 112	112.6
1977-78	642	2 559	20.0	3 034	327.4
1978-79	708	2 556	21.7	3 204	415.0
1979-80	759	2 567	22.8	3 135	472.7
1980-81	820	1 718	32.3	2 784	608.6
1981-82	782	2 254	25.8	2 836	793.9
1982-83	926	1 865	33.2	2 889	879.2
1983-84	810	1 973	29.1	2 693	905.0
1984-85	939	1 928	32.8	2 885	953.0
1985-86	929	1 918	32.6	2 775	1 033.9
1986-87	952	1 820	34.3	2 744	1 080.0

^a F.O. Licht data, based on a September–August year. ^b 1 October to 30 September.
Sources: Licht (1987a); Mitsui (1986).

A Sweetener imports and consumption



the Japanese sweetener industries. BAE (1985) and Borrell, Sturgiss and Wong (1987) have shown that high levels of protection for the sugar industries of the European Community and United States have lowered and destabilised the world sugar price and imposed large costs both on consumers in those regions and on producers in exporting regions. The level of price support afforded the Japanese sweetener industries is higher than that provided in the European Community and the United States (Miller 1986). Because of the size of the Japanese market, Japan's sweetener policies too have the potential to create adverse economic effects in the world market, as well as domestically. The policies of countries such as Japan are of considerable interest to Australia, which exports around 80 per cent of its sugar.

For a number of traditional, cultural and political reasons, Japan provides a very high level of protection to its agricultural industries. The cost to the Japanese economy of this protection has probably increased in the 1980s, and particularly since 1985 following the marked appreciation of the yen (BAE 1987). As well as imposing costs directly on consumers, Japan's restrictions on agricultural imports may also have restricted the growth of that country's export and domestic industries.

The BAE (1987) has argued that Japan's agricultural policies have imposed an implicit tax on its export industries. First, by raising the costs of the export sector,

they have retarded its growth. Second, protection in Japan invites retaliation by countries importing Japanese goods. Thus protection for some industries puts at risk employment and incomes in others. Third, high protection to agriculture is one of the factors tending to increase land prices. In Japan extremely high land prices make housing very expensive compared with other developed nations, and thus directly restrict growth in the construction sector. High site costs, coupled with fears of retaliation against Japanese goods, may encourage Japanese export manufacturers to relocate away from Japan.

Problems of this sort, and the effects of Japanese policies on other countries, are of growing concern to Japan and its trading partners. The Advisory Group on Economic Structural Adjustment for International Harmony (1986) — an extragovernmental advisory panel — has considered Japan's macroeconomic problems, growth strategies and international economic relations and has recommended that:

- efforts should be made to increase imports of agricultural products where there are marked discrepancies between domestic and world prices; and
- where imports are subject to quantitative restrictions, efforts should be made to increase market access in line with the long term objective of opening up the Japanese market.

To date, there has been little action to implement these or other recommendations of the Committee for the major agricultural commodities. At the economic summit meeting of the seven major industrialised nations held in Tokyo in May 1986, the then Prime Minister, Mr Nakasone, joined with other heads of government in acknowledging the serious nature of world agricultural problems and the difficulties of achieving structural adjustment in agriculture. This theme was developed at the General Agreement on Tariffs and Trade (GATT) ministerial meeting in Punta del Este to launch the 'Uruguay Round' of multilateral trade negotiations. The contracting parties agreed on the desirability of greater liberalisation of world trade, and in particular of

overcoming the present restrictions and distortions in agricultural trade, including those related to structural surpluses.

Since then, international support for action to be taken to overcome the serious imbalances in world agricultural markets has continued to grow. At the OECD Ministerial Council meeting held in Paris in May 1987, for example, all OECD countries acknowledged, for the first time, the existence of an international agricultural crisis and the need to halt and reverse the deterioration in the market situation. This stance was reaffirmed by the seven heads of government attending the Venice Summit Meeting of June 1987, at which they also stressed their interest in cooperating to achieve the necessary adjustment of agricultural policies both domestically and multilaterally. It would seem, therefore, that the major world agricultural trading nations now recognise the magnitude of the problems facing

world agricultural trade. The Uruguay Round of multilateral trade negotiations being held under the auspices of GATT provides a timely opportunity to translate these concerns into action.

To provide a sound foundation for international cooperation and multilateral trade negotiations, a clear understanding of the effects of policies presently pursued by the major trading nations is needed. Hitherto, no detailed analysis of Japanese sweetener policies has been readily accessible in English. In this paper the operation of Japanese sweetener policies is outlined in detail, and an analysis of the economic effects of these policies on world sugar markets is presented. In particular, the paper addresses the effects of the policies on the welfare of producer and consumer groups in Japan and elsewhere, on import demand and on the world price, including the destabilising effect on the latter.

2. Japan's sweetener industry and policy

2.1 The structure of the industry

For climatic and agronomic reasons, the sugar cane industry is confined to a small southern part of the Japanese archipelago. The area that can be used for sugar beet is also confined, because of the rotational requirements of beet and other crops. Cane is grown on the Nansei Islands in the Kagoshima and Okinawa prefectures and beet on the Tokachi Plain and in the north-east of Hokkaido. Of these areas, Okinawa is particularly dependent on sugar; in 1985, 50 per cent of cultivated land in that prefecture was devoted to sugar cane, reflecting the limited opportunities available to agriculture. Japan's sugar cropping farms are small, averaging under 0.7 ha for cane and 3.6 ha for beet. Figure B shows the relative sizes of the beet and cane sectors.

Most of the increase in Japanese sugar production in recent years has been due to increase in the beet area. Production of beet sugar is much more variable than that of cane sugar because alternative enterprises are available to beet growers, such as grains, soybeans and fodder crops;

there are no major alternatives to cane production.

Beets are processed in eight factories, while cane is crushed in 23 mills (Mitsui 1986). In 1986, there were 34 sugar refineries in Japan, located mainly in the major cities and using both imported and domestic raw sugar. However, not all these refineries were operating; there has been some rationalisation of refinery operations since the last world price peak in 1981.

Since 1975, 17 high fructose corn syrup plants have been established. These factories are located mainly in the major port areas, as their main input is corn from the United States.

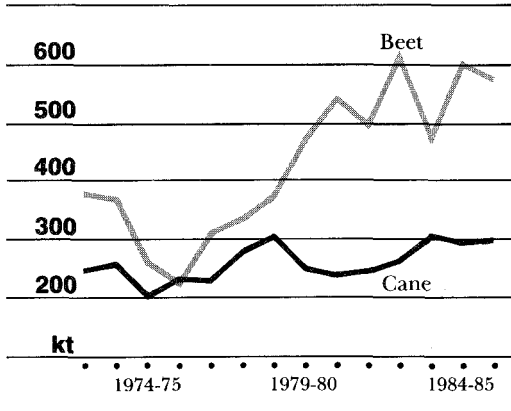
2.2 Policy instruments

On 1 October 1965 the Sugar Price Stabilisation Law came into effect and the Sugar Price Stabilisation Agency (now the Raw Silk and Sugar Price Stabilisation Corporation) was established to implement this law. The aims were to stabilise the domestic sugar price, to protect the markets of domestic beet and cane growers and related industries from import competition, and to provide income support to farmers. These aims were consistent with the broader aims of Japanese agricultural policy, of achieving a high level of food self-sufficiency and ensuring that the incomes of farm families are comparable with those of non-farm households.

The Stabilisation Agency trades in both domestically produced and imported sugar. Japanese consumer and producer prices have both been maintained well above the world price except for a short period in the mid-1970s. Consumer prices are kept above the world price by subjecting imported raw sugar to high tariffs and a complex system of variable levies, surcharges and rebates. In addition, subsidies are paid to producers so that producer prices exceed (in equivalent

B Production of beet and cane sugar

ABARE chart



terms) the prices paid for raw sugar by refiners. The high producer prices are intended to encourage domestic production, and are set broadly in line with millers', processors' and growers' production costs. These support systems are described in detail below.

As also in the United States, the high level of sugar price support has allowed a high fructose corn syrup industry to develop. By 1977, corn syrup production together with increased domestic sugar production had decreased the raw sugar import requirements and created surplus domestic sugar refining capacity. The latter led to strong competition between refiners for shares of the refined sugar market, and hence to fluctuating domestic prices for refined sugar. To limit this competition, the then Ministry of Agriculture and Forestry introduced a temporary law which froze refiners' market shares. Though competition was reduced and prices stabilised, the problem of surplus refining capacity remained. The temporary law expired in 1982.

Corn syrup production continued to expand, and in 1982 — apparently in order to protect the sugar refiners — the Government amended the Sugar Price Stabilisation Law to bring high fructose corn syrup under the coverage of the Agency. Here again, a complex mechanism is used to determine the level of taxes payable on the syrup. However, the charges imposed on corn syrup are much lower than those on raw sugar imports, so corn syrup manufacturers are still able to undercut the consumer price for sugar and thereby continue to increase their share of the sweetener market.

Price support for domestic growers and processors

The prices growers receive for their cane and beet comprise the 'minimum producer prices' (which millers and beet processors are virtually forced to pay to growers, as a condition of obtaining supported prices themselves), plus a production incentive from the Agency (per tonne of cane or beet). The production incentive system, introduced in 1974, is intended to

encourage production of sugar in place of rice. As figure B shows, domestic production has expanded under these support arrangements.

The minimum producer price is determined by a formula based on an 'agricultural parity index':

$$PN_t = PN_{t-1} \cdot \frac{I_t}{I_{t-1}}$$

where PN is the minimum producer price in nominal terms, I is the parity index and the subscripts signify years. The parity index expresses prices of items required for farm production and household use relative to those prices applying in 1950 and 1951. Movements in production costs specific to sugar growing may also be taken into account in setting the minimum producer price.

Table 2 shows the prices received by growers for their beet and cane.

The minimum prices are promulgated by the Agency by a process of simultaneous buying and selling. The Agency guarantees to buy domestically produced sugar from cane millers and beet processors at specified prices (designed to cover the cost of purchasing, collecting and processing the crop) provided the miller or processor has paid at least the specified minimum producer prices to farmers. The Agency's buying prices vary slightly between beet sugar (¥240.75/kg in 1985-6), Okinawa cane sugar (¥259.9/kg) and Kagoshima cane sugar (¥271.2/kg). The Agency simultaneously sells the sugar back to the same millers and processors at a resale price which allows them to compete with imported sugar (see figure C) and which is usually less than the purchase price; the difference is then a direct government subsidy to millers and processors (see figures C and D).

Because of the large subsidies paid to millers and processors, the Agency can incur a substantial deficit. This deficit is met from two sources: government budget allocations, and an Adjustment Fund which is financed through surcharges on raw sugar imports.

