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STRATEGIC INVESTMENT AND EXCESS CAPACITY: A STUDY OF THE TAIWANESE FLOUR INDUSTRY

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The Taiwanese flour industry's capacity utilization rate has maintained an extremely low level of 40% for more than 20 years. This article sets up a two-stage game model and uses the strategic effect of the firm's capital investment on its rivals' outputs to explain the nature of this excess capacity. The model is tested with panel data from the Taiwanese flour industry by using non-linear three-stage least squares. The evidences indicate that a large capacity built in the past could have been used strategically to reduce other firms' outputs, in the context of a concerted action among the incumbent firms.

JEL classification codes: L13
Key words: strategic investment, two-stage game, collusion, conjectural variation

I. Introduction

In 2000, an antitrust case brought Taiwan Fair Trade Commission (TFTC, hereafter) against the flour industry association, which was alleged to eliminate price competition by collusive arrangements. The most interesting part of the case is that the industry has maintained an extremely low level of capacity utilization rate at around 40%-50% for more than 20 years.[1] If the period of 20 years is considered as long-run in terms of economics, flour firms should have had enough time to adjust their capacity. Faced with such a contradiction,

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[1] According to Chen (1986), excess capacity has been built, at least, since 1980s.

economists might want to check the determination of capacity with a more detailed investigation of the IO model.

Recent game theoretic contributions, such as Osborne and Pitchik (1983, 1986, 1987), Allen, Deneckere, Faith, and Kovenock (2000), and Roller and Sickles (2000) emphasize the strategic effect of capacity. These models have a two-stage setup in common. In the first stage, firms make a capacity decision followed by a price-setting game in the second stage. The stage-one variable (capacity) is used to develop a strategic effect to influence other firms' stage-two decision (price). Higher investment in stage one induces a softer action by other firms in stage two. Following this line of argument, this article introduces an expected effect of the firm's first-stage investment on its rivals' outputs in the second stage. We find that a large capacity built in period one can be used strategically to reduce other firms' outputs in period two. This leads to an overinvestment in the first stage and causes the misallocation of resources.

Based on this line of argument, this article tries to build a model to explain the excess capacity in Taiwanese flour market. The model is also tested with panel data from the industry by using non-linear three-stage least squares. The data used for the empirical investigation are given in a report by the TFTC (2001) about collusive behavior in the Taiwanese flour market. The report provides detailed data on prices, outputs, and fixed capacity as well as a great deal of more qualitative information which is valuable in interpreting those data. The information in the report is derived directly from the working of a real-world cartel. Its main drawback is that it is related only to 5 years, and standard econometric models are difficult to be applied, in particular to the estimation of a demand function. Nevertheless, we hope to demonstrate that some quite strong conclusions can still be drawn, in particular on the extent to which the excess capacity reduces industry output. The empirical evidences are consistent with those proposed by the model. Flour firms expect that the long-term effects of their capacity investment may act to deter their competitors' outputs. Besides, a certain amount of collusion exists in the second stage. The results are robust to the sensitivity analysis.

This paper is divided into five sections. Section II contains a brief discussion on some stylized facts of the Taiwanese flour industry. Section III contains a theoretical model to discuss the effect of excess capacity on collusion. Section IV and V present the major empirical results.

II. Stylized Facts in the Flour Market

This section sets out briefly some stylized facts about the flour market in Taiwan.

- *Production*. Flour is a homogeneous product. It is shipped in barrels to grocers who in turn package the flour for final users without any identification of the manufacturers. Price therefore tends toward uniformity, and flour firms compete in quantity in the market. In addition, the demand for flour is not seasonal.

