INDUSTRIAL PROCESSING OF CEREALS IN AUSTRALIA

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1. Introduction

The principal use of wheat produced in Australia is as food for human consumption, with the greater part of this consumption occurring in export markets (74% of Australia's wheat production was exported 1980-81 to 1984-85, although not all for human consumption). There is also a relatively small, but thriving, "industrial wheat" industry which processes wheat into a wide variety of products some of which are consumer goods but of which the greater proportion is used in further industrial processes.

In this paper are noted the principal industrial uses of wheat (Section 2) and the disposition of world cereal production into industrial uses (Section 3). Economic characteristics of the Australian industrial cereals processing industry are described in Section 4, and exports and imports of industrial wheat products in Section 5. In Section 6 are discussed aspects of the Australian and international industrial cereals markets in the context of the current review of wheat marketing arrangements by the Industries Assistance Commission.

There has been recent rapid growth of industrial wheat processing in the European Community (EC) - which appears to result from surpluses generated by price policies under the Common Agricultural Policy - and emerging starch processing industries in the Third World. These developments may begin to create pressures for change in the established industrial cereals processing industries. These developing pressures may require re-assessment of policies affecting cereals growing and processing industries.

2. Industrial Uses of Cereal Grains

Maize dominates the industrial processing of cereal grains in western industrialised countries (cf. Section 3). In North America, the production of wheat starch is essentially a by-product of gluten manufacture (Knight and Olson 1984). The principal use of gluten is in food manufacture. The principal use of wheat starch in the U.S. is in paper manufacture (Moore and Majors 1973; Carlson and Mullen 1973; Knight and Olson 1984). In countries where maize is not a major starch source (e.g. Australia), uses of wheat starch parallel those of maize starch in other countries (Carlson and Mullen 1973; also Knight and Olson 1982). Uses of wheat starch include paper and paperboard manufacture, textile manufacture, pastes, adhesives, dextrin manufacture, pharmaceuticals and cosmetics, building materials, binding (e.g. castings, briquettes) and food uses (thickeners, fillers, colouring).

2.1 Gluten

Because the protein fraction of wheat has traditionally been the more highly valued product of the industrial processing of wheat, gluten is conventionally produced by dry-milling processes (i.e. produced from flour) to preserve the properties of the gluten (cf. the wet milling of whole maize grain) - e.g. Hunwick (1980, p.463). Hunwick gave details of wet and dry fractionation of wheat, as did Fellers (1973) and Knight and Olson (1984).

Simmonds and Orth (1973, p.82) noted that the cost of cereal protein manufacture reserves its use for food manufacture and higher-priced specialty items. These authors reviewed the chemistry of cereal proteins and noted several possible future developments. Gras and Simmonds (1980) noted that the main human food use of gluten is in baked products; other uses include meat extenders and emulsion stabilizers (see also LeGrys, Booth and Al-Baghdadi 1981, pp. 243-244). Gluten proteins have been claimed to be the key to the behaviour of wheat flour (LeGrys et al 1981, p. 245), but it has also been argued that the starch itself has "a profound affect (sic) on the structure of bread, and other baked goods" (Angold 1975, p. 154). Textured protein products based on vegetable products have been a recent area of considerable interest, including the use of wheat gluten. Gluten has also been widely used as a meat extender or substitute in pet foods. Industry sources report that the demand for gluten in the U.S. might be substantially increased if farinaceous products, (e.g. gluten) were permitted in smallgoods manufacture (cf. Sosland 1986, p. 15).

2.2 Starch

In a major review of the industrial uses of maize starch, Russell (1973) listed its major uses as being as sizing agents and adhesives in making and coating paper, and paperboard; sizes in textile manufacture; and as adhesives in producing boxboard, insulation board, paper bags, cardboard cartons, and gummed labels and tapes (see also Young 1984; Rutenberg and Solarek 1984; Watson 1984; Rohwer and Klem 1984; Mentzer 1984; Moore et al. 1984; Kennedy and Fisher 1984); Mitch (1984) discussed the particular uses of potato starch, and Juliano (1984) noted particular uses of rice starch.

In paper making, starches are used in wet-end addition (starch-based adhesives to increase paper strength); surface sizing (to improve the writing and printing characteristics of paper and paperboard); and papercoating (starch-based adhesives used to hold pigments to improve printability appearance, and brightness and to increase opacity). The principal starch-based products used in wet-end addition are unmodified starch and cationic starches; other starch-based additives include hydroxyethyl starch, lightly oxidized starch, and dialdehyde starch. Principal starches used in surface sizing are enzyme-converted starch, jet-cooked starch, oxidized starch, and hydroxyethylated starches. Coating adhesives include enzyme converted starch, oxidized starch, dextrins, hydroxyethylated starches and starch acetates.

Starch-based adhesives are used in the manufacture of corrugated boxboard, paper bags, folding cartons, laminated paperboard, spiral-wound tubes, for coating paper after (as opposed to during) manufacture, and for gummed labels and tapes. Products used include unmodified starch, dextrins, hydroxyethylated starches, oxidized starch, waxy maize starch, acid modified starch, and starch acetates.

The principal use of starch products in textile manufacture is as a warp size to strengthen warp yarns and to improve their resistance to abrasion during weaving. Other uses include fabric finishing, printing, and glazing sewing thread. Starch use in printing has, in the last two decades, been largely replaced by resins. Modified and unmodified starches are used in textile finishing operations (modified prior to use). High amylose unmodified starches, and cationic and hydroxypropyl starch derivatives are used to size synthetic and glass fibres. Russell (1973, p.278) reported that starch use in the textile industry had been declining at a rate of 5-6% p.a. Russell also reported then-contemporary developments in new uses for starch. More detailed analysis of the physical properties of cereals and their products, particularly relating to starch components, may be found in Muller (1973), Medcalf (1973) and Angold (1975).

A major modern development in the use of maize starch has been the development of High Fructose Corn Syrup (Lloyd and Nelson 1984). By 1980, corn sweeteners comprised 32% of per capita U.S. consumption of all nutritive sweeteners, and High Fructose Corn Syrup comprised 15% of all nutritive sweeteners consumption (Cantor 1981). It was estimated that, by 1986, corn sweeteners would comprise 45% of U.S. consumption of nutritive sweeteners, and High Fructose Corn Syrup 28% (Niall and Smith 1983); it appears that this estimate was, in fact, too low (USDA 1986, p. 11).

Doane (1981) discussed the potential of starch as an industrial feedstock for producing low molecular weight chemicals conventionally derived from petroleum. The suggested route for the production of such chemicals was via the depolymerization of starch into glucose, and its subsequent conversion into a wide variety of industrial chemicals (polyols, aldehydes, ketones, acids, esters, ethers). One particular potential use was seen to be the production of starch-based polymers (e.g. biodegradable plastics). Other detail is provided in Daniel and Whistler (1981) and Otey and Doane (1984).

Finally, starch may be used as a substrate in biotechnology processes (Otey and Doane 1984). For example, Bunge Australia Ltd has recently floated a new company, Cirius Biotechnology Ltd, in which it has a reported 25% shareholding, to operate a commercial scale plant for the production of citric acid using starch-derived glucose (Ingram 1986a,c).

Particular uses to which wheat starches and their derivatives can be put were briefly noted in Gagen (1973) and Knight and Olson (1984). These uses, paralleling those of the corn starches, include the use of cationic starches and flours, cereal xanthates and xanthides, acid-modified wheat flours and derivatives, mechanically modified starches, and enzyme modified flour in paper manufacture; unmodified wheat starch, dextrins and thin-boiling acid-modified wheat starches in fabric and textile finishing; blends of British gums, wheat starch and starch ethers for dye paste preparation in fabric printing; modified wheat starches, flours and dextrins in box and carton sealing, envelope gums, paper bag seam sealing, paper container labelling and other paper-paper bonding; and modified starch adhesives in interior plywood manufacture. Uses of starch-based products reported by Australian industry in 1987 also include food uses (bulk fillers, colouring agents); wallboard; foundry casting adhesives; flocculants in mineral processing; and brickmaking.