In 1985-86 the return to millers (on Okinawa) above raw material costs was ¥110/kg. Millers' total returns comprised

2 Prices paid to producers for sugar beet and sugar cane

Crop year	Beet		Cane	
	Minimum producer price	Including production incentive	Minimum producer price	Including protection incentive
	¥/kg	¥/kg	¥/kg	¥/kg
1968-69	7.26			
1969-70	7.50		6.41	
1970-71	7.76		6.57	
1971-72	8.00		6.75	
1972-73	8.25		6.95	
1973-74	8.56	8.56	8.70	8.70
1974-75	11.11	15.00	11.20	15.00
1975-76	12.14	16.00	12.34	16.10
1976-77	13.10	17.00	13.31	17.10
1977-78	16.04	18.12	16.28	18.37
1978-79	17.41	18.47	17.66	18.73
1979-80	17.99	19.09	18.25	19.35
1980-81	19.38	20.48	19.73	20.82
1981-82	19.92	21.03	20.31	21.41
1982-83	20.18	21.02	20.58	21.45
1983-84	20.26	21.02	20.65	21.47
1984-85	20.26	21.02	20.77	21.47
1985-86	20.26	21.02	20.88	21.47
1986-87	20.01	20.71	20.81	21.47
1987-88	19.00	19.70		

Sources: MAFF (1985); Mitsui (1986); Ministry of Agriculture, Forestry and Fisheries.

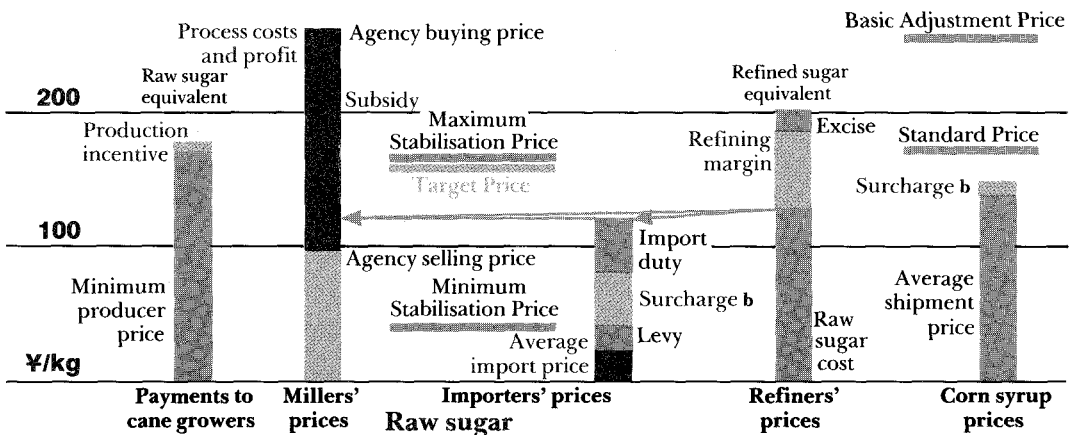
C Japanese sweetener price interventions a

ABARE chart

a Figures are for 1985-86.

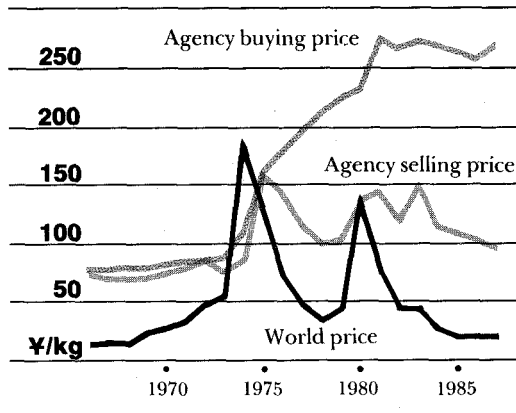
b Proceeds from corn syrup surcharge are used to reduce sugar surcharge.

300



D Nominal world and Agency prices for raw sugar

ABARE chart



the Agency buying price plus the difference between the Agency selling price and the price paid by refiners to millers for raw sugar. Since the net returns are designed to cover millers' costs, it appears that Japanese milling costs are very high by world standards. In Australia average transport, milling and handling costs have been estimated at around \$A100/t (Borrell and Wong 1986), which is around ¥12/kg at 1985-86 exchange rates. (This estimate does not include an allowance for depreciation, which could amount to an extra \$A20/t.) Indeed, the apparent Japanese processing costs far exceed the 36-year average world price of raw sugar — around ¥60/kg — and are about five times the 1985-86 world price (approximately ¥24/kg).

In 1985-86, the minimum producer price plus the production incentive was ¥180/kg (raw sugar equivalent). Thus, the combined payments to cane growers and raw sugar millers were ¥290/kg (raw sugar), or around US73c/lb — some twelve times that year's world price, and five times the 36-year average world price.

The combined payments to beet growers and processors in 1985-86 were ¥280/kg, which was nine times the world price for refined white sugar.

It is evident that both production and milling (or processing) are subsidised at levels so high as to suggest that sugar farming and processing in Japan are exceptionally costly by world standards.

Import price control and protection of refiners

Imported sugar is virtually all raw.¹ It is subject to an import duty, which was ¥41.5/kg (raw) in 1985-6, and a system of variable charges and rebates. In addition, an excise tax is imposed on all refined sugar at the point of sale, at a flat rate of ¥16/kg. To put these charges into perspective, the world sugar price during the 1985-86 Japanese sugar year averaged US6c/lb (fob Caribbean ports). At the exchange rates prevailing at that time, the import duty was US10.4c/lb and the excise duty US4.0c/lb (on raw sugar basis). The effect of the import and excise duty alone was therefore to raise the price of sugar in Japan to over three times the world price, even before any of the variable charges were added.

The variable charges and rebates are determined by the interaction of four raw sugar price levels, three of which are set by the Ministry:

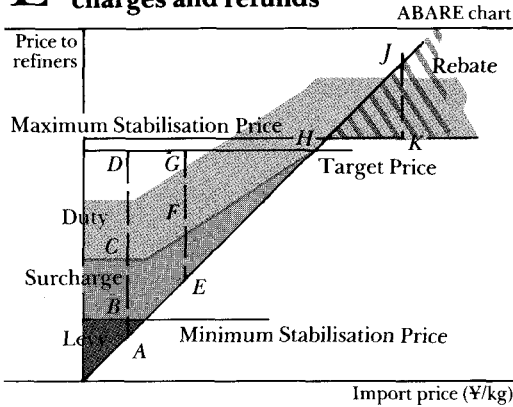
- the maximum stabilisation price (in 1985-86, ¥162.7/kg, or US41.0c/lb at 1985-86 exchange rates);
- the minimum stabilisation price (in 1985-86, ¥41.7/kg, or US10.5c/lb);
- the target price (in 1985-86, ¥161.7/kg or US40.7c/lb); and
- the average import price, which is estimated twice each month.

Their effect, combined with the fixed charges already mentioned, is to insulate the domestic consumer price from the world price and to stabilise it at a level which is usually several times the world price.

The maximum and minimum stabilisation prices are set 15 days before the beginning of the Japanese sugar year (1 October–30 September), and may be adjusted during the year. The Sugar Price Stabilisation Act 1965 stipulates that these prices should be based on an index of imported sugar prices, taking into account

1. Only negligible amounts of refined sugar are imported into Japan. The duty on refined sugar imports is ¥63/kg, as against ¥41.5/kg on raw sugar imports. This higher duty and the higher world prices and freight costs for refined sugar all discourage its importation.

E Determination of sugar import charges and refunds



'ordinary fluctuations' in these prices. In practice, from the London Daily Prices for raw sugar, a centre price is estimated for a selected period (of the order of five years) and the maximum and minimum stabilisation prices are set one standard deviation above and below this centre price. This method is subject to some flexibility, according to what are regarded as 'ordinary' fluctuations.

The target price, which is set between the minimum and maximum stabilisation prices, is based on a 'target production cost' of sugar from domestic beet and cane. The target production cost is said to take into account such factors as future prospects for the production of domestic sugar products, rationalisation targets for the domestic sugar manufacturing industry and the trend in international sugar prices. However, the target price is substantially less than the domestic production costs implied by the minimum producer prices and the direct payments made to millers (see figure C).

The average import price for each half month is calculated by converting the average of the London Daily Price for 90 consecutive calendar days prior to the commencement of that half month into a price cif at refiner's warehouse. It includes delivery costs from the wharf to the warehouse of about ¥4/kg.

To impose the levies, surcharges or rebates, the Agency buys all raw sugar imports at the average import price (regardless of the price paid by the

particular importer) and simultaneously sells the sugar back to the importer (refiner) with these additions or deductions.

The variable charges and rebates are determined as follows.

(a) If the average import price is below the minimum stabilisation price (for example, A in figure E), a levy of the difference between the average import price and the minimum stabilisation price (AB) is imposed by the Agency. In addition, a surcharge (BC) is applied. The surcharge is in this case the difference between the minimum and target prices (BD) multiplied by the level of sugar self-sufficiency — the estimated proportion of total sugar and dextrose supplies (production plus imports) that are produced domestically. In 1985-86, the self-sufficiency was estimated to be 33.3 per cent, so the maximum surcharge applied was approximately ¥40/kg, or around US10.0c/lb (at 1985-86 exchange rates).

(b) If the average import price is (E, figure E) above the minimum stabilisation price but below the target price (G), only the surcharge (EF) is added. In this case the surcharge is the product of the self-sufficiency level and the difference between the target price and the average import price.

(c) If the average import price is (H) between the target and maximum stabilisation price, no transaction between the importer and the agency is required.

(d) If the average import price is (J) higher than the maximum stabilisation price (K), the Agency returns the difference between the average import price and the maximum stabilisation price to the importer as a rebate.

In all of the above cases, importers also pay the import duty.

The proceeds from the levy charged in case (a) are placed in a Price Stabilisation Fund used for payment of the rebate in case (d). Since the peak in world sugar prices in 1980 and 1981, prices have consistently been below the minimum stabilisation price, and this decline in world prices has been exaggerated (when measured in yen) by the strong appreciation of the yen against the US dollar. As a result, the Stabilisation Fund has been

growing steadily. At current exchange rates a levy will continue to be paid on raw sugar imports as long as world prices remain below US13c/lb, and a rebate would be paid only at prices above US56c/lb.

The surcharge is paid into an Adjustment Fund used by the Agency to meet the cost of subsidies to domestic millers, processors and growers. However, the fund has proved inadequate for this purpose, and the government has been forced to subsidise the industry from general revenue. This situation has arisen because expansion in domestic sugar production has increased expenditure on subsidies, while at the same time reducing the need for imported sugar and thus the revenue base.

Since October 1982 (see following subsection) a surcharge has been imposed also on high fructose corn syrup production. In recognition of the adverse effect of rising corn syrup production on sugar refiners, the revenue collected from this surcharge is used to reduce the surcharge imposed on imported raw sugar. In 1985-86 this transfer enabled the surcharge on raw sugar imports to be reduced by ¥3/kg.

At the same time, a second sugar import surcharge was introduced, to be applied if the Japanese market price for refined sugar falls below a certain 'theoretical market price'. This theoretical price (see figure C) is the sum of the Agency's resale price to importers for raw sugar, the import duty (both of these being expressed in their refined sugar equivalents), a standard refining margin which is determined annually (¥58.449/kg in 1985-86) and the excise tax. The second surcharge is applied at a flat rate (¥5.08/kg in 1985-86).

The standard refining margin has been diminishing, but is still very much higher than refining costs elsewhere. In the United States, for instance, in 1985-86 the difference between the Chicago West wholesale price for refined sugar and the New York No.12 spot price for raw sugar (cif, duty paid) was around US2.94c/lb (US Department of Agriculture 1987), or ¥11.5/kg. The difference between the London Daily Prices for white sugar (fob

Europe) and raw sugar (cif United Kingdom) was at that time US1.55c/lb (Licht 1987b), or around ¥6.15/kg. Here again, the high rate of protection suggests very high costs of production in the Japanese sugar industry.