Flour is produced via a simple process and flour firms use a common technology. Wheat is transformed at a fixed, and generally accepted, coefficient into flour. As TFTC (2001) notes, the production of one kilogram of flour needs 1.37 kilograms of wheat on average. This coefficient remains constant over the sample period. Besides, the value-added of production of flour is quite low. Estimates of TFTC (2001) show that, in 1994-1998, material (wheat) cost comprised 69% of the flour price.[2] Since wheat is the main variable input and the input-output coefficient is fixed, we can translate this into the assumption that, over the relevant range of outputs, average cost of production is constant as output varies, and that it is equal to the marginal production cost.

- *Entry*. Although the production of flour is quite simple, a quota system instituted by the flour industry association seems to rule out entry almost completely. Since Taiwan does not produce any wheat, all of the production materials have to be imported from abroad (mainly from the US and Australia) and are subject to the high cost of transport. TFTC report shows that economies of scale to import wheat can be achieved only when firms use a 50,000 tonnage vessel for each voyage. However, this figure is far beyond the material needs of a single firm. Thus, flour firms have to procure and ship wheat jointly under the supervision of the flour industry association. This gives the association an opportunity to block entry by not allowing new entrants to join the procurement group through a quota system. Since 1990, there has been only one entrant (Global Flour Company), who joined the industry in 1998

[2] For an individual flour firm, therefore, almost the only possible cost advantage depends on its procurement price of the wheat input.

and was a joint venture of several incumbent flour firms in Southern Taiwan. Besides, the 20% tariff rate for the flour is too high to allow for imports, and exports are rare, too. Thus, the collusive behavior of the incumbents has not been influenced by the threat of new entry for decades.

- *Concentration*. Though the industry contains 32 firms, the TFTC report shows that the leading 10 firms control 75% of the Taiwanese flour market. Table 1 shows that the market share is about the same across incumbent firms, except for firm 10. Although TFTC (2001) does not indicate firms' name to protect their secret information in the business, we can still identify that firm 10 is President Company, which happens to be the largest producer in the market. According to TFTC (2001), President Company did not conform to the cartel occasionally, and even threatened the cartel by bringing together several small firms to import the wheat by themselves so as to obtain more quotas to import the wheat. For Table 1, numbers between parentheses stand for the statistics of mean and standard deviation for the sample excluding President Company. These figures show that market share is quite the same across the remaining 9 firms.

- *Capacity*. As the production technology for flour is quite simple and experiences little innovation, the capacity to produce flour is relatively long-lived. Generally speaking, the machinery in flour firms could last for at least 15 years. According to Ma (2004a), the depreciation outlay takes up only 5% of the flour price.[3] Thus, the cost to build an excess capacity to facilitate the cartel is not expensive.

The capacity utilization rates of flour firms have been maintained at an extremely low level of 40%-50% between 1994 and 1998, which were by far lower than the level of 80% for the manufacturing industry during the same period. This evidence indicates a huge excess capacity at the industry level that shapes a credible threat, since firms can easily dump a large amount of output on the market to punish the cheaters. As entrants could not get the wheat quotas issued by the association, either, it follows that incumbent firms do not invest in excess capacity to preclude outsiders but to restrict the behavior of their established rivals within the dominant group.

Although Table 1 shows that two of these flour firms had capacity

[3] As we mentioned above, the main cost to produce is the wheat input.

Table 1. Firms' Production, Market share, and Cost (1994-1998, Yearly Averages)

Firm	Production (ton)	Market share (%)	Capacity (ton)	Utilization rate (%)	Wheat cost (NT$/kg)
1	33,760	4.68	100,980	33.43	7.30
2	33,853	4.69	114,000	29.70	6.24
3	34,564	4.79	87,120	39.67	8.13
4	35,507	4.92	90,000	39.45	6.63
5	36,543	5.01	94,900	38.51	6.60
6	36,913	5.11	109,500	33.71	7.09
7	41,199	5.71	86,400	47.68	7.09
8	53,629	7.43	98,940	54.20	6.85
9	53,713	7.44	69,677	77.09	6.64
10	110,412	15.30	128,986	85.60	6.71
Mean	47,009	6.51	98,050	47.90	6.93
	(39,965)	(5.53)	(94,613)	(43.72)	
Standard dev.	23,546	3.27	16,623	19.10	0.52
	(8,087)	(1.12)	(13,339)	(14.59)	

