Increasing Concentration in the U.S. Hard Wheat Milling Industry:

Efficiency Gains or Market Power?

by

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Abstract

This research evaluated market power-cost efficiency trade-offs in the U.S. wheat milling industry. The principal findings are that the hypothesis of competition could not be rejected, and increasing concentration has helped to reduce the marketing margin by $0.65/100lbs flour. Social concerns about market power in this industry probably are unwarranted.
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Introduction: The U.S. wheat milling industry has undergone significant structural change in the past 30 years. Average mill size has grown by over 40%, location advantages are relatively more favorable for plants located nearer consumer markets, and the four-firm concentration ratio has more than doubled from 30% in 1969 to 77% in 1995 (Wilson). Concentration levels of this magnitude typically raise concern about the degradation of competition in an industry and the resulting welfare implications on upstream suppliers and downstream consumers. However, the role of increasing concentration in reshaping the nature of competition is far more complex than suggested by the structure-performance link to increased market power. Increased concentration also is linked to economies of scale and technical efficiency improvements, which can drive the price of outputs down and the price of principal inputs up and increase output.

This fundamental trade-off between market power and efficiency is at the heart of more recent interpretations of antitrust laws and stems from the points in Williamson’s (1968A) classic article over three decades ago. Mueller made this point most forcefully: “As the 1960's wore on, and the Supreme Court endorsed ever bolder attempts by the government to extend the reach of antitrust laws, dissent by economists began to grow. Responding to Justice Douglas’ dismissal in Procter and Gamble . . . , Oliver Williamson (1968[A]) advocated a welfare trade-off approach to mergers. Instead of focusing exclusively on their anticompetitive effects, courts were to weigh the anticompetitive effects of mergers against their efficiency gains.”

The philosophical shift from simple consumer welfare to a more comprehensive antitrust policy to include efficiency arguments generated important pro-business U.S. antitrust rulings in
the 1970s (Mueller). By 1984, the Department of Justice formally changed its Merger Guidelines to specifically limit the scope of merger challenges in cases when cost efficiency gains outweigh noncompetitive effects (Mueller). These changes and the rise of conservative politics in the 1980’s paved the way for major structural changes in U.S. businesses. Most noteworthy was increased merger activity, vertical arrangements, and rapidly increasing industrial concentration (Lande).

Peltzman found considerable evidence supporting Williamson’s proposition. Dixon demonstrated how aggregated cost functions generate testable hypotheses about cost efficiencies. Like Peltzman, he found considerable support across a group of U.S. industries that cost efficiencies accrue from increasing concentration. Azzam (1997) used Dixon’s aggregation technique to test the cost-efficiency trade-off question on the U.S. beef packing industry. He found that the benefits from cost efficiencies outweighed the impact of market power.

Given the results supporting Williamson and subsequent changes in antitrust law, it is indeed perplexing that the economics field has not addressed the issue of market power more in this way.¹ The market power-efficiency debate is also important in light of increased global competition, freer trade, and negotiations to harmonize competition policies across nations and free trade regions (Immenga, Jenny, and Petersmann). As Mueller pointed out, the United States has maintained the most stringent antitrust laws in the world. Yet theory and empirical evidence point to strategic trade advantages to nations that allow complex vertical structures, nationally sanctioned commodity marketing boards and high levels of concentration (Hamilton and Stiegert, 2003).

¹For example, of the 33 studies summarized in Azzam and Anderson that investigated market power in the U.S. meat processing industries, only three addressed the efficiency issue (Ward, Hall et al., Schroeter and Azzam), and only Schroeter and Azzam did so as a principally stated objective. Furthermore, both Schroeter and Azzam and Hall et al. suggested that increased concentration led to net efficiency benefits, and Ward’s study was inconclusive.
Stiegert and Hamilton). Clearly, understanding the impact of increasing concentration is more than just measuring market power.

This study had two objectives. The first was to evaluate the null hypothesis of a competitive flour-wheat marketing margin for the U.S. wheat milling industry. A statistical test of market power was generated for each quarter from 1983-I through 1995-II for the wheat input market and for the flour output market. By evaluating each quarter, these tests helped to reveal when or if noncompetitive pricing occurred in the wheat input and/or flour output markets.

