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Liberalization of the Taiwan Wheat Milling Industry

ABSTRACT: Taiwan, in just the past two years, lifted quoto restrictions on wheat imports and lowered tariff barriers. These changes along with the antitrust movement and severe overcapacity will be the catalysts for tremendous structural changes in the way wheat millers compete for domestic market share and contracts for flour. The purpose of this study was to examine the impact of liberalization on the Taiwan milling industry.

Taiwan relies on 100% imports for its food wheat requirements and will likely continue to do so in the foreseeable future (see U.S. Wheat Associates, 1993). The United States has been the primary exporter of wheat to Taiwan for the past four decades. Canada and Australia have supplied significant, but considerably lower quantities. The United States' high market share is a result of several economic and political factors. In the past, the U.S. has supplied wheat under Public Law 480 (PL-480), and contractual agreements have also been used to guarantee shipments. Prior to 1993, all wheat import activity was coordinated through the Taiwan Flour Milling Association (TFMA), which enforced these contractual arrangements. However, in 1993, Taiwan enacted its first set of general antitrust laws. These laws assured wheat mills direct access to wheat import markets and brought into question the validity of guaranteed shipments by source. Although the contracted import levels with the U.S. have been maintained, and almost all wheat is still purchased through TFMA, the future market share of the U.S. is not guaranteed (Peng and Stiegert, 1997).

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Taiwan has, in just the past two years, lifted quota restrictions on wheat imports and lowered tariff barriers. These changes along with the antitrust movement and severe overcapacity will be the catalysts for tremendous structural changes in the way wheat millers compete for domestic market share and contracts for flour. They are also likely to effect the relative share of different wheat classes supplied by large exporting nations. Although opinions vary, most experts think that operating capacity of the industry will shrink by at least 50% in upcoming years. The purpose of this study was to examine the the impact of liberalization of the Taiwan milling industry. In Section 1 we develop a framework for examining the policy changes that have been made, those which are scheduled to be made, and discuss the likely implications on the industry. Section 2 presents a simple modeling exercise that evaluates the quality-price relationship of imported wheat to determine which wheat export nations stand to benefit in the post-liberalized period.

1. THE HISTORICAL DEVELOPMENT OF TAIWAN MILLING INDUSTRY

Taiwan wheat milling began in 1907 and developed in three distinct periods (*The Taiwan Milling Industry,* 1987). In the first period (1907-1951), the industry grew to eight small mills with aggregate annual production of 9100 metric tons of flour, which translates to approximately 25 metric tons per day (Table 1). The industry used only domestic wheat: wheat imports were not possible primarily because of tight foreign exchange constraints. Additional flour needs were imported from the U.S. under PL-480.

The second period (1951-1966) marks a time of unprecedented growth in milling capacity, wheat imports, and government regulation. In 1952, the TFMA was established to provide significant regulation and control over much of the industry activities. Initially, they successfully negotiated with the U.S. government to import wheat instead of flour under PL-480, which created an instantaneous need for milling capacity. Further, TFMA established a quota on imported wheat, and allocated these imports based on each mill's design capacity. As a result, milling firms found it rational to seek quota rents by building excess capacity or capacity they had little intention of utilizing. Five mills were added from 1952 to 1954. In

Table 1. Taiwan Flour Production and Number of Mills

Year	*Production (M.T)*	*Number of Mills*
1950	9,102	8
1951	17,880	8
1954	136,944	13
1955	133,362	34
1966	261,960	41
1991	626,101	34
1995	711,260	34

Source: The Foundation of Taiwan Grain Development (1987)
TFMA Quantity reports (1991,1995)

1955, 21 mills were added which led to over seven times the production levels of the early 1950's. The government limited new entry and expansion of existing mills after 1955. By 1966, only six additional mills were added to reach a peak of 41. The wheat allocation formula based on capacity was abolished, albeit temporarily, in 1966 after PL-480 ended for Taiwan.

The third time period (1966-present) also had significant influence in shaping the milling industry. A relaxed regulatory environment existed from 1966 to 1970, and the power of the TFMA in controlling the industry was significantly scaled back. Entry limitations on new mills and expansion limitations on existing mills were removed. Mills were allowed to source their own wheat directly. Several factors led to highly unstable and aggressive competition in the industry. Excess capacity was extremely high due to the past allocation formula. Although we do not have data for that time period, expansion has basically kept pace with increased population and demand since 1970; and currently (1990s) , the industry only operates at roughly 30-40% of capacity. Given similar capacity utilization numbers for the late 1960s, the conditions existed for firms to aggressively compete for market share, which they did. To further complicate matters, milling firms for the first time faced prices that fluctuated according to market forces. Price uncertainty and excess flour production led to short term accounting losses for the industry, which were followed by periods of low imports and supply shortages.

The unstable supply situation created general consumer and political unrest, which led to a re-regulated structure in 1970. Allocation of quota restricted wheat imports was once again coordinated by TFMA and based on individual milling capacity (U.S. Wheat Associates, 1993). The wheat allocation was adjusted every three years. So once again, milling firms competed for these allocations by investing in excess capacity. However, because of the already severe overcapacity problem, these investments tended to be coordinated with population and demand increases. Based on several private interviews with millers in Taiwan, the problem of excess capacity certainly began in the 1950s but still remains a significant problem because of the return to old allocation policies in 1970. The Taiwan Council of Economic Affairs reports that only 40% of the total capacity is being used (*Survey of Baking Products*, 1990). Interviews with industry insiders suggest that the problem may be much worse. With total capacity of the industry at about 3,000,000 tons flour per year and demand for flour at about 1 million tons, capacity utilization is perhaps in the 30-35% range.