When the second surcharge is applicable, it is imposed not on all imports but only those in excess of what is needed by refiners to produce the quantity allotted to them under the Ministry's quarterly demand and supply forecasts. An effect is to discourage the more efficient refiners from importing additional sugar and thereby lowering the Japanese refining margin.

Regulation of high fructose corn syrup production

Until 1982 there were no restrictions or policy arrangements directly affecting high fructose corn syrup. Maize could be imported at the world price, and syrup made from it could be sold at any price up to the domestic wholesale refined sugar price. In that year, both the wholesale price of refined sugar and that of high fructose corn syrup expressed in sugar equivalents were around US35c/lb. If the costs of production of high fructose corn syrup in Japan are similar to those in the United States (which is likely, since the maize prices and technology are similar) profitability in the corn syrup industry would have been very high. In the United States, high fructose corn syrup production costs in 1982 were about US12c/lb (raw sugar equivalent) (Hoff and Lawrence 1985). Even if Japanese production costs were 50 per cent higher than this (allowing for the slightly higher cost of maize imported from the United States), corn syrup profits in Japan would have been very large.

In April 1982 an amendment to the Sugar Price Stabilisation Law enabled the Agency to impose a surcharge on high fructose corn syrup production from October of that year. The surcharge is imposed by essentially the same procedure as is used in taxing sugar imports: the Agency simultaneously buys syrup from, and resells it to, the manufacturer at

different prices. It reduces the profitability of corn syrup manufacturing — though only by a small proportion — unless maize prices are very high. As has been mentioned, the funds collected from this surcharge are used to reduce surcharges on imported raw sugar.

In Japan, unlike the United States, the starch base for high fructose corn syrup manufacture is obtained not only from maize but from a combination of imported maize and domestic potatoes and sweet potatoes. Starch producers are required to use domestic potatoes and imported maize in a ratio fixed by the Ministry, which during 1987 was such as to give 1 part domestic potato starch to about 7.6 parts of imported maize starch. Japanese potato starch production in recent years has totalled around 230 kt. Domestic potatoes and sweet potatoes currently cost about five times as much as maize (which incurs no import duty).

The cost of domestic potato starch is usually several times that of starch from imported maize, because of this large difference in the cost of the raw materials. The cost of starch to the corn syrup producer is not subsidised. Each corn syrup producer is required to buy a quota of starch specified quarterly by the Ministry. Thus the Ministry indirectly, but effectively, controls imports of maize for corn syrup manufacture.

The Agency imposes a 'primary' surcharge, which depends on the relative prices of corn syrup and sugar, and a fixed 'secondary' surcharge in cases of overproduction.

There are four elements involved in the calculation of the primary surcharge:

- the average shipment price (in 1985-86, around ¥140/kg);
- the basic adjustment price (in 1985-86, ¥229.2/kg);
- the standard price (in 1985-86, ¥170/kg); and
- the rate of surcharge.

The average shipment price is an ideal wholesale price announced each quarter by the Agency. It includes the cost of raw materials and a margin to cover syrup manufacturing costs and profits. (The equivalent price in the sugar regime is the

sum of the average import price, converted to a refined sugar equivalent basis, and the refining margin.) No figures were available for the costs of manufacturing high fructose corn syrup in Japan. In the United States in 1985-86, the wholesale price for high fructose corn syrup (55 per cent fructose) was US\$19.5c/lb, or ¥77.5/kg, well below the Japanese average shipment price. The margin allowed to Japanese corn syrup manufacturers to cover their costs and profits seems at first sight very high by US standards. Moreover, the Japanese corn syrup wholesale price has at times exceeded the average shipment price plus the surcharge, so profits to corn syrup manufacturers have been even higher than the average shipment price suggests.

The basic adjustment price is based on the target price for raw sugar. It is derived as follows. The raw sugar target price (see preceding subsection) is adjusted by the addition of the import duty, is converted to its refined sugar equivalent, and the refining margin and excise tax are added. This 'refined sugar target price' is then multiplied by 0.8, to allow for the difference in the sweetener properties of sugar and high fructose corn syrup.

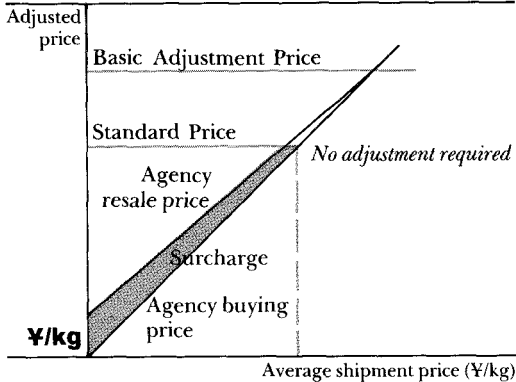
The standard price is calculated by multiplying the theoretical market price for refined sugar (see preceding subsection) by the same factor of 0.8.

The rate of surcharge is a measure of self-sufficiency. It is the production of domestic sugar and dextrose expressed as a percentage of total production and imports of sugar, dextrose and high fructose corn syrup. At present this figure is about 25 per cent. However, the Ministry's formula for calculating the rate of surcharge also includes a factor for 'the degree of high fructose corn syrup's influence on the sugar market price'. As a result, the rate of surcharge was set at 8.18 per cent in 1985-86 and 9.55 per cent in 1986-87. It appears that the Ministry considers corn syrup to have only a minor influence on the market price of sugar.

The primary surcharge for each quarter is determined by subtracting the average shipment price from the basic adjustment price and multiplying by the rate of surcharge. There is thus no surcharge if

F Price adjustment mechanism for high fructose corn syrup

ABARE chart



the average shipment price is equal to or above the basic adjustment price.

When (as is usually the case) the average shipment price is below both the basic adjustment price and the standard price, every processor is required to sell all high fructose corn syrup produced to the Agency at the average shipment price. The Agency then sells the syrup back to the manufacturers at one of the following prices (see figure F):

- if the average shipment price plus primary surcharge is less than the standard price (the usual situation, unless the imported maize price is high), then at the average shipment price plus the primary surcharge;
- if the average shipment price plus the primary surcharge is greater than the standard price, then at the standard price.

The standard price is thus a benchmark, used to place an upper limit on application of the surcharge. If the average shipment price is equal to or higher than either the standard price or the basic adjustment price, no transaction between processors and the Agency is required. This is likely to occur only if the imported maize price is unusually high. The suspension of the surcharge would then improve the competitiveness of corn syrup.

In the first quarter of 1987, the basic adjustment price was ¥255.04/kg and the average shipment price was ¥147.73/kg. At the surcharge rate of 9.55 per cent, the surcharge was ¥10.248/kg. The resulting

revenue enabled the sugar surcharge to be reduced of ¥3.065/kg.

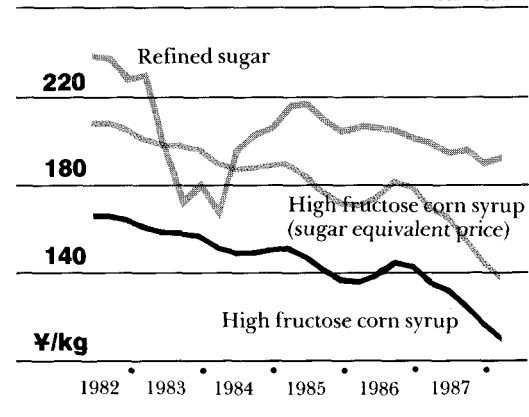
An extra, relatively minor 'secondary' surcharge can be imposed on a manufacturer producing more corn syrup than the quota allotted by the Ministry. The secondary surcharge is added to the Agency's resale price on the excess quantity only. In 1985-86, the secondary surcharge rate was ¥4.26/kg.

In spite of these surcharges, profitability in the high fructose corn syrup industry has probably remained very high, although it may have begun to decline a little in recent years. Figure G shows recent movements of wholesale prices for refined sugar and high fructose corn syrup (55 per cent) the latter being shown also in sugar equivalent terms. The decline in corn syrup prices since 1986 can be attributed to a combination of three factors: the maturation of the corn syrup market, resulting in increased competitive pressure among the manufacturers; the appreciation of the yen; and weakening maize prices.

In the past, the high profits of the syrup producers have been protected against oversupply in two ways. First, it was difficult to enter the industry, since it is regulated to deter excessive production and maize imports. Second, increases in capacity by existing firms were more than matched by rapidly expanding demand. Now, as shown in figure A, the growth in corn syrup use has begun to slow down.

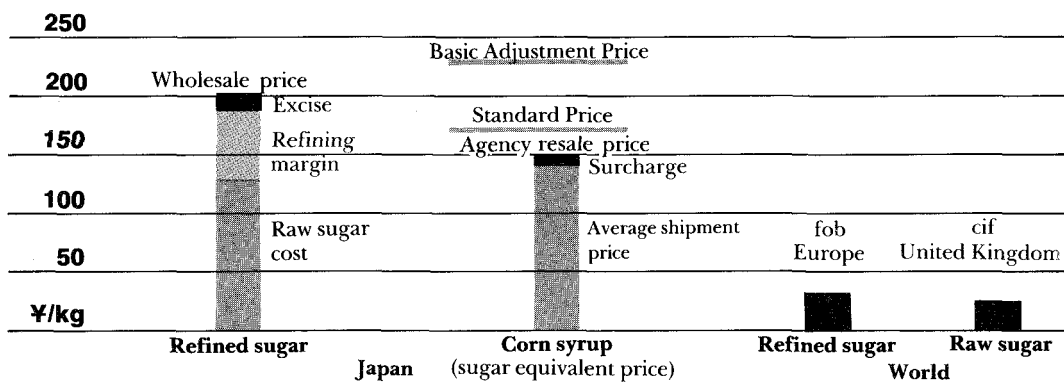
G Japanese wholesale sweetener prices

ABARE chart



H A comparison of world and Japanese sweetener prices

ABARE chart



Between the beginning of 1986 and March 1987, maize export prices (fob Gulf ports) dropped from US\$105/t to US\$72/t, a decline of 31 per cent. Measured in yen, the decline has been even greater — from ¥21.0/kg in January 1986 to ¥10.9/kg in March 1987, or 48 per cent. This decline in maize prices has led to decreases in average shipment prices and hence in corn syrup prices. In contrast, there is no mechanism whereby declines in sugar import prices (likewise partly due to the appreciation of the yen) can be passed on in lower wholesale and retail prices for refined sugar. Regardless of how far the world price for sugar may fall, the variable levy raises the average import price to the minimum stabilisation price, to which the surcharge and duty are added (see figure E).

The surcharge on high fructose corn syrup is effectively the only impost used to adjust its price, since there are no import duties on maize. The current surcharge on

high fructose corn syrup, of about ¥10.250/kg, is very small in comparison with the charges on imported raw sugar, such as the duty of ¥41.5/kg. The syrup is also not subject to an excise tax, as is imposed on refined sugar at the rate of ¥16/kg. Thus corn syrup is highly favoured by Japanese sweetener policies.