Notes: The figures are yearly averages between 1994 and 1998 for each firm. TFTC data does not expose firms' name so as to protect their privacies. Numbers between parentheses exclude the data corresponding to President Company. The industry output to calculate the individual firm's market shares comes from the Ministry of Economic Affairs. The source of all the other data is TFTC (2001).

utilization rates above 70%, readers being familiar with the Taiwanese flour market can easily identify that these two firms are President Company and Lien-Hwa Company. These two firms are separately owned by the integrated food processing conglomerate with a portfolio of businesses spanning downstream in the industry, and most of their products are used within the conglomerate and not traded in the market.

- *Cartel members.* Although we have identified 10 major firms between 1994 and 1998, the TFTC detailed data contains only nine of them. We do not have the cost and capital stock data for firm 4. Thus, the empirical investigation

contains only the collusive behaviors among these 9 dominant firms, and the remaining 23 firms are ignored. These dominant firms are hypothesized to behave collusively to restrict output among them. In addition, the excess capacity is used to restrict cheating within the dominant group. Since we focus on dominant firms, and cheating probably happens, then the remaining 23 firms are implicitly irrelevant.

III. A Model of Competition for the Flour Industry

In this section, a two-stage game model is set up to deal with the competition issue in flour market. The framework is inspired by Roller and Sickles (2000) and Dixon (1986). Ma (2004b) also investigates the relationship between strategic effects and conjectural variations under this framework. Flour firms simultaneously decide the fixed factor input (capital stock) in the first stage and then choose the variable factor input (such as wheat or labor) so as to resolve quantity in the second stage. Thus, capital is treated as an endogenous variable and is determined in the first stage, which affects both the production cost and market competition in the second stage. This specification allows for the possibility of a semicollusive market where firms compete in a long-run variable, such as capital investment, and collude with respect to a short-run variable, such as quantity or market share. For an individual firm, our concern is about the effect of long-run capital investment on its rivals' short-run output decision.

We begin by specifying a quantity-setting game in which each flour firm produces a homogeneous commodity and faces an inverse linear demand function of the form:[4]

$$P(Q) = a + b(q_i + Q_J) \tag{1}$$

where P is the price and Q is the quantity demanded, and in equilibrium the market quantity demanded equals the sum of the outputs of the individual

[4] These assumptions could be justified by the technical structure of the industry that we mentioned in section II. For instance, the output of industry is homogeneous and the wholesale price is uniform across firms. Therefore, the inverse demand function applies well.

firms. Let there be n firms, each producing q_i, such that $Q = \sum_{i=1}^{n} q_i$ is the industry output, and $Q_J = \sum_{j \neq i}^{n} q_j = Q - q_i$ is the combined output of other firms.

Following Roller and Sickles (2000), we assume that cost structure is used as a channel through which the first and the second stage decisions have an effect on firms' profitability. In the first stage (long-run), firms can vary their cost through the adjustment in capital stock. However, in the second stage (short-run), cost relies only on variable inputs, which is determined by the quantity produced,[5] given the capacity determined in the first stage. Thus, the cost structure can be specified as follows:

$$C_i^{LR}(q_i, k_i) = C_i^{SR}[q_i(l_i) \mid k_i, r_i] + r_i k_i \tag{2}$$

where l_i is the variable factor input, C_i^{LR} is the long-run cost function which amounts to short-run cost $\left(C_i^{SR}\right)$ plus fixed cost ($r_i k_i$). Note that, given a capital stock $\left(k_i = k_i^0\right)$ and a fixed capital price $\left(r_i = r_i^0\right)$, C_i^{SR} is determined only by q_i, which is a function of l_i. In the second stage, firms choose l_i to determine q_i. However, in the first stage, capital turns out to be variable and firms can change their cost by purchasing k_i at a given price r_i^0.