A second objective was to evaluate the role of increased concentration as a potential source of lower marginal costs for the industry. Once again, a statistical test is generated at each data point to allow the model to reveal when or if such benefits arose.

**Conceptual Framework:** Consider an industry with firms that have the potential to buy a principal material input with oligopsonistic power and to sell a processed good with oligopoly power. The supplier of the principal input and the buyers of the output good are assumed to be perfectly competitive. This particular structure fits nicely into the institutional framework of wheat milling, which relies on a simple technology to process a principal input into a principal output and a byproduct (Azzam, 1992). We proceed with a terse presentation of the model. A complete version is available on request.

A wheat production/storage (hereafter upstream) sector is assumed to be competitive, with each upstream firm facing a cost function that aggregates to an industry-wide cost function. The first order condition of the upstream industry solved for the price of wheat is given by:

\[
(1) \quad p_w = e \frac{\partial C(\frac{q_f}{e}, z_w)}{\partial q_f}.
\]
where \( p_w \) is the price of wheat, \( q_w = eq_w \) is wheat flour obtained from the product of total wheat processed at the extraction rate \( e \). \( C^w \) is the cost function, and \( z_w \) is a vector of producer input prices. The above conversion to flour using wheat extraction implies a fixed proportion between wheat and flour but leaves flexible the remaining cost relationships. Taking the first order condition of the profit equation representing the baking sector and rearranging yields:

\[
(2) \quad p_f = k_1 p_b - \frac{\partial C^b(p_f, q_f, z_b)}{\partial q_f}.
\]

where \( k_1 \) is a constant to convert bread output to a flour equivalent basis, \( p_b \) is the price of bread, \( q_b \) is the quantity of bread produced, \( p_i \) is the price of flour, \( C^b \) is the processing cost function, and \( z_b \) is a vector of baking input prices.

The milling profit equation for firm \( i \) is given by:

\[
(3) \quad \pi_{fi} = (1-e)p_m \frac{q_{fi}}{e} + p_f q_{fi} - C^f(p_w, \frac{q_{fi}}{e}, z_f) - p_w \frac{q_{fi}}{e},
\]

where \( p_m \) is the selling price of byproducts (e.g. middlings), \( C^f \) is the milling processing cost function considered to be a function of wheat processed, wheat prices, and a vector of other processing input prices. The first term in (3) is the percentage of wheat sold in the byproduct market. Substituting (1) and (2) into (3) incorporates the profit maximizing first order conditions of the upstream and downstream sectors into the miller’s profit equation, which is given by:

\[
(4) \quad \pi_{fi} = q_{fi} \left[ (1-e)\frac{p_m}{e} + k_1 p_b - \frac{\partial C^b(q_f, p_f, z_b)}{\partial q_f} - \frac{\partial C^w(q_f/e, z_w)}{\partial q_f} \right] - C^f(q_{fi}/e, p_w, z_f).
\]
Taking the first derivative of (4), substituting back in the price of flour from (7) and the price of wheat from (2), and aggregating the share-weighted sum of all firms in the industry yields:

\[
\left( \frac{p_f}{e} \right) (1 - e) \left( \frac{p_m}{e} \right) - \frac{p_w}{e} = q_f \Phi \frac{\partial^2 C^b(q_f, p_f, z_b)}{\partial q_f^2} + q_f \Phi \frac{\partial^2 C^w(q_f/e, z_w)}{\partial q_f^2} + \frac{\partial C^f(q_f/e, p_f, z_f)}{q_f}.
\]  

The left side of equation (10) is composed of two revenue terms in the brackets minus the flour equivalent price of wheat. This expression for the marketing margin fits precisely the data reported by the USDA in *Wheat Situation and Outlook Report*. The right side of (4) indicates that the margin is made up of three different components that represent, from left to right, a downstream market power term, an upstream market power term, and marginal processing costs.