After the 1966-1970 period of instability, the government perceived wheat flour to be a daily necessity and its price stability to be essential to the general economy (*Determinants of Wheat Import Demand: Taiwan*, 1994). Therefore, the Council of Agriculture also intervened in the wheat-flour sector. They controlled imported wheat prices and domestic flour prices by applying a stabilization program, price ceilings, and import tariffs. Quota limitations were controlled by the Board of Foreign Trade, in conjunction with the TFMA.

In the 1990s significant policy oriented changes were made. The general set of antitrust laws adopted in 1993 prohibited the monopoly power of the TFMA and essentially abolished the quota system. Taiwan is applying for membership in WTO as a developed economy, which led to partial dismantling of the stabilization program, elimination of import restrictions on flour, and reducing the flour import tariffs from 30% to 20%. Currently, the stabilization program will still subsidize imported wheat whenever world price is higher than the chosen standard price. However, the government will not collect the revenue when world price is less than the standard price. In time, the stabilization program will be abolished when the fund is drained.

Even though mills are no longer bounded by legal constraints to source their wheat from the TFMA, it has remained in operation from 1993 to the present. The milling industry continues to rely on the TFMA for reliable shipping schedules, some reduction of price variability, and necessary storage facilities. The future direction and viability of the TFMA is very uncertain as milling firms explore the free market system perhaps finding more efficient ways of doing business. Certainly, one area mills are likely to improve will be in the value-adding process of sourcing of wheat based on quality parameters. The U.S. has supplied 77-100% of imported wheat in Taiwan from 1981-1995 (see Taiwan Four Mill Association, shipment data, 1995) The ability of the US to maintain these kinds of market shares will depend critically on the price-quality relationship that it maintains with the Taiwan flour mills. In the next section, we turn to an economic analysis of the policy changes ongoing in Taiwan. The fourth section is devoted to addressing the issue of price-quality competition for market share between the U.S., Canada, and Australia.

1.2. Effects of Government Intervention

The TFMQ wheat allocation policy, used from 1951-1966, 1970-1993) was based on a formula that provided quota restricted quantities of wheat to mills based on milling capacity. The combined effect of the allocation and quota policies were to give firms incentive to add significantly more capacity than would have otherwise been the case. Figure 1 depicts this situation in a simplified case of only two mills operating in the industry. Mill 1 chooses capacity Q1 and faces a short run average cost given by SAC_1. Mill 2 chooses milling capacity Q2 and faces a short run average cost given by SAC_2. These two SAC curves add together to give the aggregate industry average cost curve (SAC_i). If the average cost functions of the firm differ only by a scale factor, then allocation of wheat as a percent of total capacity will lead to the same average costs. Suppose the quota restricted wheat import quantity is given by Q^q and allocations follow accordingly by $Q_1{}^q$ and $Q_2{}^q$. Average costs facing each firm are given by AC, which is higher than minimum average costs at AC'. As long as the price of flour is above AC, mills generate an economic profit. Because parts of the quota rent accrued to the industry, profits

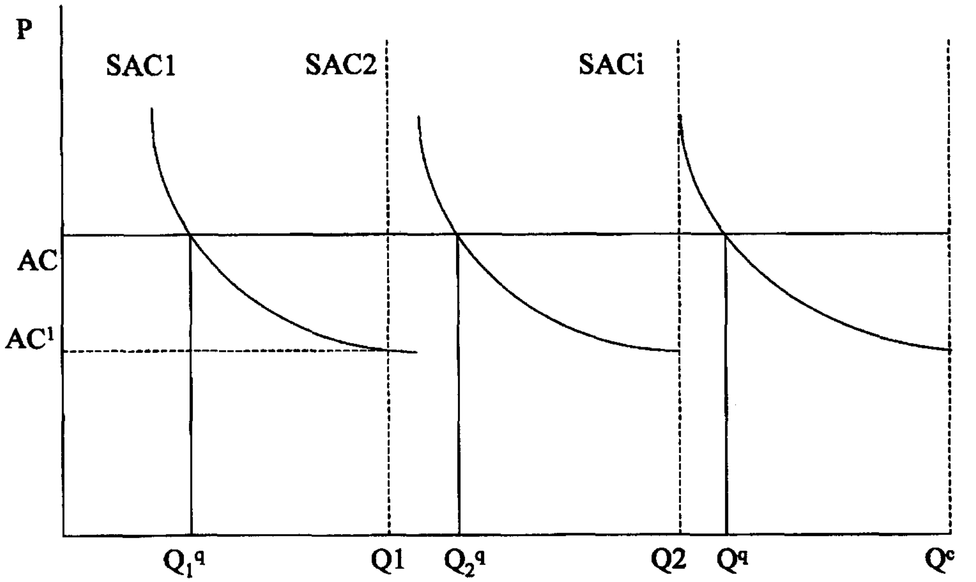
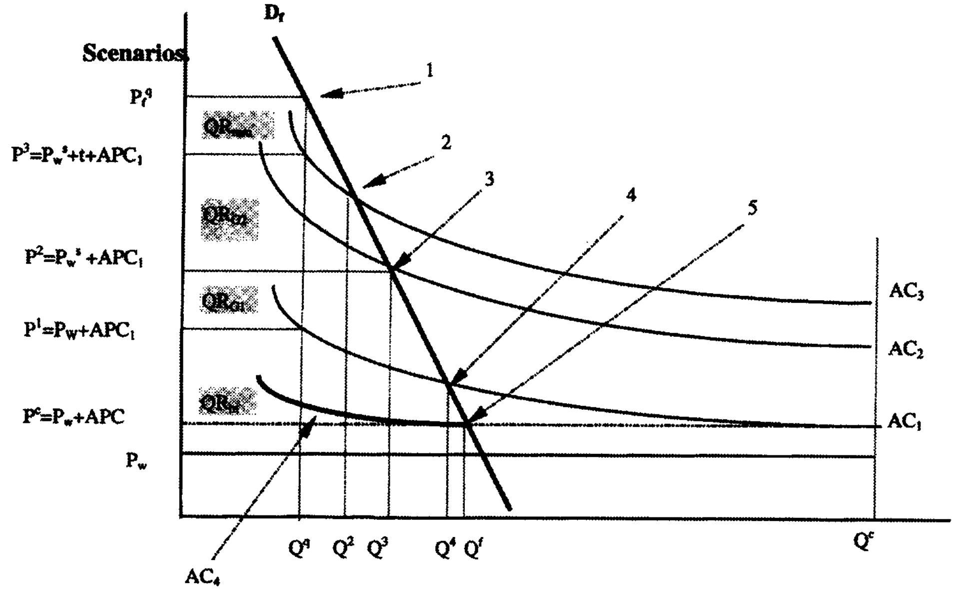