3. World Industrial Cereals Processing

The major world usage of cereals in the late 1970s and early 1980s is shown by broad categories in Table 1. The principal uses of cereals are as livestock feed, or for human food and industrial use.

In the U.S.A., the percentage use of the two major cereal grains, maize and wheat, across use categories is shown in Table 2 for 1980. Domestic feed uses dominated maize use, with all domestic industrial uses comprising 9.3% of total production; food uses dominated wheat consumption, with industrial uses comprising 5.6% of production. In both the U.S.A. and the EC in the 1970s, the dominant cereal grain used in starch manufacture was maize (imported in the case of the EC) (Tables 3 and 4). For all types of starch in the U.S., starch use is dominated by the production of paper and paperboard (Table 3).

Because maize dominates industrial cereals processing, world gluten production is on a much smaller scale than starch production. Until the early 1970s, Australia and the U.S. were the world's major wheat starch producers (Carlson and Mullen 1973). By 1980, Western Europe had emerged as a major location for gluten production and, by 1985, its production was reported to have been approximately equal to the combined production of Australia and the U.S., with projected expansion reported as continuing on a major scale (Table 5).

The emergence of large surpluses of wheat in the EC as a consequence of the Common Agricultural Policy has undoubtedly been one element in the large increase in industrial wheat processing capacity in Western Europe.

4. Australian Industrial Cereals Processing

Because maize production in Australia is low, wheat is the dominant raw material for industrial processing of grains. As shown in Table 6, the dominant industrial use of wheat in Australia is in the production of starch and gluten. The use of flour of this purpose averaged approximately 20.4% of flour use for the period 1976-77 to 1984-85. Wheat sold by the Australian Wheat Board for flour production (including exports) averaged 9.0% of the estimated Australian production of wheat for the seasons 1976-77 to 1984-85. The mean average use of wheat for starch and gluten production as a proportion of wheat grain production in Australia (at 1.8%) is therefore substantially less than in the U.S.A. (5.6%).

The use of flour for starch and gluten production in Australia increased by an average of 3.6% p.a. in the period 1976-77 to 1984-85. The Australian production of gluten increased by an average of 4.6% p.a. in the period 1977-78 to 1985-86, and the production of starch (including non-wheat starch) increased by 2.4% p.a. in the period 1976-77 to 1985-86 (Table 6).

In his review of the international gluten industry, Sosland (1986) dealt with the Australian industry in some detail because of its role as a major producer and exporter. Some of Sosland's statements should however be treated cautiously, for example:

> In Australia, ... a strong vital wheat gluten industry has been nurtured by the government. Wheat is the major cereal in Australia and the primary source of needed starch for diverse Australian industrial applications. Here starch rather than gluten is the primary product, and it is the gluten for which outlets must be found. (Sosland 1986, p. 14).

There is little evidence that the Australian government has "nurtured" the gluten industry, although, since 1953, there has been special assistance for the <u>Tasmanian</u> wheat starch/gluten industry in the form of the Tasmanian Wheat Freight Subsidy (IAC 1987a, p.122). While wheat starch is used in "diverse" industrial applications in Australia, this use is claimed by industry to result from the urgent need to dispose of the otherwise low-valued starch. Knight and Olson (1984, p. 493) remarked that "Wheat starch manufacture is competitive with corn starch manufacture because of the high value of the co-product [<u>i.e.</u> joint product] gluten". Moreover, wheat starch use in Australia merely parallels that of maize starch used in the U.S. and Western Europe. Industry would also dispute the claim that "starch rather than gluten is the primary product" since gluten has readily-available markets, and considerable ingenuity has apparently been required to develop saleable products from the starch fraction of wheat. Finally, the claim that it is the gluten for which outlets must be found is simply a reflection of the fact that Australia is a low-cost producer of wheat and gluten, and therefore is highly competitive on world gluten markets. This last statement of Sosland's suggests a mercantilist attitude where trade is only considered as occurring because nations subsidize exports. This attitude is subsequently made explicit by Sosland (1986, pp. 14-15).

> Assisted by indirect subsidies for domestic cereal grains production ... the Australians are able to export gluten at prices that cannot be ignored by foreign buyers. ... Australia's exports successfully compete for markets at most U.S. ports and adjacent areas up to the point where rail freight charges finally equalize the Australian subsidy ...

The nature of the putative subsidy was not detailed. (Note that a subsidy for wheat <u>production</u> is not necessarily the same as a subsidy for wheat <u>processing</u>, especially when the processors pay maximum export prices for their wheat - cf. IAC, 1987a, p.25.) As argued below (Section 6.2), far from there being a subsidy on Australian gluten/starch production, it is more probable that there is a net tax on this industry.

Bureau of Industry Economics (1986, Table A.4) estimates of Total Factor Productivity suggest rates of Hicks-neutral technological change for the "Flour mill and cereal food products" industries as shown in Table 7. However, the substantial year to year variability in the implied estimates of technological change, the apparent lack of quality adjustment to workforce variables, the crude estimates for quality adjustment in investment price series, the lack of correction for quality change in outputs, and the implied measurement of total factor productivity on a value added basis (thus ignoring technological change embodied in intermediate outputs) suggests that considerable caution is required in accepting these estimates at face value.

Because starch and gluten production in Australia uses flour as the raw material, characteristics of both the flour and starch/gluten industries are discussed below. Flour milling in Australia is a quite highly concentrated industry which has become increasingly concentrated in the 1980s (Table 8.1). The number of "enterprise groups" fell from 52 in 1972-73 to 23 in 1984-85. The number of "establishments" fell from 83 to 48 over the same period, while the proportion of establishments controlled by the largest four enterprises (4-firm concentration ratio) rose from 0.20 to 0.48, and the corresponding 8-firm concentration ratio rose from 0.31 to 0.65. The 4-firm concentration ratios for turnover and value added rose more slowly than that for establishments in the 1970s and more rapidly in the early 1980s, while that for employment rose more rapidly in the 1970s and less rapidly in the 1980s, and the 4-firm concentration ratio for investment actually fell. The 8-firm concentration ratio for establishments rose by a (lower) similar proportion to the corresponding 4-firm ratio in the (1970s) early 1980s, indicating a (lower) similar accretion of establishments in the 5th-8th largest firms as in the four largest. However, 8-firm concentration ratios for turnover, value added, and employment grew much less rapidly, suggesting that the 5th-8th largest firms' market influence was growing much less rapidly than that of the top four firms. However, although the share of the four largest firms in gross fixed capital expenditure was 15 percentage points greater in 1977-78 than in 1982-83, the corresponding 8-firm concentration ratio was 7 percentage points less in 1977-78 than 1982-83. Since investment is a volatile variable, it is difficult to interpret this figure, particularly since deflated fixed capital expenditure fell by 25% over the same period. Unfortunately, 4-firm concentration ratios for most variables (including investment) were not available for 1984-85.

The starch, gluten and starch sugars industry is much more highly concentrated than flour milling (cf. Table 8.2). There were only six enterprise groups, having 12 establishments in 1977-78 and 10 in 1984-85. For confidentiality reasons, concentration ratios were not available except for establishments. The four largest firms controlled between 73% and 83% of establishments over the period 1977-78 to 1984-85. Over this period, deflated total turnover for these firms rose an average of 2.0% p.a., deflated value added fell 4.2% p.a., employment was approximately static, deflated wages rose 1.5% p.a. Deflated gross fixed capital expenditure was 25% lower in 1982-83 than 1977-78, but was 300% higher in 1984-85 (mirroring a similar pattern in the flour milling industry).

The only firms now engaged in industrial cereals processing are believed to be George Weston Foods Ltd; Goodman Fielder Industries Ltd (a recently merged group comprising the Goodman Group, Fielder Gillespie Davis and Allied Mills); Bunge Australia Ltd; and Manildra Flour Mills Pty. Ltd. The other two enterprise groups engaged in starch and gluten production in 1984-85, as shown in Table 8.2, are believed to have been Allied Mills (now merged into Goodman Fielder Industries Ltd) and Corn Products-Fielders, whose CPC (Corn Products Company) International Inc's majority interest has been bought by Goodman Fielder in exchange for the sale of Goodman Fielder's interest in Wheat Industries Ltd in Ireland to CPC Europe, a company in the CPC group (Ingram 1986b).