The market power terms each contain an aggregate conjectural elasticity \( \Phi = \sum_j s_j \phi_j \) where \( \phi_j = (\partial q_f / \partial q_f) \times (q_j / q_f) \). For this study, identifying \( \Phi \) was not an issue. We were only concerned if marginal costs adequately explain movement in the marketing margin.

**Methodology and Data:** Following equation (5) and specifying the processing, upstream and downstream industry cost structures using generalized Leontiff cost functions, a model useful for econometric analysis of the industry is given by:

\[
\left[ \frac{p_f}{e} (1 - e) \left( \frac{p_m}{e} \right) - \frac{p_w}{e} \right] = \frac{2q_f \Phi \sum_j \beta_{j,i} z_{i,j} + 2q_f \Phi \sum_j \mu_{j,i} \gamma_{i,j} \sqrt{\sum_j \gamma_{i,j}^2} + \frac{2q_f}{e^2} \sum_i \delta_{i,j} z_{i,j} + g(\cdot)}{e^2}.
\]  

s.t. \( \frac{2q_f}{e^2} \sum_i \beta_{i,j} z_{i,j} \geq 0 \), \( 2q_f \sum_j \mu_{j,i} z_{i,j} \geq 0 \)
As described in reference to (5), the first two terms on the right side of (6) are components of the margin attributable to market power in the pricing of the material input and the material output. Our theory essentially restricts these market power terms to be nonnegative. The final term in (6), \([g(\cdot)]\), is a general expression to capture shifts in marginal costs due to structural changes and allows for inclusion of an intercept term. The specific function for \(g(\cdot)\) is given by:

\[
g(\cdot) = v_0 + v_1 \text{CR4} + v_2 \text{CU} + v_3 \text{CR4} \times \text{CU}
\]

where the \(v_s\) are parameters to be estimated, CR4 is the four firm concentration ratio, and CU is capacity utilization. Imposing symmetry of the processing cost function of the miller requires that \(\gamma_{ij} = \gamma_{ji}\). This study used two upstream prices, two downstream prices, and two prices in the milling cost function. The complete empirical specification of equation (6) is given by:

\[
\text{MARGIN} = e^{a_1*US1 + a_2*US2} + e^{a_3*DS1 + a_4*DS2} + a_0 + a_1*\text{MENGY} + a_2*\text{MWAGE} + a_3*\text{MM1} + a_4*\text{MILL1} + a_5*\text{MILL2} + b_1*\text{CR4} + b_2*\text{CU} + b_3*\text{CR4} \times \text{CU} + \eta
\]

where US1 and US2 are two upstream market power terms derived from the second derivative of the upstream cost function. US1 contains a real farm input cost index, and US2 contains a real farm labor price index. DS1 and DS2 are two downstream market power terms. DS1 contains a deflated formula index of baker inputs, which is based on a common high production bread formula from Pyler. The second downstream term, DS2, contains a wage price series for average hourly production worker earnings for bread, cakes and related products.

Two mill processing input prices were used. One is an energy price index (MENGY) industrial power 500 kw demand, and the other (MWAGE) is average hourly production worker
earnings for flour and grain mill products. Both upstream and downstream market power terms are restricted to be nonnegative by use of the exponential transformation of the appropriate pairs of terms. The term MM1 is the square root term as dictated by the third term on the right side of (6). The terms MILL1 and MILL2 each contain \((2q/e)\) and one of the input prices as dictated by fourth term on the right side of (6). The last row in (8) contains the efficiency terms from (6). Finally, the terms \((u1, u2, d1, d2, a0, a1, ...., a5, b1, b2, b3)\) are parameters to be estimated.

Equation (8), corrected for autocorrelation, was estimated using quarterly data from 1983-I to 1995-II. Solutions were validated across a group of different starting values.