Figure 1. Effect of the Wheat Allocation Policy

were actually significantly above that of AC. In fact, based on the added value of the quota rent in any year the policy was in effect, there would have been room for far more inefficient capacity expansion of the industry. Industry insiders suggest that uncertainty about the long-run ownership of the quota rents limited this expansion to three times the level of aggregate production.

In 1993, the quota restriction was lifted. A serious disequilibrium condition in the market resulted with each firm having an incentive to produce at minimum average cost, which is given by the capacity constraint (Q1 or Q2 in Figure 1). Without flour export relief, some firms will achieve minimum average cost (produce at full capacity) at the expense of other firms losing market share, and the latter firms will be forced to exit. As Stephens points out, perhaps the most important determining factors in explaining which firms survive the industry downsizing process are cost cutting and meeting downstream customer demand for flour quality (Stephens, 1997).

We next analyze the chronological removal of government policies which began in the early 1990s. This is done in three steps, which are all displayed in Figure 2. Figure 2 is drawn in the context of wheat flour, and it implicitly assumes constant variable processing costs and a constant rate of flour extraction, which is reasonable for this industry. There exists a market for wheat byproducts in Taiwan; however, the prices for these products are very low and are therefore ignored in this analysis. Because of the unusual case of excess capacity and intrusive government control, the industry has been operating on average cost principals for several



Note: P_w^S flour equivalent stabilization price of wheat
AC_1 Average processing costs (APC_1) + flour equivalent price of wheat (P_w)
AC_2 Average processing costs (APC_1) + flour equivalent stabilization price of wheat (P_w^S)
AC_3 AC_2 + import tariff (t)
AC_4 Free market average cost after capacity adjustments.

Figure 2. Economic Effects: Taiwan Liberalization Policy

decades. Therefore, this analysis operates on the same principal but recognizes the eventual adjustment to the marginal based conditions of zero economic profits and the competitive forces that will drive the industry to operate at full capacity.

1990-1993: The first price-quantity setting, depicts the market as it was prior to any major policy changes. In place were the stabilization program, the import tariff, the quota restriction, and the allocation policy. Turning to Figure 2, the flour demand curve is given by D_f, total industry milling capacity by Q^c, the quota constrained level of wheat flour production by Q^q, and the internal price flour by P_f^q. To evaluate the quota rent and how it is distributed, consider the average cost curve labeled AC_4, which has a minimum associated with price P^c. This price represents the minimum average cost for a set of firms operating in a policy-free environment at full capacity. Note that this is the same price that could sustain the current capacity situation if the industry could operate at full capacity. The price associated with this cost level is, therefore, the competitive price (P^c). The four boxes above line P^c and to the left of Q^q represent the total quota rent generated. The lowest box, QR_m, represents the inefficiency of the wheat allocation policy that led to overcapacity. This is seen noting that average costs are much higher than at P_c when industry average cost, given by AC_1, is determined at production a level that is less than full capacity. The next box, QR_{G1}, is government revenue collected as part of the stabilization program. In the early 1990s, world wheat prices were below the stabilization price. Government simply paid the world wheat price and sold wheat at the higher price to wheat mills: area $(P_w{}^s - P_w)Q_q = QR_{G1}$ The third box, QR_{G2}, represents tariff revenue collected by the government: $t^*Q_q = QR_{G2}$. Finally, the last box, QR_{mm}, represents quota rents accruing to the industry as economic profits.

Figure 2 shows average cost curves for the industry at current capacity levels. The lower curve (AC_1) was discussed above and includes only the per unit cost of wheat and average processing costs. The middle curve (AC_2) adds the tariff and the highest curve (AC_3) adds the per unit stabilization costs. The average total costs (AC) faced by milling firms include paying for the per unit stabilization cost, $P_w{}^s$, the tariff (t), and processing wheat (APC) into flour ($AC_3 = APC + P_w{}^s + t$). At the quota restricted level of output, zero economic profits occur at P_3. Therefore, the industry received a quota rent equal to $(P_f{}^q - P_3)Q_q = QR_{mm}$. Point 1 represents price of flour at the quota restricted output of the industry in the 1990-1993 period.