5. Trade in Starch, Gluten and Related Products

5.1 Exports

Australian exports of starch/inulin and gluten, are shown in Figure 1 (average unit values are shown in constant 1979-80 dollars). The volume of starch exports increased 162% in 1983-84 and a further 72% in 1984-85 accompanied modest falls in deflated average unit values (14% between 1982-83 and 1983-84, and a further 6% between 1983-84 and 1984-85). Starch export volumes fell 16% from 1984-85 to 1985-86, accompanied by a 17% increase in deflated average unit values. Between 1976-77 and 1982-83, deflated total export values for starch were approximately trendless; corresponding values for 1984-85 and 1985-86 were approximately 260% above the deflated total export value for 1982-83. With the single exception of South Africa, the principal destinations of starch exports are Pacific and Pacific Rim countries. New Zealand emerged as a dominant destination taking approximately 50% of starch exports in 1984-85 and 1985-86. It is understood that New Zealand starch (and gluten, see below) imports from Australia have risen because of the closure of a starch factory in New Zealand resulting from CER.

The volume of gluten exports trended upwards reasonably steadily over the period 1976-77 to 1985-86 at a mean rate of 4.6% p.a. Deflated average unit values for gluten exports have been more erratic, with a major rise in 1979-80 and a tendency to fall in most other years. The mean trend in the deflated average unit value for gluten was -2.2% p.a. in the period 1976-77 to 1985-86. The average trend in deflated total export value for gluten was therefore 1.7% p.a. over the same period. During 1976-77 to 1979-80, the U.S.A. was the dominant destination for Australian gluten exports, taking an average of 81% of total gluten exports by volume in this period. In later years the U.S.A., while still the dominant destination, has taken less of Australia's gluten exports.

Over the period 1980-81 to 1985-86, the U.S.A. took an average 67% of Australian gluten exports by volume. Japan and New Zealand have emerged as importers of significant volumes of Australian gluten, with moderate amounts also being imported by Taiwan, South Africa and the U.K. The consequences of rapid increases in gluten production in Western Europe are clearly seen in Australian export data; only the U.K. remained as a significant European importer of Australian gluten in 1985-86, with other European countries having ceased imports by 1983-84.

The downward trend in the deflated average value of gluten exports is probably the result of the major expansion of world industrial wheat processing capacity, principally in Western Europe, since 1980, and probably related to the emergence of the European Community as a major wheat exporter. It has been reported that the EC has attempted to offset, for industrial wheat processing, the high internal cost of grain under the CAP price regime by refunds on intra-EC wheat purchases (similar provisions also apply for maize). Additionally, imported starches and gluten are levied to raise their EC-landed prices at least to the level of EC-produced products (Wookey and Melvin 1981).

5.2 Imports

The major imports of starch, gluten and related products into Australia have been potato starch, other starches and dextrins. The import volumes and deflated average unit prices of these commodities are graphed in Figure 2. Of interest are the rapid increases in import volumes of potato and other starches. The deflated prices of potato starch trended downwards early in the sample period, and have been trendless thereafter; this price experience was accompanied by rapid increases in import volumes after 1979-80. The deflated prices of other starches were similarly approximately trendless over the sample period, with rapid increases in import volumes after 1978-79. The deflated prices of potato dextrins fell early in the sample period, and were thereafter approximately trendless with one high value in 1983-84; corresponding imports trended generally downwards over the period, with a peak import level in 1983-84 mirroring the price peak of the same year. The prices of other dextrins trended generally upwards over the sample period, with a marked peak in 1982-83 to 1983-84; import volumes rose rapidly 1979-80 to 1982-83 from a low base, and there was a marked peak import level in 1985-86.

Industry sources suggest that continued imports of potato starches and potato dextrins into Australia result from the failure so far to replicate the properties of these products in wheat starch products. Continuing research and development in Australian industrial wheat processing may result in the development of products which emulate the characteristics of these potato-based products.

Considerable Australian imports of starch from Thailand are reported to be based on manioc production. These imports appear to be the indirect result of actions of the EC. Imports of manioc (principally from Thailand) into the European Community for animal feed rose from 1.348 million tonnes in 1975 to 5.613 million tonnes in 1980; "voluntary" export controls were subsequently instituted by Thailand (e.g., Nelson 1983, Table 1 and pp. 44-46; Thai production of manioc continued to increase 1980-85 - see FAO Production Yearbook). The Thais have apparently turned to starch production as one alternative use of manioc. Industry sources report that CPC International Inc. has exported a de-commissioned U.S. starch plant to Thailand for the processing of manioc into starch. Some of this production appears to be now finding its way into Australia at constant real prices.

The EC's CAP has therefore begun to severely affect industrial wheat processing in Australia in two ways. Firstly, the reported rapid increase in industrial wheat processing in Western Europe, based on the massive cereal surpluses of the EC, has resulted in exported gluten which is depressing traded gluten prices. Secondly, the high prices for feed grain within the EC previously stimulated the growth of imports into the EC of carbohydrate substitutes such as manioc. Once these imports seriously interfered with intra-EC feed grain disposals, imports of these substitutes were (voluntarily) controlled. Now the producers of these carbohydrate products are seeking alternative markets, and are even able to import at competitive prices into Australia against domestic wheat starch production. Clearly, Australia's agricultural trade disputes with the EC are not simply confined to trade in bulk agricultural commodities.

The Australian starch and gluten industry appears to be fairly lightly protected against import competition. Tariff rates for starches (other than manioc) and gluten are low (Table 9). Rates for manioc starch are somewhat higher (10%, and 5% for developing countries including Thailand), as are rates for general starch-based products such as soluble or roasted starches, dextrins, and dextrin or starch glues (15%, or 10% for developing countries). As far as can be ascertained, there are no non-tariff barriers to the entry of gluten or starches (Australian Customs Service, 1988, pers. comm.).

It was noted in Section 4 that the Australian gluten/starch industry was highly concentrated. However gluten, starch and starch products enter Australia at relatively low tariff rates, and modest levels of starch imports are occurring accompanied by recent rapid growth rates in these imports. The opportunities for deleterious effects to result from concentration in this industry appear relatively small, as long as there are no additional restrictions on imports of these products into Australia.

6. Economic Considerations

6.1 Model of World Market for Gluten or Starch - Australian perspective

In Figure 3 is presented a standard partial equilibrium model of international trade in a single product, with the Australian market in part (a), the "rest of the world" in part (c) and the international trade market in part (b). Australia is assumed to be a net exporter of product, and the "rest of the world" a net importer. In the absence of trade, equilibrium in the Australian market, with supply and demand schedules S_A and D_A respectively, occurs at price P_A. This price is also the point of intersection of the excess supply schedule ES with the vertical axis in Figure 3(b); ES represents the horizontal distance between S_A and D_A above price P_A in Figure 3(a). In Figure 3(c), with supply and demand schedules S_R and D_R respectively, equilibrium in the "rest of the world" market would occur at price P_R in the absence of trade. With trade, price P_R represents the intersection of the excess demand curve ED with the vertical axis in Figure 3(b); E_D represents the horizontal distance between S_R and D_R below price P_R in Figure 3(c). The intersection of ED and ES in Figure 3(b) represents the world trade equilibrium at price P_W and quantity traded Q_W; where $Q_W = (Q_A - Q_D)$, the difference between Australian production and domestic consumption and $Q_W = (Q_R - Q_S)$, the difference between rest of the world consumption and production.

This model quite neatly captures the essential elements of the world market for gluten, where Australia is a major exporter (Australia exported an annual average of 22 000 tonnes of gluten 1980/81 to 1985/86, and imported an annual average of 15.5 tonnes over the same period).