**Results and interpretation:** Results from the first model are presented in Table 1. To avoid the ambiguity associated with concentration and capacity utilization, the first model was run without the efficiency terms. Five of the six parameters of the milling cost function \((a0, a1, a2, a4, a5)\) and one of the upstream market power terms were statistically significant. Significance of the singular portions of upstream or downstream market power is of little importance. What is of interest is the statistical significance and applied importance of total upstream and/or downstream market power terms. A test of the total upstream market power at the mean of the data is presented at the bottom of Table 1. Then a test for market power was conducted at each data point using the parameter variances and covariances (Table 2). The mean estimates for both upstream and downstream market power were not significant. Only 5 of the 50 upstream data points in the study were statistically significant whereas none of the downstream market power terms were significant. Furthermore, the significant upstream market power data points were early
in the study: three quarters in 1983 and one quarter in 1985 when concentration was the least problematic.²

The first model provides little or no evidence of market power, and the role of increased concentration in fundamentally restructuring the competitive conditions of the industry must also be very limited. If increased concentration is having an impact on the industry, it must be limited to technology and scale efficiencies. The resulting a priori hypothesis for model two is that \( \frac{\partial \text{MARGIN}}{\partial \text{CR4}} = b_1 + b_3 \times \text{CU} \leq 0 \). Capacity utilization varies because of shifts in demand and in supply of aggregate capacity. If market power is not present, firms move along their marginal processing cost curve in response to demand shifts, which immediately implies for model two that: \( \frac{\partial \text{MARGIN}}{\partial \text{CU}} = b_2 + b_3 \times \text{CR4} \geq 0 \).

The results from model two are presented in Tables 1 and 2. The parameters u₁, u₂, d₁, d₂, and a₀ through a₆ are very similar in magnitude and sign, but fewer are now statistically significant. Similar to model one, the tests of market power at the means failed to reject the null hypothesis of competition. Furthermore, market power tests were not significant in the upstream and downstream markets at each data point.

Although none of the efficiency parameters were statistically significant as shown in Table 1, the marginal effect of concentration and capacity utilization is dependent on the direct effect

²This is a strong result in light of Jones and Purcell’s study that evaluated the impact of aggregation in identifying market power. Using data generated from various simulated firm level production technologies, they showed that standard NEIO specifications for aggregate cost functions tend to identify market power when an industry is purposely structured to be competitive and nearly competitive. The results tend to suggest that NEIO studies using aggregated data increase the possibility of a Type I error above that suggested that by standard inference of parameters. In cases where market power was simulated, aggregation did not hamper its identification. The main point here is that if market power had been present in the wheat milling industry, we probably could have identified it using aggregate data.
and on the interaction term. The standard errors for these marginal effects are calculated at each data point. The marginal effect on the marketing margin for concentration is negative and statistically significant at the mean. Furthermore, concentration is statistically significant for 34 of the 50 data points. The mean value of the marginal effect of concentration at -2.2 implies that for every 1% increase in concentration the margin has tightened by about $0.022. Concentration has risen through the study period from about 50% in 1983 to about 77% in 1995. As a result, concentration appears to be responsible for about a 65¢ reduction in the marketing margin.

The marginal effects of capacity utilization on the marketing margin were positive at each data point but none were statistically significant. Results showed no indication that firms use excess capacity to limit price or that economic losses can be avoided when the industry operates below design capacity. In summary, the results associated with excess capacity were not inconsistent with the industry operating in a competitive environment.

**Summary and conclusions:** Wheat milling has become quite concentrated, with over 75% of milling capacity owned by the four largest firms. The purposes of this study were to test for tacit market power in the wheat buying and flour selling activities of the U.S. wheat milling industry and to evaluate the role of increasing concentration on efficiency improvements in the industry. The model used data from the first quarter of 1985 through the second quarter of 1995.

The overwhelming result from this study was that the hypothesis of a competitive U.S. wheat milling industry cannot be rejected. Specifically, hypothesis tests for market power in the upstream sector indicated that only 5 of the 50 quarters were statistically different from zero. A similar test of market power in the downstream sector yielded no statistically significant observations. Furthermore, the marginal effect of concentration proved statistically significant.
and negative, which suggested that increasing concentration has more to do with increasing efficiency than in generating market power. The results indicate that increased concentration has led to about a $0.65 reduction in the marketing margin over time.