1994-1996: After 1993, the industry began adjusting to the removal of the quota system. Production level Q^2 depicts this condition. Mills still paid the tariff and paid for the per unit cost of the stabilization system. No firms exited as of early 1997, flour output has increased, and price has declined. The industry lost its portion of the quota rent, while the government portion of the quota rent was converted to tariff and stabilization revenues, which increased because imports expanded. Obviously, point 2 (or Q^2) is not a stable long run solution. When some firms are able to increase market share in the quota free period, it implies they would be able to drive price even lower which will make it very difficult for firms that lose market share to compete. In 1997, however, this process had only begun.

1997-2000+: In 1997, the government converted the stabilization program to a price ceiling program which protected consumers from high flour-equivalent world wheat prices. Thus far, this price has not been triggered in world markets so the government is essentially operating with only a tariff. Point 3 , coinciding with production level Q^3 in figure 2 represents the free market solution when no firms exit the market and all operate at the same average cost level. As the government import tariff is removed, industry production will increase to Q^4, price will drop and the average cost curve of the industry will shift to AC_1. Once again, movement from production level Q^q to Q^4 assumes no firm exits the market and prices are coordinated with the average cost of production. The process of firm exit due to severe overcapacity is depicted as moving from point 4 to Point 5. AC_4 represents a fully adjusted industry average cost curve. At this point, the industry's capacity will be Q^f, which is equal to the market demand.

Stephens (forthcoming) has observed a three-phase process caused by policy liberalization in wheat milling industries elsewhere. In phase one, a significant battle for market share ensues with price reductions, and new flour pricing formulae being introduced. In phase two, firms compete in cost cutting strategies to gain a competitive pricing edge. Phase three is consolidation in which the industry moving from many medium-sized firms to a handful of large firms with perhaps a fringe group of firms supplying niche markets. Under a free export policy, Taiwan mills could develop a Pacific Rim customer base and perhaps avoid part of the drastic reduction in processing capacity. Moreover, applying an export subsidy program for exporting flour would provide incentive to mills to utilize more of their excess capacity and compete with Japan, which has subsidized flour exports in the past.

3. NEW PURCHASING PATTERNS OF THE TAIWAN MILLING INDUSTRY

The focus of the analysis presented in this section has to do with Stephens' first phase in the policy liberalization process. The removal of policy layers affecting

Table 2. Data Used for Optimal Blend Analysis: Taiwan Flour Milling Industry

Part 2A: Average Annual Wheat Price and Ocean Freight Rates (1992-1996)

Year	*DNS #2 14%*	*Freight rate (a)*	*APH #1 14%*	*Freight rate (b)*	*CWRS #1 13.5%*	*Freight rate (c)*
91-92	161	13.03	202	14.46	188	13.03
92-93	165	11.62	191	13.08	193	11.62
93-94	209	12.35	241	13.63	222	12.35
94-95	178	16.97	220	17.47	193	16.97
95-96	233	14.94	272	18.58	255	14.94
Average	189.2	13.8	225.2	15.4	210.2	13.8
Stdev	30.9	2.2	32.3	2.4	28.4	2.2

Source: International Grains Council, 1995/1996 World Grain Statistics

Part 2B: Average Wheat and Flour Quality Parameters (1992-1996)

QUALITY	*DNS*	*APH*	*CWRS*	*RHS*	*Condition*
		Wheat Characteristics			
Test Weight (kg/hl)	78.6	82.6	81.7	77.2	Min
Dockage (%)	0.8	0.1	0	0.5	Max
		Flour Characteristics			
Protein (%)	12.7	13	12.9	12.7	Min
Ash Content (%)	0.4	0.	0.5	0.52	Max
Gluten Content (%)	35.6	36.2	37.8	36	Min
Extraction Rate (%)	68.7	76.5	76.2	73	Min
Water Absorption (%)	64.5	63.5	65.1	63	Min
Peak Time (minutes)	9.1	6	5.1	7	Min
Stability (minutes)	16.2	14.1	10.1	14	Min
Fall. Number (seconds)	381	424	393.1	380	Max

Source: U.S. Wheat Associates, Crop Reports 1992-1996
Australian Wheat Board, Crop Reports 1992-1996
Canadian Grain Commission, Quality of Western Canadian Wheat Exports 1992-1996

the Taiwan milling industry have been the catalyst for significant structural changes. Mills now have the potential to compete for domestic, and possibly international, market share of flour along quality lines that were previously shielded by socially motivated wheat buying practices. To evaluate the proposed question of how best to source wheat, we set up simple linear program for a representative mill producing a standard grade flour for the bread baking industry. Then we performed considerable sensitivity analysis on the model results to evaluate their robustness and potential .

Consider a representative wheat mill in Taiwan purchasing wheat directly from the U.S., Canada and Australia. These three export countries have a geographical advantage to export into Taiwan, relative to the European Union and Argentina. The model used average price, and transport cost data from 1992 to 1996 for each wheat source (Table 2, part A). The firm is assumed to minimize costs subject to a set of quality constraints that were made available by an independent wheat mill in Taiwan. These quality constraints assure reasonable mill quality, and provide baking qualities that must to be delivered in a downstream contract.

The wheat varieties are Dark Northern Spring Wheat (DNS), grade number 2 with 14% moisture content,[1] Australian Prime Hard Wheat (APH) grade #1, 14% moisture content,[2] and Canadian Western Red Spring Wheat (CWRS), grade number 1 with 13.5% moisture content.[3] The second, fourth, and sixth columns of Table 3 report the annual average export prices, and the average for the 1992-1996 period for DNS, APH, and CWRS, respectively. Freight rates (a) and (c) (columns three and seven) are the annual average freight rates from the Pacific Northwest to South Korea. Freight rate (b) (column five) represents the cost from Australia to South Korea.