A model of the starch market is somewhat more complex. Australia annually exported an average 3400 tonnes of starch in the period 1980/81 to 1985/86 with a major increase occurring in 1983/84 because of increased N.Z. imports of Australian starch. Over the same period, Australia imported an annual average of 1590 tonnes of potato starch (with an increasing trend), 2320 tonnes of other starches (with a major, sustained increase occurring in 1981/82), and an average of 690 tonnes of dextrins. In part, these imports reflect the particular properties of some starches and dextrins, particularly those derived from potatoes. Ignoring these specialized products comprising a market which is distinct from the general starch and starch products market in which wheat starch finds its place, Australia is a small net exporter of starch, and the model of Figure 3 may be held to approximately represent the non-specialized segment of the Australian starch market.

The model represented by Figure 3 may be used to illustrate recent major changes in the world gluten and starch markets.

1. Major increase in EC industrial wheat production capacity. The immediate result of the major increase in EC industrial wheat capacity is a shift in the "rest of the world" supply schedule for <u>gluten</u> from S_R to S_R^1 (Figure 4). The consequences of this shift for the gluten market are dependent on whether there has been an equivalent shift in the European demand for gluten (e.g. D_R to D^1_R). Sosland (1986) and USDA (1987) suggest that there has been a major increase in EC consumption of gluten, but USDA (1987) noted that, in 1986, EC gluten exports to the U.S.A. has "hit a record high of 2400 tons" and flagged the possibility that EC exports of gluten to the U.S. could "jump dramatically" in the long term. The implication is, therefore, that the increase in EC production capacity would shift the "rest of the world" supply schedule proportionally more than the demand schedule, thus contracting the excess demand schedule to ED^1 in Figure 4b, and lowering world prices (and thus optimal Australian production) of gluten.

   The impact of the increased EC industrial wheat processing capacity on the starch market depends on whether the new wheat processing plants are brand new facilities, or converted maize starch plants. The plants for starch/gluten separation are likely to be new, since this is a dry milling activity, whereas maize starch processing is generally a wet milling process. It is conceivable that the subsequent processing of wheat starch could occur in existing maize starch plants; it is not at present known whether, or to what extent, this is occurring. If wheat starch is simply being substituted for maize starch, there may be little effect on the world starch market. If, however, the new gluten processing capacity incorporates new starch processing facilities, there may be some reduction in the world excess demand for starch, and thus some reduction in world starch prices. However, the world starch market is so dominated by maize starch, that any effects of increased wheat starch production are likely to be small. However, in starch markets like Australia's which traditionally use wheat starch, any increased imports of EC wheat starch could have dramatic effects on prices (see below).

2. Diversion of feed manioc to starch production. A major diversion of developing country manioc production from feed use in developed countries to starch production could have a much greater effect on the world starch market than the increase in EC industrial wheat processing capacity because the potential world production of manioc is so large. In this case, the "rest of the world" could reverse from being a net importer of starch to a net exporter, and Australia simultaneously reverse from being a net exporter of non-speciality starches to a net importer of these starches. This scenario would be accompanied by a major fall in Australian domestic starch prices because of the limited world markets for wheat starch.

6.2 Level of Industrial Wheat Processing

The price of wheat for industrial processing has been set by the Australian Wheat Board (e.g., Wheat Marketing Act 1984, s.21). The level of industrial wheat processing is therefore a consequence of the optimal pricing strategy of the Board. In Figure 5 is depicted a model of how the Board, if acting as a monopolist seller of a given quantity of a particular grade of wheat for industrial use, would price wheat to domestic processors. Assuming a highly elastic export demand for Australian wheat of industrial grades (D_W in the right hand segment of Figure 5), the Wheat Board's revenue-maximizing strategy for the given quantity of wheat is to equate marginal revenues in the export and domestic markets. If P^* is the marginal revenue at which the Board's available wheat ($OX_D + OX_x$) is cleared, then OX_x will be sold for export at price P_W, and OX_D will be sold for domestic processing at price P_D. The greater the divergence between the elasticities of D_{IW} and D_W, the greater the divergence between the domestic and export prices of the same grade of industrial wheat for a given sales volume.

The price currently charged by the Wheat Board for industrial wheat is the "card" price (IAC 1987a, p.25). The card price is the Board's asking price for various grades of wheat and is reported to relate to prices in small volume, high price markets. Since the Board does not publish realised average export prices for corresponding grades, it is not possible to evaluate the extent to which the Board is an effective monopolist in the industrial wheat market. However, some assessment of the monopoly pricing issue is possible.

Firstly, if the card price for a particular wheat type is closely related to prices in small volume high priced markets then, by definition, the card price will be greater than the weighted average price for Australian wheat exports of the same type. Thus the Australian wheat processing industry is likely to be paying commensurately more for its raw material than processors who purchase wheat at world prices (i.e. either in free export markets; or who are subsidized for the difference between world prices and higher domestic prices, as in the EC). However, since domestic industrial users are relatively small purchasers of wheat, the parcels of wheat they acquire may be similar in size to those to which the card price applies.

Secondly, during down-swings in the world wheat market, recorded export prices may be greater than actual prices. For example, favourable credit terms or extended repayment periods may be required to achieve sales when wheat prices are low, but the cost of these competitive activities are unlikely to be reflected in the recorded nominal prices. Thus the differential between the card price and the real export price is likely to be greater during down-swings in world prices.

Thus, particularly at the present time, the Australian industrial wheat industry may be paying substantially more for its raw materials than its competitors who obtain wheat at world export prices either by buying on these markets or receiving subsidies to reduce raw material prices. Even when wheat prices are buoyant, domestic Australian producers may still be paying higher prices than their international competitors because the card price will invariably be above average export returns.

There are, however, some limits on the monopoly power of the Board. Wheat grain may be imported into Australia duty-free (Customs Tariff, Schedule 3, Division 2, Chapter 10). From discussions surrounding the 1984 Wheat Marketing Act, it was agreed that the previous prohibition on wheat imports into Australian for commercial use would be removed. Thus, if the Board's domestic price for industrial use rises too far above world prices, it should be possible for industrial users to import wheat in competition with the Board. Clearly, of course, such actions would be likely to strain existing relations between the wheat growing industry (comprising wheat growers, the Board, BHA's) and the wheat using industry (millers and industrial users).

The organisation of marketing relations between domestic wheat users and the AWB provides, additionally, some off-sets to the higher price paid by domestic industrial wheat users. Users are able to:

> reserve stocks of grain (for as much as 13 months) on the basis of their particular quantity and quality requirements at stations nominated by themselves; reserve the best quality wheat at the fixed administered price; and receive the equivalent of, on average, 45 days credit on payment (IAC, 1987a, p.117).

The <u>net</u> result of these interventions is difficult to estimate. The IAC (1987b, p.181) reported average effective rates of assistance for the "starch, gluten and starch sugars" industry of 8-9% for the period 1982-83 to 1986-87. These estimates contrast strongly with those for the rest of the "flour mill and cereal food products" and "bread, cakes and biscuits" industries which all have negative effective rates of assistance. Without details of the IAC's estimations and, particularly, the appropriate export price against which to compare the industrial wheat user's wheat purchase price (the card price), it is difficult to evaluate the IAC's estimates of positive rates of assistance to the starch/gluten industry. However the IAC's (1987c) estimates of "tax on materials" in the "starch, gluten and starch sugars" industry implies that requiring industrial users to pay the card price adds approximately 6% to the purchase price of industrial wheat (in 1984-85, wheat purchases constituted approximately 50% of non-factor input costs). This estimate seems rather low. Because the price of wheat represents a high proportion of input costs in the starch/gluten industry, estimates of effective rates of protection for this industry will be highly sensitive to assumptions about the "unassisted" wheat price. The usual research caveat therefore applies a fortiori: further work is needed!

6.3 Model of Australian industrial wheat production

In Figure 6 is represented a model of the market for Australian industrial wheat production. In the bottom left hand quadrant (quadrant III) are represented the world excess demand schedules for gluten and starch which are the effective demand schedules facing Australian gluten/starch producers. The excess demand schedule for gluten (D_g) is modelled as relatively price elastic, reflecting industry perceptions that gluten is a relatively easily saleable product. The excess demand schedule for starch (D_s) is modelled as relatively price inelastic at existing production levels, reflecting industry perceptions that, given the amount of starch produced, it is much more difficult to dispose of than gluten.