We now solve the two-stage game in a standard way. First, each firm chooses l_i to maximize its profit in the second stage:

$$\max_{l_i} \pi_i = P(Q)q_i - C_i^{SR}(q_i) \tag{3}$$

$$= P[q_i(l_i \mid k_i^0, r_i^0) + Q_J]q_i(l_i \mid k_i^0, r_i^0) - w_i l_i$$

Given a predetermined capital level (k_0), the short-run production cost of firm i $C_i^{SR}(q_i)$ is determined by the variable input l_i which gives the total variable cost ($w_i l_i$) at a factor price w_i. Assuming that w_i is exogenously determined, the first order condition for (3) is given by:

$$P\frac{\partial q_i}{\partial l_i} + b(1+\theta)\frac{\partial q_i}{\partial l_i} q_i - w_i = 0 \tag{4}$$

[5] Thus, the cost in the second stage can be considered as the short-run variable cost.

where $\frac{\partial q_i}{\partial l_i}$ is the marginal product of the variable input. Under the conjectural-variation framework, $\theta_i = \frac{\partial Q_J}{\partial q_i}$ is the conjectural variation. As stated earlier, Q_J is the output of other firms in the same industry.

If we were interested in both the existence and pattern of interdependence, it would be adequate to allow each firm to have different conjectural variations. However, as we are only interested in the existence of oligopolistic interdependence, it is sufficient to evaluate the aggregate output response of the other n -1 firms anticipated by firm *i*. Thus, following Roller and Sickles (2000) and Farrell and Shapiro (1990), we assume that $q_i = q$ (i.e., that the conjectural variation is the same across all the flour firms). In the special case of Cournot behavior, $q = 0$. Furthermore, under perfect competition $q = -1$, and under a perfect collusive solution, $q = n - 1$. This provides a basis for testing these hypotheses in the next section. We then rewrite (4) as:

$$P - \frac{w_i}{\frac{\partial q_i}{\partial l_i}} = -b(1+\theta)q_i. \tag{5}$$

Since the price of the variable factor is equal to its marginal revenue product, we substitute $w_i = MR \times \frac{\partial q_i}{\partial l_i}$ into (5) and use the equilibrium condition of an oligopoly market ($MR = MC_i$). After some manipulations, the first order condition (5) becomes

$$\frac{P - MC_i}{P} = (1+\theta)\frac{s_i}{\varepsilon}, \tag{6}$$

where $s_i = \frac{q_i}{Q}$ is the market share of the individual firm, and $\varepsilon = -b\frac{P}{Q}$ is the price elasticity of demand. Equation (6) represents an oligopoly mark-up formula that is customarily used to measure market power and is determined by market share s_i, price elasticity e and market conduct parameter q. Econometrically, q can be estimated as a free parameter and interpreted as "the average collusiveness of conduct". In the Cournot model, $q = 0$, the mark-up expression is reduced to $\frac{P - MC_i}{P} = \frac{s_i}{\varepsilon}$. For perfect collusion or

monopoly, the mark-up equals $\frac{1}{\varepsilon}$, and for perfect competition it is zero. Since $w_i = MC \times \frac{\partial q_i}{\partial l_i}$, by using (4) and $P = a + b(q_i + Q_J)$, the reaction function of firm *i* is linear to the outputs of other firms, and we have:

$$q_i = r_i(Q_J, MC_i, \theta) = \frac{MC_i - a - bQ_J}{b(2+\theta)}. \tag{7}$$

where the slope of the reaction function is $\frac{-1}{(2+\theta)}$.