Table 3. Results of the Base Model

Wheat Class-Origin	*Wheat Price ($/metric ton)*	*Optimal Blend (%)*	*Shadow Value ($)*
DNS-U.S.	203	44	0
APH-Australia	240.6	31	0
CWRS-Canada	224	25	0
Quality Constraint	*Constraint*	*Activity Level*	*Shadow value ($/metric ton)*
Protein (%)	12.7	12.84	0
Ash content (%)	0.52	0.43	0
Gluten content (%)	36	36.3	0
Extraction rate (%)	73	73	5.8
Falling number (%)	380	397.2	0
Absorption rate (%)	63	64.3	0
Dockage (%)	0.5	0.43	0
Peak time (%)	7	7.1	0
Stability (%)	14	14	3.7
Test weight (kg/hl)	77.2	80.6	0

Halverson (1988) suggested that both physical and chemical characteristics determine wheat quality. Physical characteristics include test weight, kernel weight, kernel size and shape, kernel hardness, vitreousness, impurities and milling quality. Chemical characteristics include moisture content, protein content, protein quality, alpha-amylas activity, fat acidity and crude fiber and ash. Wheat quality data by wheat source measures most of these characteristics. Requirements were established for minimum levels of protein content, wet gluten, flour extraction rate, water absorption, peak time, stability time, and test weight. Maximums were established for ash content, dockage, and the falling number measure of alpha-amylas activity. We assume that wheat quality can be attained in a linear relationship when different wheat varieties are blended. This property provides economic value for mills to utilize a blending strategy to reduce the wheat cost while meeting the desired quality specifications. This model applies the linear program to identify the cost minimizing import blend of wheat classes.

Quality data from the three exporting classes were collected from 1992 to 1996. Table 2, Part B, reports the average quality from 1992-1996 for 10 quality characteristics from each source and then reports the mill's quality constraint information. The objective function and constraint system are given by:

$$Minimize\ Z = \sum_{j=1}^{3} C_j\ W_j$$

Subject to

$$A_{ij} W_j \leq B_i$$

where Z is the objective value (US$/metric ton); C_j is jth wheat purchase price (FOB) in US$/metric ton; W_j is the quantity of jth (j = 1-3) wheat used to produce the bread flour; A_{ij} is the level of the i th (i =1 to 10) quality available from each wheat j as reported in table 4; B_i is the minimum quality constraint for a blended wheat purchase (maximum constraints are converted to a minimum equivalent). A final constraint converts quantities, W_j, j = 1-3, of the optimal solution into percentages.

The unique characteristic of wheat flour to form a light and well aerated loaf of bread with proper crumb grain is based on its protein quantity content. The quality and quantity of protein is linked to other measurable properties used in this study including gluten content, water absorption, mixing peak times and mixing stability (Pomeranz and Moore, 1975). These other measurable properties are included in the model because their relationship to protein varies across wheat varieties grown within each class, wheat classes and weather conditions (Stiegert and Blanc, 1997).

The percentage of flour water absorption, the peak time, and stability time of dough, are measured by using the Farinograph. The Farinograph uses a constant speed to mix flour and water into a dough, then develops the dough, and overmixes it. The dough develops and peaks at the 500 Brebender Unit line (B.U.). The elasticity and mobility of dough are measured subject to prolonged, relatively gentle mixing at constant temperature (Shuey, 1984). The baking industry requires a minimum water absorption for bread flour and uses it as a reference to control the amount of water needed. The Baking industry requires a minimum peak time and stability time to assure dough is cohesive and stable enough to withstand a standard mixing time procedure.

Ash content is the percent of wheat mass remaining after being incinerated. It is an important wheat quality because it is a cost predictor in the mill process and is also a measure of bran contamination in flour. One of the objectives of milling is to separate the bran and germ from the endosperm and to convert the endosperm into fine flour. Wheat that is high in ash is typically more difficult to mill because kernel quality is poor and nonuniform. Therefore, more costs are involved to extract flour and more bran remains in the final flour output. The freedom of flour from bran material can be easily measured by the ash test. Taiwan bakers and retail customers demand very white flour, which implies low ash content bread in flour. Therefore, the ash content is a primary index for purchasing wheat in Taiwan.

The falling number procedure determines alpha-amylase activity in flour, which are present in a limited amount in wheat flour but produce a complex and negative effect upon the starch molecule. A certain amount of alpha-amylase is favorable for bread baking. However, an excess of alpha-amylase may cause sticky doughs with reduced water absorption. The loaf volume, interior grain and texture are reduced. The level of alpha-amylase present in the flour is increased by either damaged starch or sprouted wheat.

Test weight is an index of flour yield potential. The test weight instrument tests a portion of the sample wheat with dockage removed. The test weight expresses as a weight in pounds per 60 pound bushel and is a quality factor of the grading system. Test weight is influenced by kernel shape, uniformity of kernel, kernel size, and wheat density. Small thin wheat kernels have low test weight and typically result in lower flour yield that tends to have higher ash content (Tesarek, 1994).

Extraction rate is the percentage of flour produced from 100% clean wheat. The importance of the extraction rate is directly related to mill output. At a 0.4% ash content, the representative mill requires a 73 percent of extraction rate to produce bread flour. With a one percent loss in the extraction rate, the mill which has a 300 tons per 24 hours capacity encounters a loss of 3 tons of flour productivity per day. In the other words, the 3 tons of flour loss went into millfeed, which is a serious profit loss.

Dockage is defined as all matter other than wheat that can be removed from the original sample. Taiwanese mills prefer low or even zero dockage in wheat shipments because dockage is useless for the flour mill.