In the bottom right hand quadrant (quadrant II) of Figure 6 are represented functions for converting wheat into starch and gluten (t_s and t_g respectively). For convenience of exposition, these functions are presented as linear (see below).

In the top right hand quadrant (quadrant I) of Figure 6 is depicted the derived demand schedule for wheat for industrial processing (D_{IW}) This schedule is derived as follows. Consider the quantity of wheat grain X: the conversion functions in quadrant II indicate that M tonnes of gluten and N tonnes of starch could be made from X tonnes of wheat. At corresponding prices \$A/t of gluten and \$B/t of starch, the total revenue from processing X tonnes of wheat is \$(A.M + B.N). Thus, if it costs c(X) dollars per tonne to process X tonnes of wheat, the maximum price the processor would be prepared to pay for this wheat is Px:

$$Px = (A.M + B.N)/X - c(X)$$

Prices corresponding to other quantities of industrial wheat can be derived, and these price/quantity vectors form points on the derived demand schedule for industrial wheat.

Before considering the optimal/equilibrium level of industrial processing, some remarks are desirable on the functions depicted in Figure 6. In quadrant II, the gluten and starch conversion functions are probably not linear. Firstly, for a given plant capacity, these functions are probably concave to the x-axis indicating that, as the volume of wheat processed rises, the marginal recovery of gluten and starch per tonne of wheat falls (a simple diminishing marginal returns relationship). Secondly, as technology improves, and particularly as newer plant embodies better technology, the conversion functions in quadrant II will rotate away from the X-axis - i.e. the quantity of starch and/or gluten recovered per tonne of grain will rise. Thirdly, the cost of processing grain - represented by the function c(X) - is likely to be characterised by an increasing marginal cost function, and will also fall over time as new plant embodies new technologies.

The demand schedule for gluten in quadrant III of Figure 6 will have several important shifters. These shifters include the demand for (essentially food) products incorporating gluten, the development of new products utilizing gluten, changes to regulations governing use of gluten and changes in gluten supply conditions in other producing countries. Important contemporary illustrations of some of these points are the relatively recent "discovery" by European flour users of the possibility of substituting gluten for higher protein, imported wheats (cf. Sosland 1986), and the prohibition against the addition of gluten to flour and pasta in Italy and prohibitions against using gluten as a binder in meat products in the USA (Sosland 1986).

The simple demand schedule for starch represented in Figure 6, quadrant III, masks a much more complex reality. Each of the enormous number of starch-derived products has its own demand schedule although, conceptually at least, there exists a derived demand schedule for "starch". Because starch products generally constitute only a small proportion of the final price of products into which they are incorporated, the demand for each starch product is likely to be price inelastic. In general, there is also likely to be little substitutability between starch and other inputs in manufacturing such products. There is likely to be, however, easy substitution between types of starch in many uses - e.g. in Australia, imported starches such as manioc may readily substitute for wheat starch in many uses. In some uses, however, there may not be ready substitutability between some uses (e.g. potato starch is reported to have properties not yet able to be replicated by wheat starch, hence continuing potato starch imports into Australia). Part of the key to a successful industrial wheat processing operation is therefore the continuing development of new, and preferably higher-valued, uses to which starch-based products can be put.

The continued profitability of industrial wheat processing is therefore likely to be allied to a continuing commitment to research and development (R & D). (Note that the recovery of vital wheat gluten was first effected in Australia). This continued commitment to R & D covers the area of recovery of product; the cost of processing; and the development of new and enhanced products, particularly of starch. An essential precondition for continuing R & D is the generation of sufficient profitability in industrial wheat processing to justify continued R & D expenditure.

Using the presumption that the Australian Wheat Board follows monopoly pricing practices in its wheat marketing, equilibrium in the industrial wheat market can be described using Figure 6. Assume P* is the marginal revenue which optimises the disposal of industrial wheat on both export and domestic markets. The corresponding domestic price which the Wheat Board would accordingly set is P_Z, leading domestic users to purchase Z tonnes of wheat for industrial processing.

If the Wheat Board did not monopoly price, industrial users would purchase Y tonnes of wheat at price P*. Depending on the elasticity of the derived demand for industrial wheat D_{IW} - itself a function of the elasticities of starch and gluten demands - there could be a considerable difference between the volume of industrial wheat processing in Australia if the Wheat Board prices monopolistically compared to a free market for industrial wheat. The Wheat Board's pricing policies therefore have a potentially significant impact on the level of activity in the downstream flour milling, and starch and gluten, industries.

6.4 Implications

The economic viability of the industrial wheat processing industry in Australia depends on five broad parameters. These parameters are the export prices of gluten and starch, domestic prices for gluten and starch, prices paid for wheat grain for processing, other processing costs, and research and development (R&D) for new products and improved production processes.

The large increase in industrial wheat processing in Western Europe was noted above, together with its apparent impact in creating a downward trend in deflated prices for Australian gluten exports. Recent increases in Australian starch imports, also probably a consequence of EC agricultural policies, are also likely to put pressure on Australian industrial wheat processing. While the Australian industrial wheat processors must live with these broad trends, at least in the short term, these trends should add further urgency to the Australian government's efforts to limit the damaging effects of massive agricultural subsidies in the EC. Both the reduced real unit value of Australian gluten exports and increased domestic competition for starch from imports will require appropriate response from processors. An appropriate response from government may also be required.

From the available information, it is not clear whether or not the domestic wheat processing industry has been subjected to greater pressures from declining wheat and wheat product prices than the wheatgrowing industry. The interests of the industrial wheat industry are to seek to improve its short-run profitability by a range of not-mutually exclusive options, including:

(i) seek lower prices for its grain purchases, and thus shift more of the competitive pressure back on to growers and/or the government;

(ii) improve the efficiency of its operations; and/or

(iii) reduce production by reduction of plant throughput and/or plant closure.

7. Conclusions

The world market for gluten is reported to have undergone a major increase in demand through the "discovery" by the Europeans in recent years of the commercial value of gluten. However, this demand shift appears to have been rapidly followed by a marked increase in European gluten production capacity. Recent evidence suggests that this supply shift may have been proportionally greater than the demand shift, leading to downward pressure on prices for internationally traded gluten. These changes are likely to have the following consequences:

(i) a continued downward trend in world gluten prices and, particularly if accompanied by appreciation of the Australian dollar, a continued downward trend in Australian gluten prices in deflated Australian dollars; and

(ii) an increased elasticity of demand for wheat by industrial wheat users as the demand for Australian gluten becomes more elastic as its share of world trade declines under competition from Western Europe.

These developments in the gluten market may be exacerbated by the growth of starch processing capacity in the developing countries if these trends lead to falling real prices for starch and starch-based products and/or ued contingrowth in Australian starch imports.

The optimal pricing policy for industrial wheat sales in Australia is therefore a complex decision including the following factors:

(a) the optimal pricing of industrial wheat in the short run from the wheat producers' viewpoint, including the possible appropriation of monopoly rents;

(b) an efficient short run pricing strategy from the Australian community's viewpoint given the monopoly position of the Australian Wheat Board (as circumscribed by Section 92 of the Constitution) and the highly concentrated nature of the starch/gluten industry - it is possible that, if the opportunity exists for appropriating monopoly rents from industrial wheat sales, the failure of the AWB to appropriate these rents may result in such rents being appropriated in the starch/gluten industry; and

(c) an efficient long run pricing strategy for Australian industry wheat, which would take into account not only short run pricing decisions, but providing sufficient profitability in the starch/gluten industry for the development or purchase of new technologies to improve the efficiency of starch/gluten operations and to encourage the development of new products based on this starch and gluten.

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Table 1: World Grain Production and Use (million tonnes)

Crop year	Use Categories				
	Livestock	Food/Industry	Seed	Waste	Total
1977	489	502	59	43	1094
1985 (projected)	634	622	71	51	1377

Source: Hill and Mustard (1981, Table 2). Categorization by use between 1977 and the projected 1985 figure was not presented.