When prices received by Japanese growers, millers, processors, refiners and high fructose corn syrup manufacturers are compared with world prices for raw and white sugar and high fructose corn syrup (see figures C and H), it is readily apparent that substantial subsidies are paid to Japanese sweetener producers. For instance, the combined payments to cane growers, raw sugar millers and refiners was around ¥350/kg (refined sugar) in 1985-86 — eleven times the world price. It is clear that under present sweetener policies, Japan does not have a competitive advantage in these products.

3. The economic effects of Japanese sugar policy

The main objective of Japanese sugar policy is to provide income levels to sugar producers broadly comparable with those earned by non-agricultural workers. Because of the concentration of the cane industry in areas where alternative opportunities are lacking, it is quite likely that this industry is also seen as a way of achieving regional objectives. One of the overall aims of Japanese agricultural policy is to maintain as high a level of self-sufficiency as possible. While the policy may have partially achieved these objectives, it has done so only at considerable cost. At the very least the consequences of the policy can be shown to include:

- reduction of sugar imports;
- reduction of the world price of sugar and increase in its variability;
- loss of income to sugar producers in other countries;
- resource misallocation in Japan and other sugar trading nations;
- loss of income to Japanese consumers; and
- increases in income for Japanese sweetener producers and for consumers in importing countries.

Under current policies, imports constitute the residual element of the Japanese sweetener market, meeting the difference between domestic demand and supply. Under current policy, demand for sugar is lower than would be the case under a free trade policy, and domestic supply is higher. Demand is lowered because consumers pay a very high price for sugar compared with the world price. This high price, together with policies that favour high fructose corn syrup, has encouraged the establishment and growth of the corn syrup industry, at the expense of demand for sugar.

Domestic supply of sugar is higher under current policy than in a free trade regime because of the very high Japanese

producer prices for beet and cane. However, the extent to which Japanese production can be increased is constrained by the shortage of suitable land.

The consequent reduction in import demand lowers the world price for sugar. The size of this effect has not hitherto been determined. The effects of other countries' interventionist policies on the world price have been estimated to be quite large. The effects on world price of the protective policies of the European Community and the United States have been estimated at between 5 per cent and 11 per cent for the European Community (BAE 1985) and 9 per cent for the United States (Borrell, Sturgiss and Wong 1987). In the United States, high consumer prices have encouraged the rapid growth of high fructose corn syrup production, to the stage where it now accounts for half the US sweetener market.

Japanese sweetener policies, like those of the United States and the European Community, will have contributed to a lowering of the incomes of sugar producers in exporting countries. This reduces the ability of these countries to trade, lowering either directly or indirectly the demand for Japanese exports. As well, sugar exporting countries are induced to shift resources out of the production of sugar. Thus, there is a global misallocation of resources, reducing trade, income levels and employment worldwide. Because domestic intervention leads to lower world prices, it might be thought that consumers in other countries would benefit. However, the deleterious effect of resource misallocation on these consumers should also be remembered.

Protectionist agricultural policies in Japan impose costs on other sectors of the Japanese economy, lowering incomes, output and economic growth in Japan. Japanese agricultural policies cause a diversion of resources out of productive

economic activities elsewhere in the economy and into the relatively inefficient agricultural sector.

The high prices paid for agricultural products tend to be capitalised into land values. The high demand for agricultural land raises the price of land for residential, manufacturing and recreation purposes. In Japan, land prices directly restrict growth in the housing and construction sector of the economy. High site costs may encourage Japanese manufacturers of tradable goods to locate in lower cost countries rather than in Japan, and development of recreation industries such as golfing is restricted. Thus, to the extent that Japan's sugar policy increases the demand for land for agriculture it probably restricts growth in other sectors of the economy. Other factor prices will also be bid up by the sugar and high fructose corn syrup industries. This raises the resource costs of the export sector, reducing its international competitiveness.

Sugar using industries in Japan are also adversely affected. For example, in an effort to circumvent the high charges placed on imported raw sugar, there has been a gradual rise in imports of products such as cocoa which has been blended with sugar (see Czarnikow 1987). Imports of other foodstuffs containing sugar, such as soft drinks and canned fruit juices, have also increased. As a result, the demand for raw sugar, and perhaps the profitability of the sugar refining and sugar using industries, have declined.

Income distribution in Japan is also changed by the policy. Income is redistributed from consumers to producers because of the high consumer price. Because variable levies are used to maintain relatively stable prices, a fall in world price causes the size of the transfer from consumers to increase. The appreciation of the yen has exacerbated the fall in world sugar prices measured in yen, and thus increased the size of the transfer from consumers. Because the consumption of sugar is unlikely to vary greatly between low and high income earners, the policy is likely to be regressive, placing a larger burden on low income earners, relative to their income.

Because support is provided through the price mechanism, the size of the transfer to individual growers and producers (including producers of corn syrup) increases in line with their production. Thus, large farms and companies obtain more support than small ones. High fructose corn syrup producers have also been beneficiaries at the expense of Japanese sugar refiners, due to the decline in sugar's share of the sweetener market.

Despite the protection afforded the Japanese sugar industry, the resulting high producer prices do not ensure its long term profitability. Not only do these high prices tend to become capitalised in land values and to cause other input costs to be bid up, thus eroding profits, but high levels of protection reduce producers' incentives to be cost-efficient. To these costs must be added the costs of lobbying for support, which may be considerable.

The redistribution of income in Japan is caused by direct intervention. The redistribution of income in the rest of the world is caused by the effect of this intervention upon the world price for sugar. On the world scale, income is redistributed from exporters to importers. To the extent that Japan provides aid to developing countries which are sugar exporters, such as the Philippines, there is an obvious contradiction between policy goals.

3.1 Representation of economic effects

To illustrate the main economic effects of Japan's sugar policy, a static partial equilibrium analysis is presented in figure I. This captures the direct effects of the policy upon production, consumption, prices and trade flows of sweetener for Japan and the rest of the world. It ignores such effects as those on alternative commodities such as rice; however, these effects are likely to be small. It can be assumed for expositional purposes that corn syrup supply is equal to its consumption and that its consumer price is equal to that of sugar. In the subsequent estimation of costs and benefits this second assumption is relaxed.

Under free trade between Japan and the rest of the world, Japanese production of sweeteners at the free trade world price, P_{wf} , would be Q_f . Corn syrup production would then be the difference between Q_f and the corresponding sugar production, Q_{sf} . Similarly, Japanese consumption of sweeteners would be C_f . Syrup consumption would equal syrup production ($Q_f - Q_{sf}$) and sugar consumption would therefore be $C_f - (Q_f - Q_{sf})$. Imports of sugar are given by the difference between Japanese sweetener supply and demand. The world price P_{wf} is the equilibrium price, at which the supply of exports from the rest of the world (that is, the difference between the rest of the world's supply and demand) equals Japan's import demand.

Under current policies, Japanese sweetener consumers pay a price P_c , higher than the world sugar price P_{wf} , and sugar producers receive P_p , the consumer price plus subsidy. Sugar production increases to Q_{sp} , sweetener production to Q_p , and syrup production to $Q_p - Q_{sp}$, since syrup prices increase with sugar consumer prices. Sweetener consumption contracts by $C_f - C_p$. With increased local supply and reduced consumption, imports fall, and the world price therefore falls, from P_{wf} to P_{wp} . (Further, as will be explained, the lack of response of Japanese imports to the world price destabilises the world price.)

3.2 Measures of welfare change

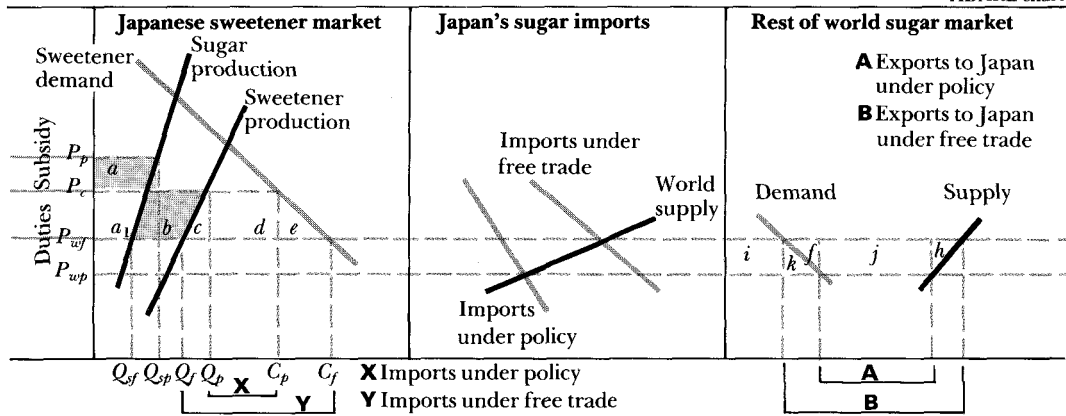
The measures of welfare change used in the analysis are consumer surplus and producer rents. Willig (1976) has shown that in most cases (where the product accounts for only a small proportion of total consumer expenditure), change in consumer surplus is a very good approximation to the ideal measure of consumer welfare change (the so-called 'compensating variation', whose evaluation is impracticable). This condition is easily satisfied by sugar.

An approximation to short term producer rents on fixed capital (whether this is equipment or agricultural land) is given by the area between the price axis and the supply curve, provided that the supply curve can be interpreted as an industry marginal cost curve excluding factor rents (Mishan 1968). For the sugar industry, at least in the short to medium term, this condition is met. Similarly, for the corn syrup industry, the measure can be interpreted as the rent accruing to processing capital (which is fixed in the short term).

The loss to consumers depends on the amount by which the consumer price exceeds the world free trade price, and on the diminution of consumption consequent on this price increase (that is,

I Price and welfare changes due to sweetener policy

ABARE chart



on the price elasticity of demand). The increase in welfare of producers depends on the price increase (the level of support) and on the consequent increase in supply (that is, on the price elasticity of supply). The size of the transfer between producers and consumers in the rest of the world will largely depend on the change in the world price.

These changes in welfare are represented in figure I:

Change in Japanese consumer surplus:

$$-(a_1 + b + c + d + e)$$

Change in Japanese sugar producer rents:

$$a + a_1$$

Change in Japanese corn syrup producer rents: b

Change in rest of world producer rents:

$$-(i + k + f + j + h)$$

Change in rest of world consumer surplus:

$$i + k$$

Net cost to world:

$$c + e + f + h$$

Net cost to Japan:

$$c + e$$

4. Estimates of the effects of Japanese policy

An econometric model was developed to estimate the effects of present and possible alternative Japanese policies on the welfare of consumers and producers both inside and outside Japan, and to quantify the costs of some alternative policies. This analysis entailed estimating the short and long run effects of Japanese policy on the world price and on Japanese sugar imports. The model, presented in the appendix, has the following features.

- The Japanese and 'rest of the world' markets are modelled specifically.
- These two sectors of the model are linked, so that the effects of Japanese policy on the world price can be estimated. The Japanese sector directly affects the world market through its import demand. The world price feeds back into the Japanese sector through its influence on Japanese government price setting. The model is run as a complete system.
- The model includes dynamic linkages of market variables from one year to the next, so that the effects of Japanese policy can be observed through successive time periods in a consistent and detailed fashion.

The estimated effects of Japanese sugar policy fall into three main categories: first, the effects of policy on key variables, such as sugar production and consumption in Japan and world sugar price, for the period 1985–87; second, the effects on the incomes of Japanese and other producers and consumers over the same period; third, the effects on the levels and variability of world price and sugar imports in the longer run.