We now turn to the first stage of the game in which capital stock is determined. It is noticeable that the firm's equilibrium quantities defined by the second-stage game are functions of its own capital and its rivals' capital in the first stage. Thus, the equilibrium outcome of the second stage can be represented by $q_i^*(k_i, K_J)$, where K_J is the sum of the capital stocks of the other firms. The fact that the capital is committed before the firm makes its output decision implies that the firm can use its investment decision strategically: the firm can influence its rivals' outputs through its choice of capacity. Given this specification, the profit of firm *i* in the first stage is:

$$\max_{k_i} \pi_i = P[q_i^*(k_i, K_J) + Q_J]q_i^*(k_i, K_J) - r_i k_i - w_i l_i .$$

Without loss of generality, we can omit the functional arguments "*" to keep notation uncluttered. Thus, the corresponding first order condition for each firm is given by

$$P\frac{\partial q_i}{\partial k_i} + b[(1+\theta)\frac{\partial q_i}{\partial k_i} + \frac{\partial Q_J}{\partial k_i}]q_i - r_i = 0$$

which could be rewritten as

$$\frac{P\frac{\partial q_i}{\partial k_i} - r_i}{P} = \frac{s_i}{\varepsilon}[(1+\theta)\frac{\partial q_i}{\partial k_i} + \frac{\partial Q_J}{\partial k_i}]. \tag{8}$$

Here, $\frac{\partial q_i}{\partial k_i}$ is the marginal productivity of the capital, and $\frac{\partial Q_J}{\partial k_i}$ is the strategic

effect of firm *i*'s capacity on its rivals' outputs. Formally, we should write this strategic effect as $[\frac{\partial Q_J}{\partial k_i}]^e$, since $[\frac{\partial Q_J}{\partial k_i}]^e$ is firm *i*'s conjecture, or expectation, about its rivals' output responses for its capital investment. We assume that $\frac{\partial Q_J}{\partial k_i}$ is constant and is the same across the firms. In the subsequent empirical work, we try to estimate $\frac{\partial Q_J}{\partial k_i}$ to check if overinvestment is used to reduce the output of rivals.

The economic significance of $\frac{\partial Q_J}{\partial k_i}$ is evident if we bring the optimality conditions of the first stage and the second stage together. The arrangement could be done by substituting (6) into (8) and reducing (8) to,

$$\underbrace{r_i - \frac{\partial q_i}{\partial k_i} MC_i}_{\text{Direct effect}} + \underbrace{\frac{\partial Q_J}{\partial k_i} \frac{Ps_i}{\varepsilon}}_{\text{Strategic effect}} = 0. \tag{9}$$

Based on the propositions of Fudenberg and Tirole (1984) and Roller and Sickles (2000), (9) can be decomposed into two effects. By changing k_i, firm *i* has a direct effect on its profit $\left(r_i - \frac{\partial q_i}{\partial k_i} MC_i \right)$, which is the effect of firm *i's* stage-one investment on its cost. This effect cannot influence the output of firm *j*. On the other hand, the strategic effect $\left(\frac{\partial Q_J}{\partial k_i} \frac{Ps_i}{\varepsilon} \right)$ results from the two-stage specification that allows for the influence of firm *i*'s investment on the output of firm *j* in the second stage. Whenever $\frac{\partial Q_J}{\partial k_i}$ is zero, there is no strategic effect, and (9) reduces to $r_i = \frac{\partial q_i}{\partial k_i} MC_i = \frac{\partial q_i}{\partial k_i} MR = MRP_i^k$, which corresponds to a one-stage simultaneous move quantity game. However, if the strategic effect does exist and $\frac{\partial Q_J}{\partial k_i} < 0$, then the theoretical inferences indicate a firm's conjecture that a large capacity built in stage one can be used strategically to reduce other firms' outputs in stage two.