Table 2: Maize and Wheat Disposition in the U.S.A. (%)

Maize (1980)		Wheat (1979-80)	
Use	%	Use	%
Feed and residual	56.5	Food	70.5
Wet milling[a]	6.1	Industrial	5.6
Dry milling[b]	1.7	Feed and residual	11.0
Alcoholic beverages	0.7	Seed	12.9
Fuel alcohol (ethanol)	0.8		
Exports	33.8		
Seed	0.3		

Source: Hill and Mustard (1981, Tables 3 and 4)

Notes: a. Starch, sweeteners, corn oil, industrial alcohol
b. Flaking grits, breakfast cereals and other food products

Table 3: Estimated Industrial Use of Starch, 1972 (USA?)

Kind	Use by Industry			
	Paper and Paperboard	Textile	Others	Total
	Million Pounds			
Corn starch and dextrins[a]	2,600	300	400	3,300
Wheat and rice	80	10	40	130
Other starches	120	15	35	170
	2,800	325	475	3,600

a. Includes sorghum starch. Total production of corn starch (including dextrins) for shipment as such is estimated at nearly 4 billion lb. Thus, about 82% of the corn starch shipments goes to industrial use.

Source: Moore and Majors (1973, Table 1)

Table 4: Utilization of Wheat and Maize in the EC (1978/79) (millions of tonnes)[a]

	Domestic Use	Human Consumption	Animal Feed	Starch Manufacture
Wheat	37.0	22.6	11.5	0.35
Maize	28.0	1.0	21.6	4.8

a. Domestic production not reported

Source: Wookey and Melvin (1981, Table 2)

Table 5: Estimated World Production of Gluten

	1980	1985		1986 (estimated)	
Argentina	na	7,000		7,000	
Australia	15,000[a]	35,000		40,000	
Canada/USA/Mexico	na	45,000		47,000	
Japan	na	6,000		6,000	
China	na	6,000		6,000	
Korea	na	4,000		4,000	
Western Europe	25,000	75,000	69,300[b]	130,000	110,000[b]
Others	na	16,500		16,500	
Total	80,000	191,000		253,000	

Source: Sosland (1986)

Notes:
a. This figure is irreconcilable with reported Australian production of 30,000 tonnes in 1979-80 and 34,000 tonnes in 1980-81 (cf. Table 6).
b. Estimates for European Community (USDA 1987, pp. 9-10).

Table 6: Australian Industrial Wheat Usage and Product Output ('000 tonnes)

	Flour for:			Total Domestic Flour Usage	Gluten			Starch[b]
	Starch/ gluten	Brewing	Other Industrial		Dried	Wet	Total[a]	
1976-77	196	9	11	1028	26	4	-	139
1977-78	195	7	11	996	28	3	28	147
1978-79	208	4	16	1007	28	na	28	151
1979-80	218	5	18	1045	30	na	30	159
1980-81	229	2	12	1038	na	na	34	165
1981-82	209	1	12	1061	na	na	36	168
1982-83	193	9		1036	na	na	34	160
1983-84	232	3		1123	na	na	39	183
1984-85	259	2		1139	na	na	41	169
1985-86					na	na	40	172

Sources: Brennan (1983, Tables 7 and 8), and updated from: Bread Research Institute, Annual Report, various issues; Australian Bureau of Statistics, Manufacturing Commodities, Principal Articles Produced, Australia (Cat. No. 8303.0) various issues; Australian Bureau of Statistics, Production Bulletin No. 3: Food, Drink and Tobacco, Australia (Cat. No. 8359.0), various issues.

Notes:
a. Includes dried equivalent of wet gluten
b. Includes starch from sources other than wheat
na. Not available.

Table 7: Hicks-neutral technological change in Flour Mill and Cereal Food Products (mean rate in % p.a.)

	Hicks-neutral technological change
1954-55 to 1961-62	-1.2
1962-63 to 1971-72	0.1
1972-73 to 1981-82	1.0

Source: Estimated from Bureau of Industry Economics (1986, Table A.4)

Table 8: Industry Statistics and Concentration Ratios for Australian Wheat Processing[a]

Flour Mill and Cereal Food Products

8.1 Flour Mill Products

	1972-73	1977-78	1982-83	1984-85
- totals:				
number of enterprises (no.)	52	33	23	23
number of establishments (no.)	83	59	47	48
turnover ($m)	165.1 (371.0)	266.0 (318.6)	437.8 (324.5)	511.1 (332.1)
value added ($m)	38.2 (85.8)	60.5 (72.5)	118.0 (87.5)	126.2 (82.0)
employment (no.)	3367	2522	2154	2209
wages and salaries ($m)	16.5 (37.1)	25.3 (30.3)	36.5 (27.1)	41.4 (26.9)
fixed capital expenditure ($m)	2.1 (4.8)	3.9 (4.7)	3.8 (2.9)	11.8 (8.1)
- four-firm ratios				
establishments	0.20	0.37	0.49	0.48
turnover	0.43	0.53	0.71	nas[b]
value added	0.43	0.52	0.75	nas
employment	0.33	0.51	0.64	nas
fixed capital expenditure	0.89	0.76	0.61	nas
- eight-firm ratios				
establishments	0.31	0.49	0.64	0.65
turnover	0.61	0.73	0.88	0.88
value added	0.59	0.72	0.88	0.86
employment	0.54	0.70	0.83	0.84
fixed capital expenditure	0.60	0.81	0.88	0.92

Source: Australian Bureau of Statistics (various issues), Census of Manufacturing Establishments, Industry Concentration Statistics, Australia, Catalogue No. 8207.0.

Notes:

a. Values in parentheses are at 1979-80 prices; the deflator for turnover, value added and wages and salaries is the implicit price deflator for expenditure on gross domestic product (1972-73 = 0.445, 1977-78 = 0.835, 1982-83 = 1.349, 1984-85 = 1.539); for fixed capital expenditure was used the implicit price deflator for private gross fixed capital expenditure on equipment (1972-73 = 0.440, 1977-78 = 0.822, 1982-83 = 1.293, 1984-85 = 1.456).

b. Not available separately.

8.2 Starch, Gluten and Starch Sugars

	1972-73	1977-78	1982-83	1984-85
- totals:				
number of enterprises (no.)	10	6	6	6
number of establishments (no.)	18	12	11	10
turnover ($m)	39.3 (88.3)	74.2 (88.9)	114.5 (84.9)	157.1 (102.1)
value added ($m)	8.5 (19.1)	19.0 (22.8)	27.6 (20.5)	26.0 (16.9)
employment (no.)	903	733	722	748
wages and salaries ($m)	5.2 (11.7)	9.0 (10.8)	14.8 (11.0)	18.5 (12.0)
fixed capital expenditure ($m)	1.8 (4.1)	3.2 (3.9)	3.9 (3.0)	14.4 (9.9)
- four-firm ratios				
establishments	0.61	0.83	0.73	0.80
turnover	0.71	nas	nas	nas
value added	0.74	nas	nas	nas
employment	0.83	nas	nas	nas
fixed capital expenditure	1.06	nas	nas	nas
- eight-firm ratios				
establishments	0.83	1.0	1.0	1.0
turnover	0.99	1.0	1.0	1.0
value added	1.00	1.0	1.0	1.0
employment	0.99	1.0	1.0	1.0
fixed capital expenditure	1.00	1.0	1.0	1.0

Table 9: Import Duties on Starch and Gluten Products

	General Rate	Special Rates
Starches, inulin		
- Potato starch	Free	
- Maize starch	2c/kg[a]	DC: 1.9c/kg[a]
- Manioc (cassava) starch	10%	DC: 5%
- Other starches, inulin	4c/kg[a]	DC: 3.8c/kg; Can. 2c/kg[a]
Wheat gluten	2%	DC: free
Dextrins		
- Potato	15%	DC: 10%
- Other	15%	DC: 10%
Soluble or Roasted starches		
- Preglutinised (?) potato starch	15%	DC: 10%
- Other	15%	DC: 10%
Dextrin and Starch glues	15%	DC: 10%

Source: Customs Tariff, Schedule 3, Divisions 2 and 6

Notes: DC - developing countries
Can - Canada
a. Estimated *ad valorem* rates (at 1981-82 (maize) 1985-86 (other) average unit import values)

	General rate	Special Rates
Maize starch	3%	2.8%
Other starches, inulin	7%	DC: 6.8% Can: 3.6%

No records of maize starch imports were found for 1982-83 to 1985-86.