For each of these sets of estimates the model was run twice, first assuming that current Japanese policy was operating, then assuming that free trade had been introduced between Japan and the rest of the world in 1985. In addition, simulations were run with present price controls replaced by various alternative policy instruments, such as an *ad valorem* tariff or

direct income support to farmers.

To simulate free trade, the consumer price of raw sugar in Japan was set equal to the world price. The minimum producer price (see section 2.2) was then assumed to remain at a constant proportion of the raw sugar consumer price, namely the proportion actually observed in 1985 (0.7, when the minimum producer price for beets is expressed in sugar equivalents.) The refined sugar consumer price was assumed to be the raw sugar consumer price plus the historical standard refining margin (see section 2.2).

Some assumption was required as to the behaviour of the corn syrup industry in a free trade regime. Two assumptions were used in separate free-trade simulations, and the pairs of results thus obtained were taken as bounds on the possible effects of introducing free trade (and thus, conversely, on the effects of the present policy). One assumption was that the upward time trend observed in corn syrup consumption (independent of price changes) would continue at its historical rate under free trade. This assumption provides an extreme lower estimate for the depressing effect of current policy on the world sugar price, since — as has been argued above — present Japanese policies provide a highly protective environment for the corn syrup industry. The alternative assumption was that the time trend in corn syrup consumption would, under free trade, immediately flatten. This assumption provides an upper bound on the effect of present policy on world price. This bound may however be conservative. It is highly possible that, when exposed to the world sugar price, corn syrup consumption could fall. In Canada, where the industry receives no direct protection, it remains small (190 kt in 1985) and is perhaps only sustained because over half its output is exported to the United States, where a price higher than the world price

is received. If the Japanese industry were exposed to similar conditions, it might well contract.

4.1 Estimated effects, 1985–87

Estimates of the effects of Japanese policy on key variables are presented in table 3. A free trade policy is shown to increase Japanese imports (by 41–57 per cent in 1987) and hence the world price (by 11–14 per cent in 1987). Japanese consumption of sugar would be higher under free trade, due to lower sweetener prices together with some switching from corn syrup to sugar. The price elasticity² of sweetener demand in 1985 is estimated to have been -0.08 , while that of corn syrup demand is estimated at -0.49 . The latter high elasticity can be attributed to the

existence of a near substitute, sugar. The elasticity of corn syrup demand with respect to price of sugar is estimated to be $+0.51$. Thus, for example, a 10 per cent fall in the prices of both sugar and corn syrup will result in an increase of 0.8 per cent in sweetener consumption, plus a consumption shift of 0.2 per cent from corn syrup to sugar.

The steady fall in production under free trade seen in table 3 indicates the gradual response of producers to the falling producer price. It is possible, however, that production is underestimated here (because of the form of the production equation used in the model). Rationalisation and restructuring of the Japanese sugar industry could allow higher levels of production at a given producer price than the model predicts. In the absence of better information, however, it is assumed that the estimated form of the production equation holds.

The implications of the results presented in table 3 for the income transfers and net

2. Price elasticity of demand can be defined as the percentage change in consumption that occurs in response to a 1 per cent increase in price.

3 Effects of sweetener policy on key variables: 1985–87

Variable and calendar year	Unit	Under current policy	With free trade		Estimated effect of free trade policy %
			Lower bound ^a	Upper bound ^b	
Japanese sugar consumption					
1985	Mt	2.87	3.25	3.34	13–16
1986	Mt	2.77	3.22	3.40	16–23
1987	Mt	2.75	2.93	3.20	7–16
Japanese sugar production					
1985	Mt	0.88	0.88	0.88	0
1986	Mt	0.90	0.54	0.54	-40
1987	Mt	0.91	0.37	0.37	-59
Japanese sugar imports					
1985	Mt	1.97	2.48	2.56	26–30
1986	Mt	1.90	2.81	3.01	48–58
1987	Mt	1.84	2.59	2.89	41–57
World price ^c					
1985	USc/lb	5.08	5.23	5.26	3–4
1986	USc/lb	6.99	7.64	7.88	9–11
1987	USc/lb	7.26	8.03	8.30	11–14

^a Assuming that historic time trend in Japanese corn syrup consumption persists. ^b Assuming corn syrup consumption independent of time. ^c In real 1984 terms, using 1985 exchange rates.

4 Income transfers attributable to present sweetener policy ^a

Transfer	1985	1986	1987
	US\$m ^b	US\$m ^b	US\$m ^b
To Japanese sugar producers	800	698	673
(millers, growers)	801	701	677
– to growers	320	242	221
	321	244	223
To Japanese corn syrup producers	255	229	246
	268	252	279
To Japanese government	535	337	242
	535	337	242
From Japanese consumers	–1 945	–1 627	–1 519
	–1 947	–1 640	–1 544
From producers elsewhere	–361	–1 668	–2 309
	–309	–1 363	–1 704
To consumers elsewhere	360	1 715	2 288
	308	1 402	1 690
World deadweight loss	113	199	191
	91	165	141

^a The first row of figures for each group is the 'lower bound' estimate, and the second row is the 'upper bound' estimate. ^b 1984 dollars; 1985 exchange rates.

economic losses resulting from current policy are presented in table 4. The main features of this table are the high costs to Japanese consumers, the large contribution to Japanese government revenue and the high deadweight (net efficiency) losses. Assuming the 1985 average exchange rate, ¥224/US\$, the cost of the policy to Japanese consumers is estimated to be over US\$1500m — that is, US\$14 per person — in each year from 1985 to 1987. This is similar to the per person cost of US sugar policies to US consumers, as estimated by Borrell et al. (1987), even though per person consumption of sugar in Japan is only about half that in the United States. If a 1987 exchange rate is used, the Japan estimates are 50 per cent higher than in table 4.

The model estimates do not include the costs to Japanese consumers of the large refining margins that are protected by Japanese policy (since the refining margins used in the model are historical). These costs, which could be substantial, take the form of transfers from consumers to

refiners. If in a free trade situation the refining margin fell to the level that prevailed in the United States in 1987 (US\$2.94c/b), the saving to Japanese consumers would increase by an average of US\$660m a year for the period.

The contribution to Japanese government revenue is large because in the years modelled the world price was very low. In years of higher world price the variable import charges decline while the subsidies paid to producers remain high, so the net contribution to government revenue is smaller and may be negative.

The cost to consumers and the cost of the efficiency (deadweight) losses to the economy are large relative to the size of the benefits being provided to Japanese producers. For instance, for 1987 Japanese consumer costs and efficiency losses are estimated to be 227 per cent and 25 per cent, respectively, of the transfer to Japanese sugar producers. Thus, the Japanese use very costly policy instruments to meet their sweetener policy objectives.

Some further costs to the economy are not estimated by the model. They include

5 Change in national incomes attributable to sweetener policy: 1986

Country	Lower bound US\$m ^a	Upper bound US\$m ^a
From exporters		
Australia	41	50
Brazil	38	46
European Community	42	51
Philippines	5	6
Thailand	28	34
To importers		
Canada	14	17
China	19	23
India	8	10
Japan	26	32
United States	25	30
USSR	70	86

^a 1984 dollars; 1985 exchange rates.

Note: In calculating the figures in this table it has been assumed that the price responsiveness of both exporters and importers is zero, so that the export and import volumes of each country remain the same under current Japanese policy and under free trade between Japan and the rest of the world. In other words, the costs (benefits) have been calculated simply by multiplying actual exports or imports by the difference in price induced by Japanese policy. In reality, under free trade, export volumes are likely to be higher than at present, although this effect is probably small (see Gemmill 1976) and the numbers presented are therefore good approximations.

the cost of administering such a complex system, and the cost of lobbying for support by producers. In addition, as has been stated, the free trade scenarios do not allow for the possibility that the historic growth in the corn syrup industry might be reversed, which would increase sugar demand and hence the world sugar price beyond the estimates presented. Moreover, the adverse effects of import restrictions on the growth of other sectors of the Japanese economy, as discussed in chapter 3, are not accounted for. Thus the numbers presented are conservative estimates of the cost of the current policy to the Japanese economy.

The chief beneficiaries of the policy are Japanese cane millers, beet processors and corn syrup manufacturers. Transfers to refiners, as has been mentioned, have not been measured using the model, but are probably large. Because support to

sweetener producers is paid through the price system, the larger the producer the larger the transfer. Thus, of the estimated annual average of US\$463m paid in support to millers and processors in the period 1985-87, 67 per cent was shared between the three beet processing companies and the remaining 33 per cent between the 19 cane millers. For the corn syrup manufacturers, an estimated US\$243m a year was shared between 17 companies.

Through its effect on the world price, the Japanese policy will have caused a transfer of income from sugar exporters to importers (see table 5). For Australia, the reduction in export revenue in 1986 is estimated at between US\$41m and US\$50m. The major beneficiary was the USSR, with an estimated saving of between US\$70m and US\$86m. The saving to Japan was around US\$30m, which is small compared with the costs of the policies to the Japanese economy.

4.2 Long term effects on world price variability

The Japanese policy of stabilising the domestic sugar price can be expected to affect the world price cycle in the following way. When the world sugar market is undersupplied, a price peak occurs. In response, the world market adjusts through decreased consumption, worldwide, and increased production. Because the Japanese policy prevents Japanese producers and consumers from receiving world price signals, all of this adjustment takes place outside Japan, with the result that a larger price signal is needed to induce a given response. When the market is (as at present) oversupplied, on the other hand, the price trough is lower than if a free trade policy had been pursued, as is shown in figure 1 and table 5. World production therefore falls further than in the free trade case. As a result, the next undersupply phase is more acute, with a higher price peak, than under free trade. Thus, world price is more variable, with higher price peaks and lower price troughs, as a result of Japanese sweetener policy. On average, world price is lower.

To estimate the likely effects of Japanese policy on the variability of world prices, stochastic simulations were performed. These simulations capture the interactions of Japanese policy with random fluctuations in the price cycle — that is, the effects on its frequency and volatility. The model was run stochastically for the period 1985–2004, sixty times for each of three situations. In the first series, continuation of current Japanese policy was assumed. In the other two series, free trade between Japan and the rest of the world was assumed, but (as outlined earlier) two alternative assumptions were made about the time trend in corn syrup production. Comparisons of the three probability distributions of price provide estimates of the long term effect of Japanese policy on the average world price and on its variability. The large number of simulations ensured reliable estimates of these measures.

Forecasts of exogenous variables were obtained from time series (ARIMA) models. Weather variables were obtained from the historical weather pattern, using the years from 1962. The summary statistics of the simulation are presented in table 6. It is seen that in the longer run the Japanese sugar policy lowers the mean world price by 2–5 per cent. More

importantly, it increases the variability of the world price, as indicated by the higher coefficient of variation.

The effect of the policy on imports is also striking. Japan's imports of sugar would be substantially greater under free trade, though the difference would be less if the use of high fructose corn syrup (or any other alternative sweetener) continued to grow at its historical rate. If, under a free trade policy, the upward trend in corn syrup consumption ceased, future Japanese import demand could be more than double the level that can be anticipated under current policy. This is a further measure of the cost of Japanese policy to the world's sugar exporters.