3. Results and Sensitivity Analysis

The optimal solution ensures that the firm purchases any combination of wheats to accomplish its quality specifications for producing bread flour while minimizing cost. The base model evaluates buying patterns for a representative mill based upon a five year average of prices and qualities: 1992-1996. The result of the linear program shows that the minimum purchase cost was $219.56 per metric ton. The wheat sources were 44% DNS, 31% APH, and a 25% CWRS (Table 3).

The mill's original wheat formula for producing the standard bread flour was 80% of DNS and 20% of CWRS. APH was used to produce bread flour; however, the percentage of APH used to blend with DNS and CWRS has, in the past, depended upon its availability through the TFMA.

The optimal solution implies that without the restriction of imported wheat sources and quantities, the representative mill producing bread will purchase larger quantities of APH and CWRS and a lesser quantity of DNS to minimized the purchasing cost.

The quality results are shown in lower section of Table 3. The first column describes the quality constraint and whether or not it is a minimum or a maximum. The second column represents the required quality constraint level, is also called right hand side (RHS) constraint. The third column indicates the quality level of the blended wheat imports using the optimal weights. For example, the optimal blend consisted of 12.84% protein, which exceeded the minimum required level of 2.7%. The last column shows the shadow values of each quality constraint. The shadow value is the change in objective function value caused by a one unit change