Figure 1: Gluten and Starch Exports, volume and value

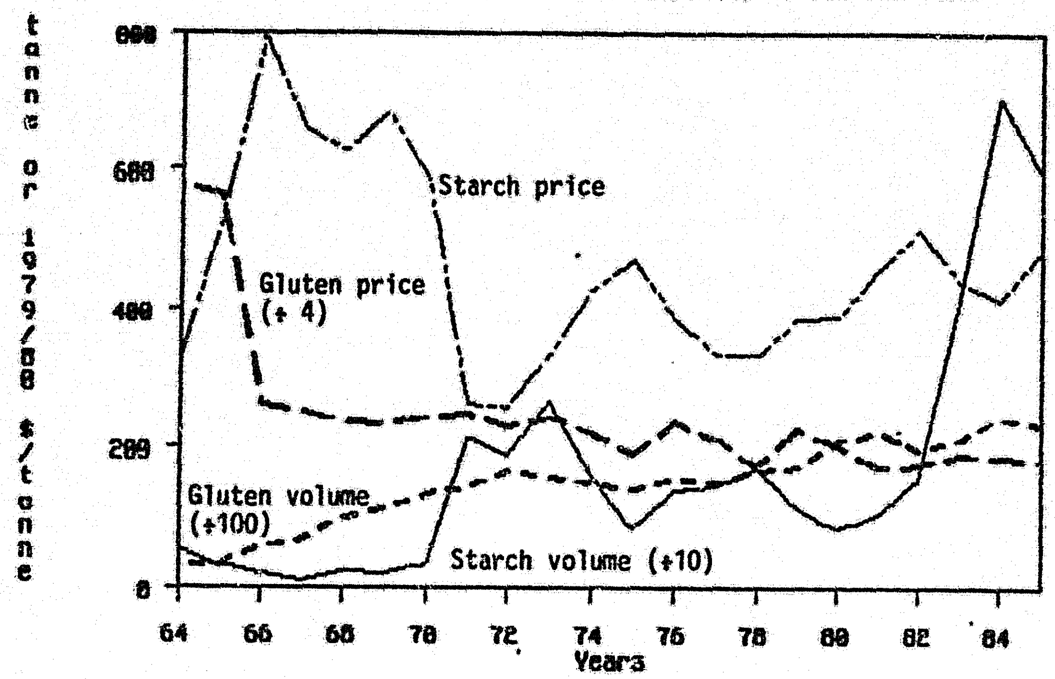
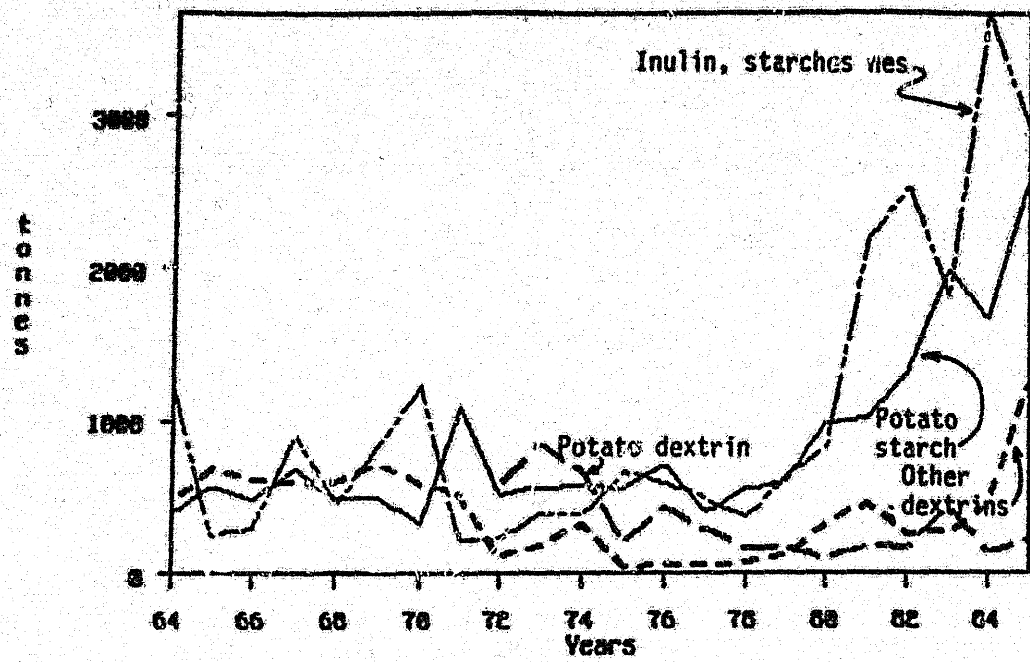
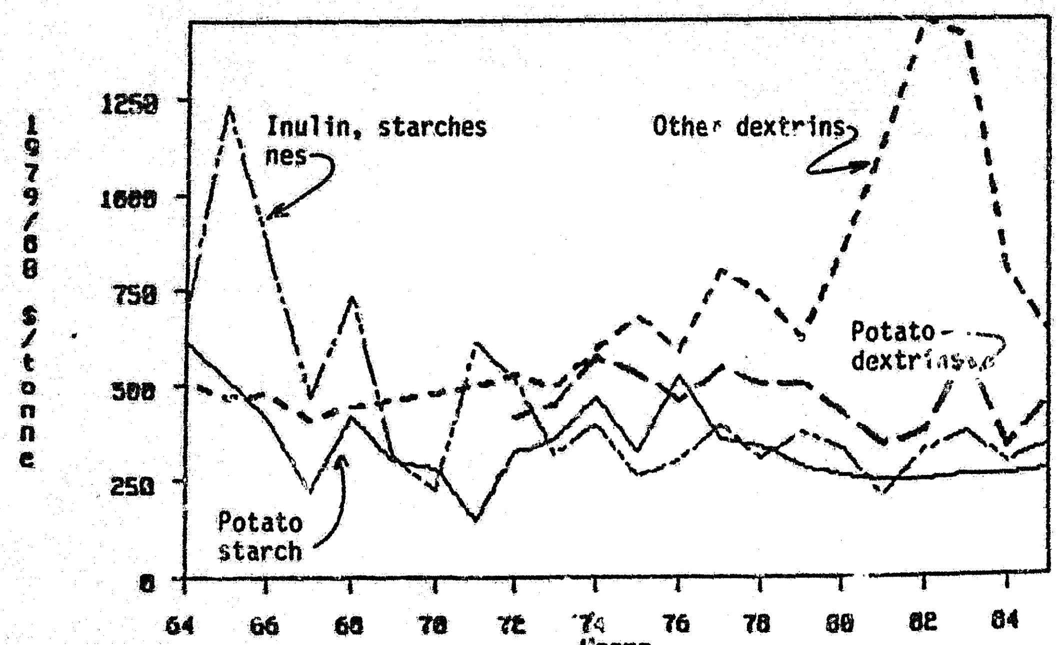