Any long term decline in high fructose corn syrup production would increase the free trade level of imports. As has been noted, this might happen if the Japanese corn syrup industry is similar to the Canadian industry. The relatively high cost Japanese industry would find it difficult to compete with imported sugar, narrowing the price differential between sugar and cane syrup. Given that the demand elasticity of corn syrup with respect to the sugar price is 0.51, this narrowing of the price differential would increase sugar demand in Japan, and hence the free trade world price.

6 Effects of sweetener policy on world price variations and on Japan's imports: 1985–2004

Statistic	Under current policy USc/lb	With free trade		Estimated effect of free trade policy	
		Lower bound USc/lb	Upper bound USc/lb	Lower bound %	Upper bound %
World price					
Mean	18.43	18.84	19.29	2.2	4.7
Standard deviation	13.49	12.44	12.73	-7.8	-5.6
Coefficient of variation	0.73	0.66	0.66		
Range ^a	4.85–47.69	5.18–46.30	5.15–47.52		
Sugar imports to Japan					
Mean	Mt	Mt	Mt	%	%
Mean	1.28	1.82	2.83	42	121
Standard deviation	0.49	0.63	0.43	29	-12
Coefficient of variation	0.38	0.35	0.15		
Range ^a	0.37–2.04	0.67–2.77	2.00–3.58		

^a Contains 95 per cent of stochastic simulation results.

5. Prospects and alternatives for policy reform

5.1 Incentives for reform

It has been shown that the costs of current Japanese sugar policy to Japanese consumers and to the world's exporters far exceed the benefits to Japanese sugar and corn syrup producers, and that the costs to the Japanese economy generally are also significant. Further, the costs are probably underestimated in this study while the net benefits to producers are probably overstated. Thus, there is a large incentive both for groups within Japan and for the sugar exporting nations collectively to support reform of Japan's sugar policy.

The Japanese sugar policy is one facet of an overall agricultural policy whose purposes include food self-sufficiency and a regional policy of maintaining the viability of rural communities, as well as income maintenance for farmers and price stability. The strength of the Japanese farm lobby has made reform difficult to achieve in the past. In addition, because the sugar scheme is largely self financing — and in fact in recent years has raised revenue for the Japanese government — the latter has had no urgent need to alter it. Instead the burden of the scheme is shared by Japanese consumers and exporting nations.

Further incentives for reform are seen by taking a broader perspective. The significant changes that have occurred since the early 1980s in the international economy — in which Japan is a major participant — have focused attention on the need for restructuring of the Japanese economy. This fact, together with the focus on agriculture in the current GATT round, has led to increased interest in the cost of Japan's agricultural policies. The BAE (1987) has concluded that there is potential for gradual reductions in Japan's agricultural protection in the longer term. There is some evidence that the strength of the farm lobby in Japan may be declining,

and there is also evidence that public support for food self-sufficiency may have weakened (see BAE 1987). In 1986, as has been mentioned in chapter 1, Japan's Advisory Group on Economic Structural Adjustment for International Harmony, taking stock of the country's macroeconomic and international economic problems, recommended the liberalisation of highly protected markets. Sugar comes into this category.

The current GATT negotiations provide an ideal opportunity for the promotion of beneficial reform through a multilateral approach. The advantage of a multilateral approach is that adjustment is shared by many countries instead of being borne by one, and in this way large adjustments can be achieved, increasing world price and lowering costs of support.

5.2 Policy alternatives

It has been shown that Japan's use of the price system to achieve policy goals causes distortions to Japanese production, consumption and imports of sweeteners, and to the world price, with large efficiency costs both inside and outside Japan. The same purposes could be accomplished at lower cost, in a variety of ways.

One such option would be to remove all import duties and other variable levies from imported sugar and replace them with an *ad valorem* tariff. This would increase the Japanese consumer price above the world price by a fixed percentage, thus allowing consumer prices to reflect world prices. Japanese consumers could then benefit from changes such as reductions in world prices and the appreciation of the yen. The *ad valorem* tariff could be set at a level that would equate government revenues from this source to the cost of maintaining existing prices to cane and beet growers, millers and processors.

7 Effect of policy alternatives on key variables

Variable and calendar year	Unit	Current policy	Self-financing <i>ad valorem</i> tariff	World prices to consumers; subsidies to producers
Japanese sugar consumption				
1985	Mt	2.87	2.98	3.34
1986	Mt	2.77	2.95	3.40
1987	Mt	2.75	3.02	3.20
Japanese sugar production				
1985	Mt	0.88	0.88	0.88
1986	Mt	0.90	0.90	0.90
1987	Mt	0.91	0.91	0.91
Transfer from (to) government ^a				
1985	US\$	(535)	0	940
1986	US\$	(337)	0	901
1987	US\$	(242)	0	903
Japanese sugar imports				
1985	Mt	1.97	2.10	2.56
1986	Mt	1.90	2.09	2.65
1987	Mt	1.84	2.11	2.36
World price ^a				
1985	USc/lb	5.08	5.12	5.26
1986	USc/lb	6.99	7.12	7.57
1987	USc/lb	7.26	7.48	7.84

^a 1984 dollars; 1985 exchange rates.

The estimated effects of such a tariff on economic variables, compared with the current policy situation, are presented in table 7, and the consequences for income transfers in table 8. This policy option would increase Japanese consumption, imports and hence the world price. Japanese consumers, the Japanese economy generally and sugar exporting countries would all benefit.

The burden of the current policy would be removed from Japanese consumers directly if they were allowed to pay the world price for sugar. Production could be subsidised completely by government so as to maintain it at current levels. The effects of this 'partial free trade' solution on key variables are also presented in table 7. The free trade world price would induce a marked increase in sugar consumption (partly by substitution from corn syrup)

and hence in imports. The lower cost of sugar would allow consumers to increase their demand for other goods as well. The annual average benefit to Japanese consumers would have been US\$1700m for the three years 1985 to 1987. Offsetting these gains would be the costs to the Japanese economy and taxpayers of raising the money for producer subsidies. The 1987 world price would have been higher by 8 per cent. The benefit to the world's sugar exporters would have averaged US\$950m in each year. (Note that Japanese sugar production is held constant.)

In the long run, the mean world price under this policy alternative is estimated to be US19.20c/lb, which is US0.77c/lb higher than the projected mean world price under current policy. This price change is 90 per cent of the change in the world price that

8 Effects of policy alternatives on income transfers ^a

Transfer	1985	1986	1987
	US\$m b	US\$m b	S\$m b
To Japanese sugar producers	0 0	0 0	0 0
From (to) corn syrup producers	40 255	6 232	(10) 253
From Japanese government	0 940	0 901	0 903
To (from) Japanese consumers	268 1 945	35 1 646	(61) 1 562
To producers elsewhere	75 361	278 1 216	483 1 285
From consumers elsewhere	75 360	286 1 250	480 1 275
World deadweight gains	4 113	1 129	2 90

^a Relative to situation under current policy (table 4). The first row of figures for each group is for a self-financing *ad valorem* tariff, and the second row is for world-level consumer prices with producer subsidies. ^b 1984 dollars; 1985 exchange rate.

could be achieved by complete free trade with Japan.

A similar option (again allowing Japanese sweetener consumers to pay the world price) would be for Japanese farmers to be given direct income support payments in place of the complex system of unit price supports which now operates. Under this option, the Japanese economy would gain (areas *c* and *e* in figure I), and world exporters would also gain (areas *f*, *j*, *h* in figure I). Again, there would be a cost to the economy in raising the funds for the income support. In this case, however, the budgetary costs of income transfers might be reduced, and perhaps eventually eliminated, if support for sugar producers were gradually reduced, encouraging growers to switch into alternative products. The full benefits of free trade would then accrue to the Japanese and world economies.

The costs of this reduction in support would be largely borne by sugar producers in several small regions, and the welfare of these regions might be adversely affected, at least in the short term. If the welfare of these regions is the major concern of policy

makers these regions could receive alternative forms of support. Assistance could be targeted directly to the development of efficient industries — that is, those industries in which Japan has a comparative advantage. Government programs could also be used to develop land for alternative uses. As has been pointed out by BAE (1987), because of rising living standards in Japan there are valuable alternative uses for land. Direct government support aimed at developing alternative land uses and industries may be a much more efficient way of delivering support to a region than the manipulation of prices, since the costly side effects could be less.

6. Conclusions

The complex Japanese sweetener policies have been only partially successful in achieving their goals. Though sugar prices have been raised and stabilised, sugar growers' incomes have been eroded by cost increases induced by these high prices. Self-sufficiency in food for Japan has probably been increased to some extent by the policy, although sugar imports have been limited only at the expense of reduced self-sufficiency in corn.

The current set of instruments, in addition to being inadequate for fully attaining the goals of policy, impose costs and efficiency losses on Japan and the rest of the world. This would be true no matter which policy instruments were used to achieve the stated aims. However, by a suitable choice of policy instruments it would be possible to minimise the costs imposed on Japan and other countries. At present, for every dollar transferred to Japanese sugar producers, Japanese sweetener policies are estimated to cost Japanese consumers about US\$2.27, sugar producers in other countries some US\$2.50 or more, and the Japanese and world economies around US\$0.25.

These costs are probably underestimates, because the adverse effects of import restrictions and high levels of protection on the growth of other sectors of the economy have not been fully accounted for; neither have the costs of administering such a complex system been included. Moreover, the gains to producers have probably been overstated in this study because, under high levels of support, land and other input costs tend to increase, and this effect was neglected; also, the economic costs of lobbying to retain subsidies and other protective measures can be considerable.

Reducing consumer prices and making them more responsive to world prices would confer major benefits on Japanese consumers and exporting nations without

hurting Japanese sugar producers. Such a move would require the replacement of the current subsidy per unit produced with direct income support. This would ensure farmer and regional security without providing unintended benefits to large companies such as corn syrup manufacturers and refiners. Although there would still be some costs to the Japanese economy and taxpayers in raising this revenue, these costs could be less than those of the present system.

Moreover, assistance granted in the form of income support could be targeted so as to shift resources out of the sugar industry, where Japan is clearly uncompetitive internationally, into industries in which Japan has a comparative advantage. At the very least, income supports in place of price supports would make farmers more responsive to changes in world price and thereby give them incentives to adjust to the world market. One effect would be to reduce the instability in world prices. Over time, income supports could be adjusted downward and Japan could move toward a completely free trade policy which would confer further benefits to the Japanese economy and to sugar exporting countries.

Appendix Model specification and estimation

The model is an annual model of the sweetener market in Japan and the sugar market in the rest of the world. It consists of four sectors — Japanese sweetener demand, Japanese sweetener supply, the Japanese sweetener price fixing sector and the 'rest of the world' sugar sector.

Following presentation of the model, its derivation is explained, sector by sector. Estimation results are then given. The model was validated by simulation.