This strategic effect may come from different sources. For instance, in the case of a cartel, the excess capacity could be used to discourage cheating

behavior.[6] This mechanism works through the channel that if cheating is observed by the cartel, then all firms will produce at full capacity and revert to competition. Subsequently, price collapses and many firms go bankrupt. Thus, excess capacity could be used as a credible threat to enforce collusion, and capital is endogenously determined in the first stage and affects the market competition in the second stage. On the other hand, higher capacity can also lead to lower short-run marginal cost, and thus to a smaller output by other firms.[7]

Finally, in equation (9), $\frac{\partial Q_J}{\partial k_i} < 0$ means $r_i > \frac{\partial q_i}{\partial k_i} MC_i$ under the oligopoly equilibrium $\left(MR = MC_i\right)$, which implies that capital price (r_i) is larger than its marginal revenue of product $\left(MRP_i^k\right)$. Thus, a small marginal product for capital $\left(\frac{\partial q_i}{\partial k_i}\right)$ caused by overinvestment in stage one leads to a misallocation of resources in stage two.[8]

IV. Data, Empirical Specification and Estimation

- *Data*. As we have already mentioned in section II, TFTC (2001) contains data about nine of ten major Taiwanese flour producers. The period that the data set covered is between 1994 and 1998. Thus, we have 45 observations for the regression analysis to be applied. The definitions of these variables are listed in the Appendix. Basically, this article uses a set of panel data to

[6] When there exists excess capacity, cartel members have an incentive to cheat and undercut the collusive price, since they can take over a larger share of the market. Thus, traditional IO theories believe that cartels break down for the sake of excess capacity. However, recent game theoretic contributions, such as Osborne and Pitchik (1983, 1986, 1987) and Davidson and Deneckere (1990), emphasize that the correlation between excess capacity and collusion is positive rather than negative.

[7] This is a usual result proposed by Fudenberg and Tirole (1984), Bulow, Geanakoplos and Klemperer (1985), and Roller and Sickles (2000).

[8] This result is consistent with the findings of Eaton and Grossman (1984), Yarrow (1985), Dixon (1986), and Roller and Sickles (2000). These models exhibit an asymmetry between *k* and *l* that leads to a non-optimal capital-labor ratio. Although production is efficient in the short-run, the strategic use of capital makes firms be not on their long-run cost functions.

test the collusive behaviors among the dominant firms. The panel data can be useful in some issues. First, it provides more available data, and increases the degrees of freedom. Second, combining both cross-section and time-series data can lessen the problem that occurs in the case of the omitted variables.

- *Empirical Specification*. Econometrically, we should deal with the above model by simultaneously estimating the demand function (1) and optimality conditions (6) and (9) from supply side. This approach needs to specify a linear demand function such as $P = a + bQ + cZ$, in which P is the flour price, Q is the industry output, and Z is a set of exogenous variables, so that we could estimate the elasticity of demand e. As the span of data covers only 5 years, demand elasticity becomes very difficult -if not impossible- to be estimated. Thus, we have selected a plausible parametric value for demand elasticity to implement the nonlinear regression analysis. We use 1.0 as the demand elasticity in the baseline specification. Furthermore, in order to make the model persuasive, a sensitivity analysis will be performed to check the robustness of the empirical result.

Since the model has to be imbedded within a stochastic framework for empirical implementation, we assume that both equations (6) and (9) are stochastic due to errors in optimization, where e_{1i} and e_{2i} are error terms. We now apply these two optimality conditions, obtained from the previous theoretical framework, to test the market behavior of flour firms. First, rewrite (6) as

$$P = \frac{MC_i}{1-(1+\theta)\frac{s_i}{\varepsilon}} + e_{1i} \tag{10}$$

Second, after some manipulations, (9) could be written as

$$s_i = \frac{\frac{\partial q_i}{\partial k_i}}{\frac{\partial Q_J}{\partial k_i}} \varepsilon \frac{MC_i}{P} - \frac{1}{\frac{\partial Q_J}{\partial k_i}} \varepsilon \frac{r_i}{P}$$