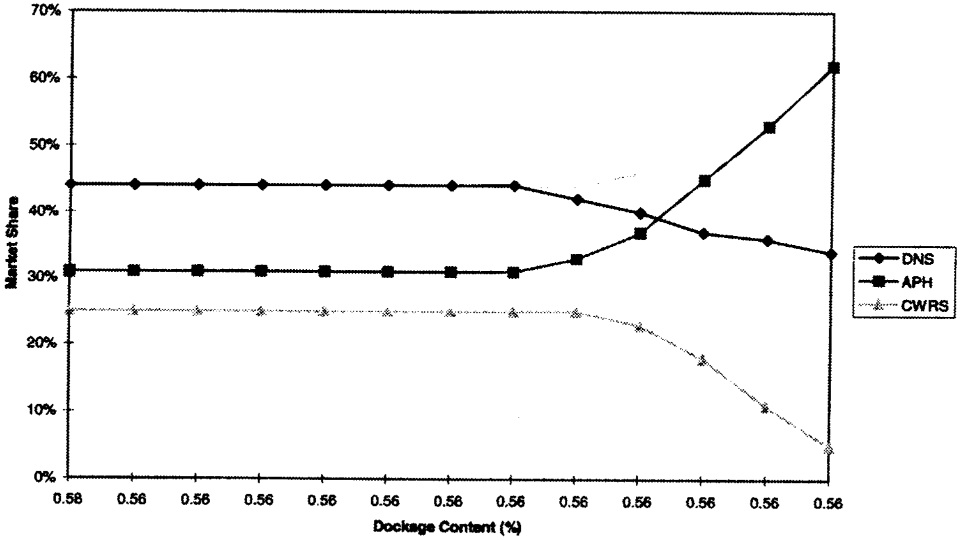


Figure 3. Sensitivity Analysis of Dockage Content

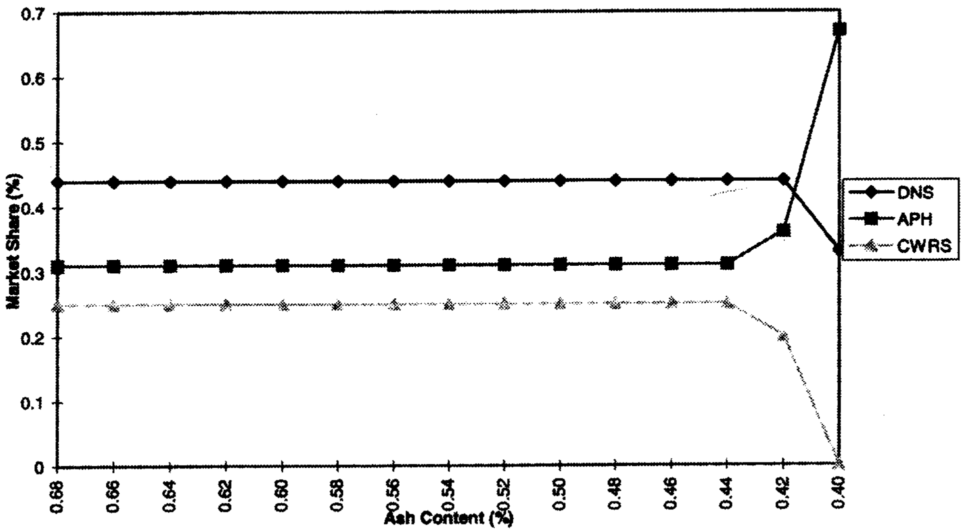


Figure 4. Sensitivity Analysis of Ash Content

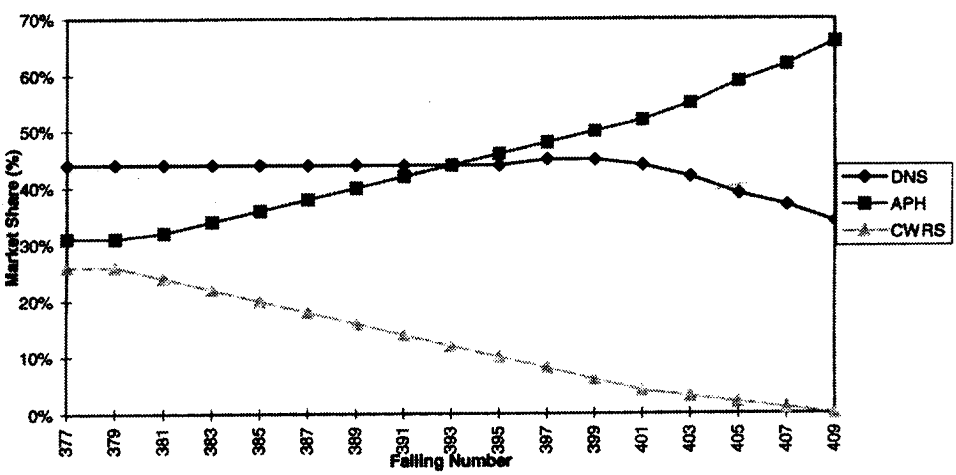


Figure 5. Sensitivity Analysis of Falling Number

in RHS constraint level. Notice that only constraints that are binding on the solution have positive shadow values. For example, the extraction rate of the blended wheat equals the extraction rate minimum constraint. Thus extraction rate is binding. The shadow value in this row implies that total costs will decline by $5.80 if the minimum extraction rate were reduced to 72%. Similar results for Farinogram

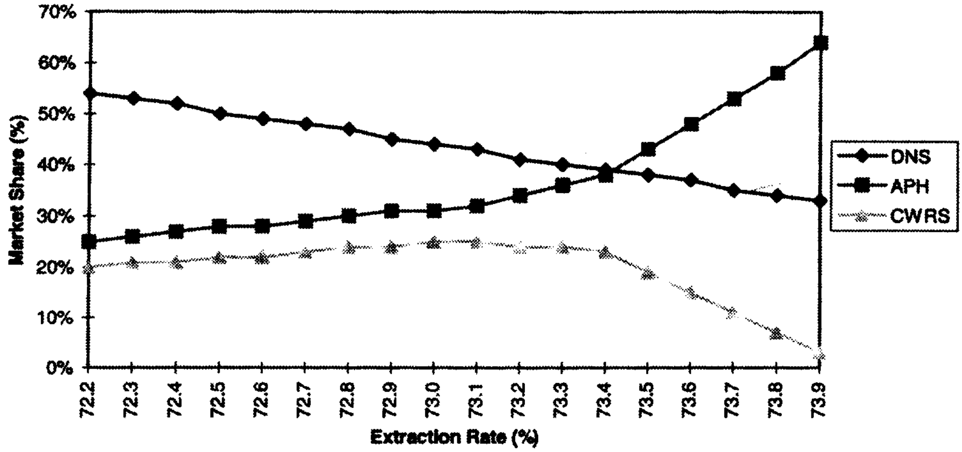


Figure 6. Sensitivity Analysis of Extraction Rate

stability indicate that a one unit increase in required stability time will increase the purchasing cost by $3.7/ton.

The sensitivity analysis measures the effects of changing quality constraints on the wheat formula. The sensitivity analysis uses a loop technique, which changes the quality constraint over a desired range, holding all others constant, and to continue running the program until the model becomes infeasible. As the quality constraints become more binding, the shadow values and the objective value increased.

Ten quality constraints for the bread flour specification were analyzed over each relevant range. The results show that only four constraints, dockage content, ash content, falling number, and the extraction rate, had much affect in changing the market share of each wheat. Interestingly, protein and the baking qualities associated with protein did not change the base result that much. The sensitivity results are presented graphically in Figures 3-6 such that the each of these constraints becomes more binding right to left.

The lower dockage content was preferred by the representative flour mill. The original maximum dockage content level was 0.5% and the range of dockage content used in the sensitivity analysis was from 0.34% to 0.58%. The result became infeasible as the constraint reached a 0.3% level. The results shows that dockage maximums from 0.44% to 0.58% do not affect the wheat formula (Figure 3). However, when maximum allowable dockage is dropped to 0.42% or lower, the amount of APH wheat purchased begins to increase. The market share of DNS decreases slightly and the market share of CWRS decreases dramatically.

Similar to dockage content, a lower ash content was preferred by the flour mill. The maximum ash content was 0.52% in the specification. The range of ash content tested in the analysis was decreased from 0.68% to 0.4% by 0.02% increments. The results, shown in Figure 4, show that the optimal wheat formula could go as low as 0.44% ash content without increasing the purchasing cost ($219.99). As this constraint becomes more binding below 0.44%, the market share of APH increases significantly, that of DNS decreases slightly, and CWRS's market share decreases significantly.

The range of falling numbers tested in the analysis was increased from 377 to 409 by two units increments (Figure 5). As the falling number becomes more binding (i.e. increases), the market share of APH increase steadily from 30% to over 60%. The market share of CWRS decreases from over 25% to zero and the share of DNS decreases slightly.

The range of the extraction rate was increased from 72.2% to 73.9% (Figure 6). As in the case of the other constraints, the market share of APH increased as this constraint became more binding. The market share for DNS decline gradually, and the level of CWRS fell significantly.

Results from the sensitivity analysis provided an important assessment of the Taiwan wheat import market. Even though DNS wheat from the U.S. is likely to lose market share from the liberalization process, it has the potential to maintain a stable market share across many different or changing quality needs of Taiwan milling firms. The APH wheat is likely to do very well in an environment that requires rising quality. At the present set of prices and qualities, The CWRS wheat does not appear poised to make a long term stable increase in market share beyond the initial adjustments generated by policy liberalization. If general quality requirements increase, the CWRS wheat is likely to lose market share or will lose revenue from lower prices that would be required to compete effectively with competing exporters.