A.1 The model

'Rest of the world' sugar sector

Production:

$$(A1) \quad Q_{wt} = Q_{wt-1} + \exp(a_1 \Delta P_{wt-2}) + a_2 \Delta S_{wt-3} + a_3 S_{wt-1} + a_4 S_{wt-2} + a_5 P_{wt-4} + a_6 P_{wt-5} + a_7 P_{wt-7} + a_8 CD_t + a_9 CD_{t-2} + \epsilon_{1t};$$

Consumption:

$$(A2) \quad C_{wt} = b_1 + b_2 Y_{wt-2} + b_3 P_{wt} + b_4 P_{wt-1} + \epsilon_{2t};$$

Stocks demand:

$$(A3) \quad S_{wt} = c_1 C_{wt} \frac{S_{wt-1}}{C_{wt-1}} + c_2 C_{wt}(P_{wt})^{c_3} - c_1 c_2 C_{wt}(P_{wt-1})^{c_3} - c_4 C_{wt} Q_{wt} - c_5 CD_t + \epsilon_{3t};$$

Market clearing:

$$(A4) \quad S_{wt-1} + Q_{wt} = C_{wt} + S_{wt} + M_{jt};$$

where Q is sugar production (Mt); C is sugar consumption (Mt); S is sugar stocks (Mt); Y is real income (index); P is real price of sugar (US\$/lb); M_j is Japanese imports (Mt); CD is a zero/one dummy for Cuban sugar production (a weather

proxy); Δ is change from previous year; ϵ is the residual; 'rest of the world' is denoted by w and the year by t .

Japanese demand sector

Caloric sweetener demand:

$$(A5) \quad \frac{CC_{jt}}{N_{jt}} = e_1 + e_2 \frac{(Y_{jt-1})^{e_3}}{N_{jt-1}} + e_4 P_{jt} + \epsilon_{4t};$$

High fructose corn syrup demand:

$$(A6) \quad \frac{CH_{jt}}{N_{jt}} = d_1 + d_2 T + d_3 PH_{jt-2} + d_4 P_{jt-2} + \epsilon_{5t};$$

Sugar demand:

$$(A7) \quad C_{jt} = CC_{jt} - CH_{jt};$$

Stocks demand for sugar:

$$(A8) \quad \frac{S_{jt}}{C_{jt}} = f_1 + f_2 \frac{S_{jt-1}}{C_{jt-1}} + f_3 P_{jt} + f_4 \Delta C_{jt} + f_5 D_{73} + \epsilon_{6t};$$

where N is population (millions); Y is real income (¥10¹²); CC is consumption of caloric sweetener (Mt); CH is consumption of high fructose corn syrup (Mt); PH is real price of high fructose corn syrup (¥/kg); T is the year (1953 = 1); D_{73} is a dummy variable with values 1 in 1973 and 0 in all other years, to account for a one-off fall in stocks; and j denotes Japan.

Japanese sweetener supply sector

Sugar production:

$$(A9) \quad Q_{jt} = h_1 + h_2 PP_{jt-1} + h_3 PP_{jt-2} + h_4 PP_{jt-3} + \epsilon_{7t};$$

Sugar imports:

$$(A10) \quad M_{jt} = C_{jt} + S_{jt} - S_{jt-1} - Q_{jt};$$

High fructose corn syrup production:

$$(A11) \quad QH_{jt} = CH_{jt};$$

where PP is the real minimum producer price for beet (set by government in nominal terms: ¥/kg beet); QH is production of high fructose corn syrup (Mt); and equations (A10) and (A11) are identities.

Japanese price fixing sector

Consumer price of refined sugar:

$$(A12) \quad P_{jt} = m_1 + m_2 P_{wt} + m_3 P_{wt-1} \\ + m_4 P_{wt-2} + m_5 P_{wt-3} \\ + m_6 PT_{jt} + m_7 PS_{jt} + \epsilon_{8t};$$

Minimum stabilisation price:

$$(A13) \quad PS_{jt} = l_1 PS_{jt-1} + l_2 P_{wt-1} + l_3 P_{wt-2} \\ + \epsilon_{9t};$$

Target price:

$$(A14) \quad PT_{jt} = i_1 PP_{jt} + i_2 P_{jt-1} \\ + i_3 P_{wt-1} + i_4 P_{wt-2} + \epsilon_{10t};$$

Minimum producer price:

$$(A15) \quad PP_{jt} = j_1 PP_{jt-1} + \epsilon_{11t};$$

Price of high fructose corn syrup:

$$(A16) \quad PH_{jt} = k_1 + k_2 P_{jt} + k_3 T + \epsilon_{12t};$$

where PS is the real minimum stabilisation price for sugar (¥/kg) and PT is the real target price for sugar (¥/kg).

A.2 Model derivation

Below, the reasoning underlying each of the four model sectors is given in turn.

'Rest of the world' sector

The model for this sector is based on the model of the world sugar market devised and validated by Sturgiss, Wong and Borrell (1987). It therefore has these features:

- Production is asymmetric: world production rises as world price rises, but

does not decrease with a decrease in world price.

- The dependence of stocks demand on price is nonlinear.

Production

World production is asymmetric in its response to world price because of both the nature of government intervention and asset fixity in production. Intervention occurs in most domestic sugar markets around the world, using a number of instruments including import controls, production controls, stocking mechanisms and price fixing. Intervention in production is not symmetric in its response to changes in world price. When the world price increases, governments are quick to allow the benefits of higher prices to flow through to producers. When world price falls, governments tend to maintain intervention and support levels to producers, for welfare and/or political reasons. Thus, producers do not reduce production when world price falls because they do not receive any market signals to do so. The second reason for production asymmetry is that most of the fixed assets used in sugar production are specialised, and are therefore more difficult to take out of use than to bring on stream.

This behaviour is represented by modelling changes in production as an exponential function of changes in lagged world price. This lag is due to delays in policy action. Policy makers also respond to stock levels, because stocks can impose a large budgetary cost. Production is affected also by absolute price with a lag of several years, because annual yields of cane plants follow a distinct pattern over the life of the plant.

These yield and policy influences operate at a national level, and will vary between countries due to differences in cane/beet mixes, farming practices, political forces and budgetary abilities to support producers. Thus, the lag and degree of response for each country will be different. Following a price boom, domestic policy action and cane yield will at first tend to be synchronised around the world. Over time, the differing responses of individual countries will blur the

aggregate response. Thus the parameters do not have an exact interpretation at the individual country level. For instance, the absence of a significant relation between aggregate production and world price lagged six years does not mean that all countries' responses at this interval are insignificant — only that the combination of their different responses at that interval is insignificant on the global scale.

In a small model such as this, it is possible that some systematic influence has not been accounted for. In this case, an initial systematic error in the residuals of the production equation was found to be attributable to weather. A zero/one weather dummy variable (CD) was constructed using sugar production in Cuba (the world's largest sugar exporter, and the centre of a large sugar cane producing region of the world). In years when there was a significant drop in Cuban production, adverse weather conditions were assumed to prevail and the dummy was set to one. This dummy weather variable was also found significant when lagged two periods. Agronomic features of sugar cane production accentuate the effect of climate over successive periods, linking yield to climatic conditions in the past. Thus, in the second year after a climatic disaster, and hence one year after replanting, the high yields of the cane plant cause a large increase in production (that is, $a_9 > 0$).

Consumption

Consumption is modelled as a function of income and world price. Consumers are assumed to maximise utility over their lifetime, or at least over an extended period. Thus current consumption decisions are influenced by past, current and anticipated income levels. The model was therefore estimated using current and lagged values of income. Strong second-order autocorrelation was found when the model was tested using current and one-year lagged income levels, indicating a misspecification. Also strong multicollinearity arose when several lags were used, resulting in insignificant coefficients. Income with a two-year lag was chosen to correct these problems. The

lag on world price reflects the delay caused by policy makers in passing on world prices to consumers.

Demand

The stock demand equation has the following features.

First, the desired stock level is a nonlinear function of world price. When stock levels are low the value of stocks is very high; their value falls rapidly as stock levels increase and security of supply is established. At high stock levels, when security of supply is well established, an increase in stocks has little effect on their value since this is already low. This relationship can be represented by the following nonlinear expression:

$$S^*_t = c_2 (P_{wt})^{c_3}$$

where S^* is desired stock level, P is world price, $c_2 > 0$ and $c_3 < 0$.

Second, there is a short run stock adjustment mechanism whereby stocks are used by policy makers to achieve domestic price targets and for smoothing price and trade flows in the face of production variability. This characteristic of stock demand can be modelled as follows:

$$S^*_t - S_t = c_1 (S^*_{t-1} - S_{t-1}) + c_4 Q_t + c_5 CD_t$$

where S is actual stocks, Q is production and CD is the Cuba dummy.

That is, stocks held by policy makers will depend on the stocks they held in the previous year and on production. Substitution of the equation for desired stocks into this equation gives an equation suitable for estimating.

Third, the stocks variable is standardised as the stocks-to-consumption ratio to remove heteroskedasticity. The equation is multiplied through by consumption before estimation.

Japanese demand sector

The Japanese demand sector is modelled using three estimated equations and an identity. The estimated equations are for consumption per person of caloric sweetener and of high fructose corn syrup, and demand for sugar stocks.

Consumption demand

High fructose corn syrup and sugar are very close substitutes in many uses, and for many consumers may be considered identical. Aggregate demand for the homogeneous good 'caloric sweetener' is determined by income, population and price. The sweetener price is proxied by the sugar price, since the corn syrup and sugar prices are highly correlated. Sweetener consumption per person is modelled as a nonlinear function of income, because at higher income levels an increase in income causes a smaller increase in consumption as saturation levels are approached.

The choice between sugar and corn syrup sweetener is made by intermediate demanders, such as manufacturers of soft drinks, and is determined mainly by relative prices of fructose and sugar. Because the corn syrup price is consistently below the sugar price, corn syrup consumption has tended to increase. However, the full potential of the corn syrup market has not been immediately fulfilled due to slow market acceptance and the time taken for manufacturers to switch technologies. Thus, the corn syrup demand curve is shifting to the right through time as the substitution for sugar occurs. It is therefore modelled as a function of time as well as price. Sugar consumption becomes the residual of sweetener demand.

To model corn syrup consumption as a function of income would be misleading since the income variable would capture the time trend, giving a gross overestimate of the income elasticity of corn syrup demand. In fact, when both income and time were included in the equation, serious multicollinearity occurred.

Stocks demand

Japanese sugar stocks demand was assumed to adjust gradually to changes in the domestic price. This implies a partial adjustment mechanism:

$$S_t - S_{t-1} = \alpha(S_t^* - S_{t-1})$$

where S_t is actual stocks and S_t^* is desired stocks, and the latter is a function of price:

$$S_t^* = \beta P_t.$$

(A nonlinear expression, as used in the 'rest of the world' sector, was in this case found inferior to the linear relation.)

Hence:

$$S_t = \alpha\beta P_t + (1 - \alpha)S_{t-1}.$$

Stocks were again standardised to remove heteroskedasticity, using the stocks-to-consumption ratio.

A term was also included for change in consumption. Though consumption per person has generally increased over time, there have been a few periods when it has markedly decreased: for example, in 1975, when world price was very high due to a general shortage of sugar, and in 1978 when corn syrup consumption first affected sugar consumption. These changes were unexpected, and because production is inflexible in the short term and refiners had entered into contracts with importers, the initial adjustment to the consumption decreases took the form of increased stocks.

The dummy variable represents the sudden fall in stocks in 1973, when Cuba, Japan's major supplier at that time, could not fulfil contracts due to two successive crop failures. Because this was also a time of general shortage, the gap could not be filled by other exporters.

Japanese supply sector

Virtually all the cane and beet grown is milled, and production therefore responds to the price that growers receive rather than that millers receive. It was assumed that production of sugar depends upon the minimum producer price, which processors must pay beet growers. The beet minimum price was used because sugar beet competes with other crops to be planted, whereas cane is unresponsive to price, being a monoculture in the areas where it is grown and being constrained by land availability.