Then, we differentiate reaction function (7) with respect to k_i to get

$$\frac{\frac{\partial q_i}{\partial k_i}}{\frac{\partial Q_J}{\partial k_i}} = -\frac{1}{2+\theta},$$

and let $\gamma = \frac{\partial Q_J}{\partial k_i}\frac{k_i}{Q_J}$ be the elasticity to measure the impact of the individual firm's investment on its rivals' output. We therefore have:

$$s_i = -\frac{1}{(2+\theta)}\varepsilon\frac{MC_i}{P} - \frac{1}{\gamma}\varepsilon\frac{r_i k_i}{PQ_J} + e_{2i}, \tag{11}$$

Note that, in (10) and (11), $s_i = \frac{q_i}{Q}$. Additionally, we have the following identity:

$$Q = \sum_{i=1}^{n} q_i \tag{12}$$

Since these functional forms are non-linear and involve a set of relationships, we have to use a non-linear simultaneous-equations model to estimate the relevant coefficients. In addition, it is inevitable for the panel data to involve the correlations of the disturbances across equations. If we do not take into account these correlations between the disturbances of different structural equations, we are not using all the available information about each equation, and therefore we do not attain asymptotical efficiency. This insufficiency can be overcome by estimating all equations of the system simultaneously, using non-linear three-stage least squares.

- *Empirical Results*: Using these functional forms, we try to estimate the system of three equations (10) (11), and (12), which endogenize firm's capital stock (k_i), firm's output (q_i), and industry output (Q), by non-linear three stage least squares. The parameters to be estimated are q and g and the regression results are the ones that appear on Table 2.

The main result obtained is that the baseline specification (e= 1.0) generates the expected sign of q and g For the measurement of market power (q) there are enough evidences to suggest that flour firms monopolize the market through collusion. The estimated q is 7.58, which is significantly different form 0

Table 2. Empirical Results for Two-Stage Game, e = 1. Non-Linear Three-Stage Least-Squares Estimates

Coefficient	Estimates	Standard Deviation
q	7.58*	0.13
g	- 0.25*	0.02

Notes: The estimate of g has been converted into an elasticity. The number of observations is 45. * denotes that the estimates are significant at the level of 1%.

(Cournot model) and -1 (perfect competition model). Since there are nine flour firms in the sample, the result of q = 7.58 approximates to $n - 1 = 8$ under collusive regime. This implies that we cannot reject the hypothesis that firms do work out some forms of concerted actions to monopolize the market, and therefore our empirical evidences support the decision made by the TFTC.

By substituting the mean value of s_i, the estimate of q and e = 1 into (6),[9] the estimated mark-up over marginal cost is equal to 55.8%, which is substantially higher than the 6.5% that would hold if the market followed a Cournot-Nash behavior.[10] We therefore have a 49.3% increase in the mark-up due to the collusion in the market.

For the effect of strategic investment which determines whether a two-stage setup can be reduced to a single-stage model, the result exhibits a negative and significant g = -0.25. Capital stock being determined before the output decision implies that an individual firm can use its investment decision strategically. It conjectures that a 1% increase in capital investment could reduce the outputs of its rivals by 0.25%. This encourages firms to increase their capacity beyond the optimal level and, since new entry is artificially precluded by the industry's quota system, the excess capacity serves as an instrument to discipline cartel members.

Empirical work by Rosenbaum (1989) also indicates that the correlation

[9] Since collusion happens in the second stage (market stage), using (6) is a standard approach to compute the price-cost margin. Please refer to Roller and Sickles (2000) for details.

[10] We compute the mark-up for the case of Cournot-Nash behavior by setting q = 0.

between a firm's excess capacity and other firms' output is negative. High level of excess capacity could be used to punish deviators more harshly, since firms will easily dump a large amount of product into the market. The collusive agreement can therefore be enforced by a threat to revert to the Nash equilibrium strategies by fixing the prices in a non-cooperative game with the same given capacity.