The results of this study should be viewed cautiously. First, the price and quality data used in this study are only representative of a specific time period (1992–1996). Changes in world demand and supply of wheat quality characteristics has an important role in determining the relative price and market share for wheat from different origins. As these conditions change each year, so too will the relative value of various quality characteristics. In Taiwan and in many other Pacific Rim nations, consumer demand for noodles and, therefore, noodle flour is advancing fairly rapidly. Some exporting nations are breeding hard white wheat varieties with characteristics that perform well in this market. The results in this study reflect import shares of hard wheats that perform well in bread production, which represents about half the current demand for hard wheat in Taiwan. If consumers continue to substitute in their diet bread for noodles, the aggregate import share profile will tend to favor wheat with outstanding noodle flour characteristics. Understanding the role of increasing demand for noodle-based flour in the overall derived demand for hard wheats is an area of important future research.

Finally, the Asian financial crisis is likely to be an important factor in the future development of this industry. Regional demand for any possible Taiwan flour exports is likely to be weaker for some time and stronger U.S., Australian, and Canadian currencies act to raise the price of landed wheat in Taiwan. Though highly uncertain, both these factors could force a more rapid and uncomfortable reduction in excess milling capacity.

4. Summary and Conclusions

The Taiwan wheat milling industry is currently in a state of severe overcapacity brought about by government import quotas, centralized control of wheat buying activities, and a wheat allocation policy based on each mill's share of aggregate capacity. To obtain the lucrative quota rents, firms in the industry maintained roughly three times the capacity necessary to meet market demand. In 1993, however, Taiwan enacted its first set of antitrust laws, which prohibited monopoly power of the TFMA. Since then, Taiwan has applied for membership in WTO as a developed economy. Therefore, the industry faces significant structural adjustments due to loss of the quota rents, downsizing, and in sourcing of wheat by individual mills. How the government and individual incumbent firms deal with this excess capacity will determine the adjustment path that the industry inevitably faces. The purpose of this study has been to trace through the effects of government intervention in the Taiwan milling industry and to analyze potentially new purchasing patterns in a liberalized policy setting. As the competition for market share intensifies, some firms will expand output and lower their average cost of production, which will cause other, less aggressive, mills to reduce output and eventually exit the market. Only a rapidly expanding export market or a return to stringent government control of the industry could stem these strong economic forces.

As the move to a free market progresses, mills are likely to wean themselves from the TFMA and will source wheat based on the prices and qualities that can be most efficiently processed or that best fit their downstream customer needs for specific flours. We examined the potential for these structural changes to affect the market share of the three principal wheat exporters into Taiwan: U.S., Canada, and Australia. The model applied an optimization program of a representative mill producing bread flour. The objective of the model was to minimize costs subject to a set of milling and baking quality constraints that were supplied to us from industry sources. Three wheat classes, DNS, APH, and CWRS, were used to blend and to produce the standard bread flour.

The results showed that the minimum purchasing cost was $219.56/ton. The wheat formula was composed of 44% of DNS, 31% of APH, and 25% of CWRS. Currently, the representative mill's standard formula for producing the bread flour is 80% of DNS and 20% of CWRS, and this can vary depending on TFMA purchases of APH wheat. Therefore, results of the optimal solution imply that without the restriction of imported wheat sources and quantities, the representative mill will purchase larger quantities of APH and CWRS and less of DNS to minimize the purchasing cost. Minimum extraction rate, a milling constraint quality, and farinograph stability, a baking quality requirement for flour, were the two binding constraints on the objective function. The shadow values of the extraction rate and stability were $5.8/ton and $3.7/ton, respectively.

The quality sensitivity analysis indicated that the wheat formula and the purchasing cost were affected by four quality constraints, which were dockage content, ash content, falling number and extraction rate. Furthermore, APH wheat was highly sensitive to quality restrictions and tended to increase its market share as quality requirements increased. The CWRS wheat tended to lose significant market share as quality requirements increased, and DNS wheat tended to either maintain or slightly lose market share as quality requirements increased.

The results of the sensitivity analysis are important for the Taiwan milling industry as well as for the major wheat exporters into this region. It appears that importing firms will be able to force more price concessions from the Canadian Wheat Board than may be commonly thought. The APH wheat does a good job of meeting much of the quality requirements for Taiwan bread, but is priced higher than other wheats. Certainly, the ability of an exporter to control and improve certain qualities such as dockage will be an important part of the negotiation process and could allow U.S. exporters greater latitude in maintaining strong business relations in the post-liberalization period.

NOTES

1. Grade #2 DNS wheat is defined by: 1) test weight of 57 pounds per bushel or higher, 2) heat damaged kernels of 0.2% or less and total damaged kernels of 4% or less, 3) foreign material of 0.7 or less, 4) shrunken and broken kernels of 5% or less, 5) total damaged kernels, shrunken and broken kernels, and foreign material of 5% or less, and 5) additional limitation for wheat from other classes, insect damaged kernels, and count limits on other grain contaminants such as stones and animal filth.
2. Australian Prime Hard grading restrictions include: 1) test weight per bushel of 74 kg/hl or higher, 2) unmillable material of 7% or less, and 3) nil quantities of heat and insect damaged kernels, grain contaminants and live insects.
3. Canadian Western Red Spring grading restrictions include: 1) shrunken and broken kernels of 0.7% or less, 2) other contaminants of 0.40% or less, 3) total heated and bin burnt kernels of 0.50% or less, and 4) wheats of other classes limited to 1.5% or less.

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