The lags on the beet price were introduced because a change in price may take several years to induce changes in production. First, a high price may need to be sustained to convince farmers that they

are justified in investing in the capital required to grow beet rather than other crops. Second, delays are unavoidable because beet is grown in rotation with other crops. (Prices of alternative crops proved to be statistically insignificant, however.)

Supply of high fructose corn syrup is assumed to adjust to demand to give equilibrium. Corn syrup demand does not adjust to a market imbalance since, as described above, it responds with a lag to its price, which itself does not adjust but is determined by an outside factor — the domestic consumer sugar price (see following subsection). No stocks are held. Thus, for equilibrium, it is corn syrup supply that must adjust to satisfy demand. The price and demand equations therefore fully describe the corn syrup market.

Japanese price fixing sector

There is a degree of joint determination among:

- the consumer price for refined sugar;
- the target price for imported raw sugar; and
- the minimum stabilisation price for imported raw sugar.

The target price and minimum stabilisation price help to determine the levies and surcharges which influence the consumer sugar price. They can be adjusted by the government in response to changes in the consumer price away from its targeted level.

The consumer price is reasonably stable, as is shown by the fact that the constant is the best determined coefficient in equation (A12). The coefficients on the lagged world price represent the response of policy makers to changes in world market conditions. The lags and the small size of the coefficients show the degree of insulation provided from the world market.

The minimum stabilisation price is simply a response to the trend in world prices, and is therefore modelled as a function of past values of itself and world prices.

The basis for the equation for the minimum producer price for beet was the

stated Japanese formula for determining the (nominal) minimum producer price:

$$PN_t = PN_{t-1} \cdot \frac{I_t}{I_{t-1}}$$

where I_t is the agricultural parity index (see section 2.2), which measures changes in rural prices and in incomes of other groups in Japan. After the minimum producer price has been deflated, the coefficient on lagged minimum producer price therefore accounts for that part of the parity index which measures growth in income of non-farming groups.

The main determinant of the corn syrup price has been the sugar price. The strategy of syrup producers has been to undercut the sugar price by a small margin; this margin has been gradually increasing. This decline in price may reflect large initial costs of establishing a new product, and growing competitiveness of the market structure. It is captured by the time trend.

A.3 Model estimation

The sources for the data used were Licht (1987a), Mitsui (1985), MAFF (1985), International Sugar Organisation (1986) and International Monetary Fund (1986). All Japanese price and income variables were deflated by the Japanese wholesale price deflator and are in 1984 yen. Prices and incomes in the 'rest of the world' sector are in 1984 dollars. The Japanese equations were estimated over calendar years. The 'rest of the world' equations were estimated using crop years (September–August) as is done by Sturgiss et al. (1987) and Borrell et al. (1987).

Crop year data were used in estimation of the 'rest of the world' sector because, in this case, calendar year data covering the estimation period conceal certain underlying economic relationships. Using crop year data, the production surge that follows a price peak does so with a two-year lag. Using calendar year data, production surges come one year after the 1963 price peak, three years after the 1974 price peak and two years after the 1980 price peak.

Two possible explanations may be advanced: that the relationship between the price peak and production surge is continually changing, or that summing data from January to December creates an artefact. The latter appears true. The production surge may take between 18

months and 30 months, depending on the timing of the price jump within a year and thus on how soon after the price jump planting is done. The average time of response is two years. Use of the calendar year gives this result, and thus minimises a possible error in estimation.

9 Parameter estimates for the 'rest of the world' sector ^a

Equation	Coefficient	Estimate	<i>t</i> statistic	Q statistic	SSR
(A1)	a_1	0.075	5.9	11.63	55.6
	a_2	-0.182	-1.4		
	a_3	-0.500	-3.5		
	a_4	0.438	2.6		
	a_5	0.122	3.2		
	a_6	-0.107	-2.7		
	a_7	0.121	3.2		
	a_8	-2.447	-2.4		
	a_9	2.689	2.7		
(A2)	b_1	24.842	21.5	7.27	17.48
	b_2	0.679	47.3		
	b_3	-0.045	-1.9		
	b_4	-0.078	-4.0		
(A3)	c_1	0.565	4.2	6.77	28.4
	c_2	0.933	2.8		
	c_3	-0.980	-3.8		
	c_4	-0.0013	-3.0		
	c_5	1.550	2.9		

^a FIML, 1966-84; $\chi^2_{2,0.95} = 21.03$.

10 Parameter estimates for Japanese demand sector

Equation	Coefficient	Estimate	<i>t</i> statistic	Q statistic	SSR
(A5) ^a	e_1	0.045	5.2	10.91	4.49×10^{-5}
	e_2	-0.019	-2.1		
	e_3	-0.706	-1.9		
	e_4	-1.276×10^{-5}	-1.4		
(A8) ^a	f_1	0.247	3.1	7.85	0.020
	f_2	0.298	1.7		
	f_3	-0.443×10^{-3}	-1.9		
	f_4	-0.090	-2.6		
	f_5	-0.096	-3.0		
(A6) ^b	d_1	-0.015	-3.3	6.09	1.09×10^{-6} $\bar{R}^2 = 0.97$
	d_2	7.28×10^{-4}	6.9		
	d_3	-2.96×10^{-5}	-2.7		
	d_4	2.12×10^{-5}	2.5		

^a FIML, 1963-85; $\chi^2_{2,0.95} = 21.03$. ^b OLS, 1976-85; $\chi^2_{6,0.95} = 16.92$.

The 'rest of the world' sector was estimated using full information maximum likelihood (FIML) techniques for the period 1966–84.

For the Japanese demand sector, equations (A5) and (A8) were estimated simultaneously using FIML for the period 1963–85. Corn syrup consumption was estimated separately because of the small number of observations. Production of sugar was estimated using ordinary least squares (OLS) over the period 1966–85. Imports are given by the residual between Japanese supply and demand. In the price sector, because of the simultaneity existing

between equations (A12), (A13) and (A14), these equations were estimated over the same period (1967–85) using FIML.

Equation (A15) was estimated by OLS, also over the period 1967–85. The price of corn syrup was estimated over the period 1976–85 using OLS (the number of observations being restricted by the absence of quoted prices before this time).

The parameter estimates for the specified equations are presented in the accompanying tables along with Ljung–Box *Q* statistics and sum of squared residuals.

Responsiveness to important variables in the Japanese market can be measured

11 Parameter estimates for Japanese supply sector

Equation	Coefficient	Estimate	<i>t</i> statistic	<i>Q</i> statistic	SSR
(A9) a	h_1	-0.337	-4.0		0.022 $\bar{R}^2 = 0.91$
	h_2	0.031	4.9	15.52	
	h_3	0.017	2.1		
	h_4	0.013	2.0		

a OLS, 1966–85; $\chi^2_{2,0.95} = 21.03$.

12 Parameter estimates for Japanese price fixing sector

Equation	Coefficient	Estimate	<i>t</i> statistic	<i>Q</i> statistic	SSR
(A12) a	m_1	187	13.4		1 010
	m_2	0.206	5.0		
	m_3	0.163	4.6		
	m_4	-0.222	-5.1	9.28	
	m_5	-0.058	-1.4		
	m_6	-0.326	-4.4		
	m_7	1.252	3.8		
(A13) a	l_1	0.717	18.6		1 549
	l_2	0.092	5.1	7.23	
	l_3	0.064	2.8		
(A14) a	i_1	12.03	18.3		743
	i_2	-0.506	-8.2		
	i_3	0.103	3.1	10.82	
	i_4	0.190	6.0		
(A15) b	j_1	1.012	45.5	8.89	49.5 $\bar{R}^2 = 0.99$
(A16) c	k_1	157	1.8		1 612 $\bar{R}^2 = 0.89$
	k_2	0.58	3.4	14.77	
	k_3	-4.34	-2.2		

a FIML, 1967–85; $\chi^2_{2,0.95} = 21.03$. b OLS, 1966–85; $\chi^2_{2,0.95} = 21.03$. c OLS, 1976–85; $\chi^2_{1,0.95} = 19.68$.

from the estimated coefficients. Japanese sweetener consumption is much less income elastic than sugar consumption in the rest of the world. In 1985, the long run income elasticity of Japanese sweetener consumption was +0.23, whereas that of sugar in the rest of the world was +0.74. This both reflects Japanese dietary preferences and suggests that Japan is approaching its saturation levels of sweetener consumption. The elasticity of consumption with respect to the Japanese consumer price is quite low — in the region of -0.08 — but appears to be in line with other countries. With respect to the world sugar price, the rest of the world's short run elasticity of sugar consumption is

-1.9×10^{-3} and that of Japanese sweetener consumption is indistinguishable from this, with a point value of -1.8×10^{-3} . The latter figure combines two effects — the responsiveness of consumption to domestic price, and the responsiveness of domestic price to world price.

Though the response of sweetener consumption to changes in price is small, that of corn syrup consumption to relative price changes between sugar and fructose is much greater. The long run elasticity of corn syrup consumption with respect to its own price is -0.49, and that with respect to the sugar price is +0.51. This reflects the very close substitutability between high fructose corn syrup and sugar.

13 Within-sample simulation estimates of key variables

Variable and calendar year	Historical	Simulated
	Mt	Mt
Japanese sugar consumption		
1984	2.75	2.91
1985	2.89	2.89
Japanese sugar production		
1984	0.88	0.86
1985	0.93	0.88
Japanese sugar imports		
1984	1.90	2.06
1985	1.98	2.05
Japanese sugar stocks		
1984	0.65	0.63
1985	0.67	0.67

A.4 Model validation

In each equation, according to the Ljung-Box *Q* test, the hypothesis of no serial correlation cannot be rejected at the 95 per cent level of significance. The coefficients required in each equation by the considerations set out in section A.2 are all significant at the 95 per cent confidence level, according to the *t* test, except a_2 in equation (A1) and e_4 in equation (A5).

The diagnostic statistics presented in tables 9-12 indicate that the model has good within-sample performance. This is corroborated by the simulation results shown in table 13. A further test of the model is to investigate its out-of-sample performance.

As can be seen from table 14, both the forecast from 1984 data and the one-year-ahead forecasts track the historical price

14 Out-of-sample simulation estimates of world price

Year	Historical USc/lb	Simulated		
		One year ahead USc/lb	From 1984 USc/lb	From 1985 USc/lb
1984	5.20	5.25	5.25	
1985	3.90	5.08	5.19	5.08
1986	5.77	4.48	7.13	6.99
1987	6.16	5.06	7.43	7.26

well enough to replicate the turning point in 1985. The errors associated with the forecasts for that year are attributable to unusually favourable growing conditions, causing production to be higher — and thus prices lower — than expected. The forecasts are for normal seasons.

Theil's U_2 statistic was calculated to be 0.83 for the forecast from 1985 to 1987 and 0.77 for the one-year-ahead forecasts of 1985 and 1986. This was in a time of relative market stability when naive

forecasts would work quite well. In other periods naive forecasts would have very large errors because of the volatile nature of the market.

From tables 13 and 14 it can be concluded that the model is capable of generating reasonable forecasts for important variables of the Japanese and world markets. The model should therefore be able to give reasonable estimates of the effects of policy on these two markets.

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