V. Sensitivity Analysis

- *Specification of demand elasticity*. Because of data limitation, we have selected a specific parametric value for demand elasticity (e= 1.0) to implement the nonlinear regression analysis. Basically, this approach is a mixture of simulation and estimation, hence there will always be some arbitrariness in the choice of demand parameters. In this section, we use sensitivity analysis to examine the robustness of our findings to alternative parameterizations of the demand elasticity. The results are presented in Table 3.

Two aspects of these results deserve comment. First, if e is larger than 0.8,

Table 3. Sensitivity Analysis

e	q	g
0.2	3,385.31	- 0.03*
0.4	5,588.78	- 0.06*
0.6	41,012.99	- 0.45*
0.8	8.13*	- 0.23*
1.0	7.58*	- 0.25*
1.2	5.09*	- 0.23*
1.4	6.11*	- 0.27*
1.6	7.12*	- 0.30*
1.8	8.14*	- 0.34*
2.0	9.15*	- 0.37*

Notes: The estimate of g has been converted into an elasticity. The number of observations is 45. * denotes that the estimates are significant at the level of 1%.

the strategic effect (g) and the degree of collusiveness (q) have the expected sign and are statistically significant. They are also robust to changes in e. The estimated market conduct is between 5.09 and 9.15. All these estimated figures are significantly different from zero (which is the corresponding Cournot-Nash solution) and provide some evidences of cartel pricing.

Secondly, e and $|\gamma|$ moving in the same direction implies that the strategic effect is evident in the elastic part of the demand schedule. Since high e means high price and low market output in the case of a linear demand, cartel members have an incentive to cheat and undercut the collusive price so that they can take over a larger share of the market. The cartel may therefore need a more severe threat to sustain the collusive equilibrium. Thus, a stronger strategic effect to induce excess capacity and to work out a credible threat is a necessary condition for the success of the cartel. Under this situation, the cartel could inflict on deviators a larger damage by producing up to its capacity.

In addition, the fact that values of q are insignificantly different form zero when e is less than 0.8 indicates that a monopolist is always reluctant to set price in the inelastic part of the demand schedule, because, if e is large enough, even a considerably small value of $P - MC_i / P$ is consistent with collusion.

VI. Conclusion

In this paper, a two-stage game model is set up to deal with the strategic effect of the firm's capital investment on its rivals' outputs. The model is tested with panel data from the Taiwanese flour industry. The empirical evidences show that oligopolists expect that the long-term effects of their capacity investment may act to deter its competitors' outputs. This leads to overinvestment in the first stage and causes the misallocation of resources. Besides, the estimate of the conjectural variations also implies that firms do work out some forms of concerted actions to monopolize the market.

Appendix. Data Description and Construction

1) P: While there are some different grades of flour, output is homogenous across producers for any given grade. For the same grade of flour, price

therefore tends to uniformity. The variable P is constructed as a Divisia price index for the three types of flour sold in the market.

2) MC_i: Since the production technology of flour is simple and firms use a common technology, it is both convenient and realistic to assume constant marginal costs, particularly during periods of considerable excess capacity. We also assume that the marginal cost comprises the wage cost, the material cost and other expenses for production.

3) k_i and q_i: The capacity of the individual firm (k_i) is an average of year capacity. Production (q_i) is the actual yearly production.

4) s_i: Market share is defined as q_i / Q.

5) r_i: Capital price is defined as $r = k_P\,(r + d - g)$, where k_P is the price of the capital, r is expected rate of return, d is the rate of depreciation and g is the rate of capital gains. There are several ways to deal with g in the empirical studies. In this article, we assume that flour firms do not care about the capital gains when they decide to invest in the first stage. Thus, the capital price is redefined as $r = k_P\,(r + d)$. Since Taiwan CPI increased only by an annual rate of 2.6% between 1994 and 1998, we omit g in the user cost expression and get $r = k_P\, r + k_P\, d$.

6) The data of the opportunity cost ($k_P\, r$) is obtained from Ma (2004a). All the other data comes from the TFTC (2001) data set.

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