Figure 2a: Volumes of Selected Starch Product Imports



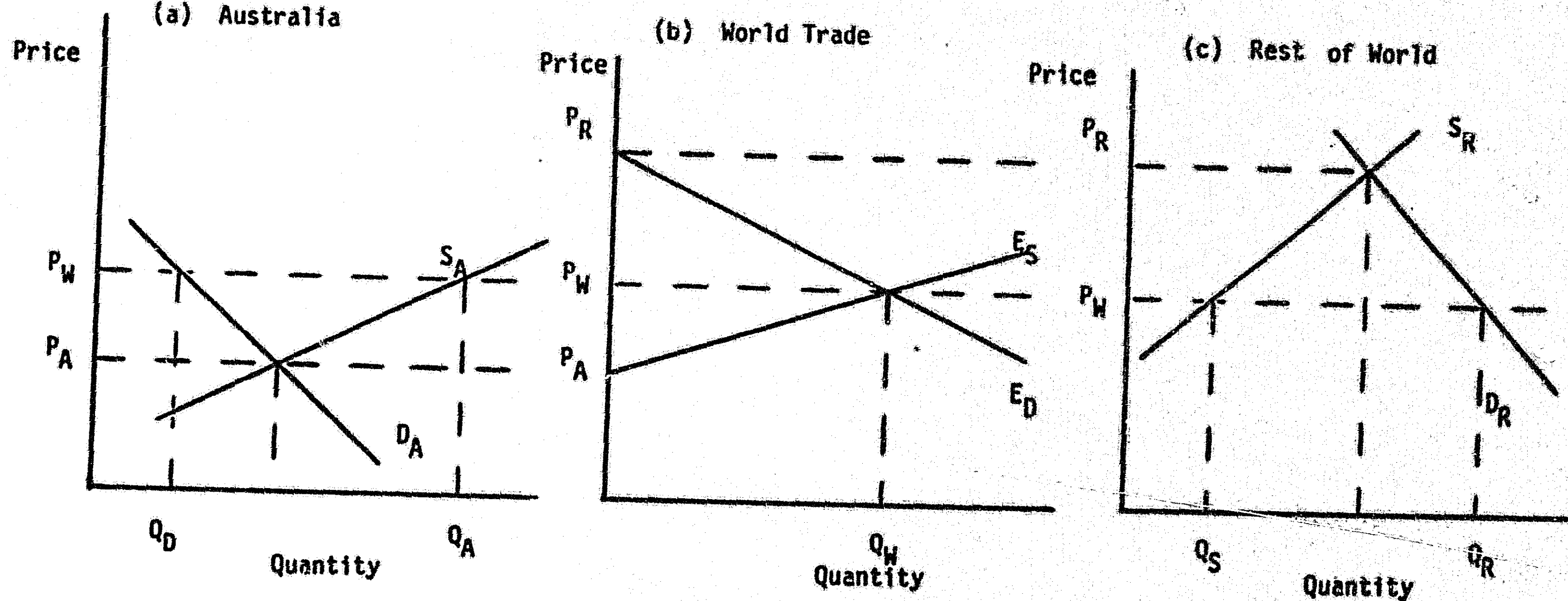
Note: Inulin, starches nes includes all starches except potato and maize.

Figure 2b: Unit Values of Selected Starch Product Imports



Note: Inulin, starches nes includes all starches except potato and maize.

Figure 3: World/for Starch or Gluten (Market)



Note: Australia is assumed to be a net exporter of starch or gluten

Figure 4: Shift in Supply and Demand in Rest of World

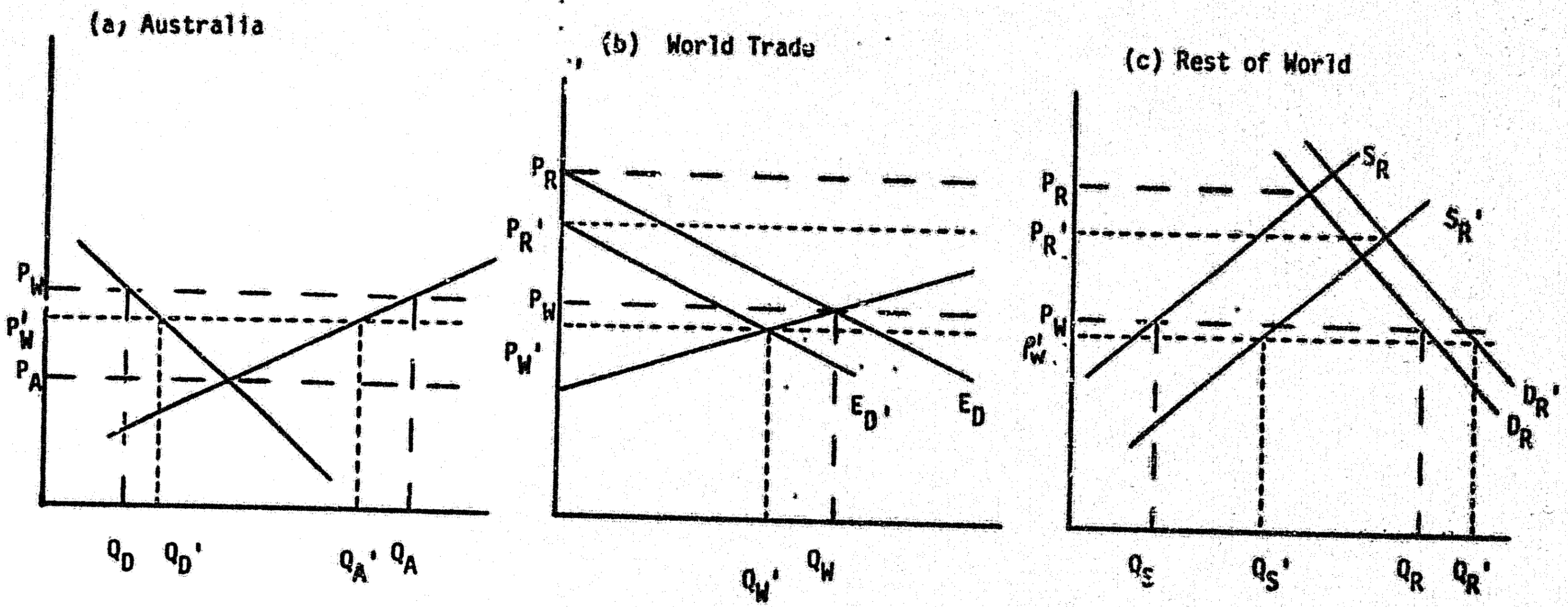


Figure 5: Schematic Representation of Australian Wheat Board's Revenue Maximizing Strategy in Industrial Wheat Market

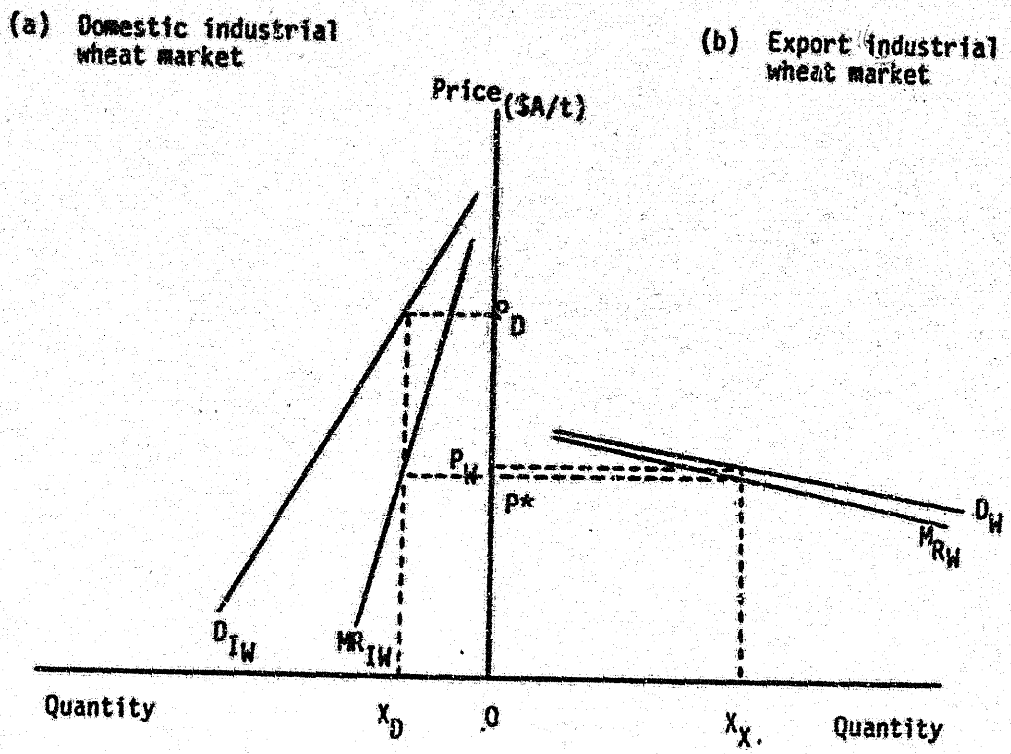


Figure 6: Schematic Representation of the Australian Industrial Wheat Market