Why would an industry with almost 80% of capacity controlled by four large firms not be able to force a noncompetitive equilibrium? Several institutional factors present in this industry may in part offer an explanation. First, wheat mills compete for wheat inputs and flour outputs on a national scale (Stiegert, Parcell, and Blanc), which is structurally quite different than industries that process perishable goods or live animals. Second, existence of a world market for wheat generates considerable competition from grain traders, which may provide a sufficient deterrent to firms trying to exercise market power. A third, and perhaps most obvious, reason is that firms have simply focused on efficiency and innovation during the period of the study. For whatever the reason, market power does not appear to be a major concern for this industry at this time.

The key consequence of increasing concentration in milling was shown to be in the form of efficiency gains. Firms in this industry apparently have been driving each other toward a more optimal firm size rather than using their size to extract monopsony or monopoly rents. This result strongly indicates the need for more intense evaluation, across the entire food sector, of the role of increasing concentration in generating cost efficiencies. Failure to do so puts our research agenda out of step with antitrust proceedings and limits the critical role that economists have in driving antitrust cases to their socially best outcomes.
Table 1: Model Results U.S. Wheat Milling Industry: 1983I-1995II.

<table>
<thead>
<tr>
<th>Variable</th>
<th>First Model</th>
<th>Second Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upstream</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u1</td>
<td>0.0621 (0.045)*</td>
<td>-2.439 (0.613)*</td>
</tr>
<tr>
<td>u2</td>
<td>-0.1505 (0.135)</td>
<td>-1.292 (0.927)*</td>
</tr>
<tr>
<td><strong>Downstream</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d1</td>
<td>-0.0550 (0.062)</td>
<td>-0.637 (0.059)</td>
</tr>
<tr>
<td>d2</td>
<td>0.1418 (0.161)</td>
<td>0.164 (0.153)</td>
</tr>
<tr>
<td><strong>Mill Processing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a0</td>
<td>2.697 (1.850)³</td>
<td>2.425 (1.35)³</td>
</tr>
<tr>
<td>a1 MENGY</td>
<td>1.609 (0.792)³</td>
<td>1.622 (1.406)</td>
</tr>
<tr>
<td>a2 MWAGE</td>
<td>0.178 (0.145)</td>
<td>0.225 (0.184)</td>
</tr>
<tr>
<td>a3 MM1</td>
<td>-0.575 (0.308)³</td>
<td>-0.595 (0.497)³</td>
</tr>
<tr>
<td>a4 MILL1</td>
<td>-0.1907 (0.113)³</td>
<td>-0.145 (0.165)</td>
</tr>
<tr>
<td>a5 MILL2</td>
<td>0.3926 (.250)³</td>
<td>0.229 (0.155)³</td>
</tr>
<tr>
<td><strong>Shift Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b1 CR4</td>
<td></td>
<td>0.014 (0.098)</td>
</tr>
<tr>
<td>b2 CU</td>
<td></td>
<td>-1.828 (15.16)</td>
</tr>
<tr>
<td>b3 CR4×CU</td>
<td></td>
<td>-0.004 (0.157)</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autocorrelation (ρ)</td>
<td>0.5725 (0.121)³</td>
<td>.573 (.153)³</td>
</tr>
<tr>
<td>R²</td>
<td>0.7992</td>
<td>0.7950</td>
</tr>
<tr>
<td><strong>Tests at the mean</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream Market Power</td>
<td>0.648 (0.662)</td>
<td>0.000 (0.000)</td>
</tr>
<tr>
<td>Downstream Market Power</td>
<td>0.255 (0.425)</td>
<td>0.196 (0.286)</td>
</tr>
<tr>
<td>Concentration</td>
<td>-2.224 (1.550)*</td>
<td></td>
</tr>
<tr>
<td>Capacity Utilization</td>
<td></td>
<td>0.011 (0.013)</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parenthesis.
*Significant at the 10% level for a one-tailed t-test
²Significant at the 10% level for a two-tailed t-test
³Significant at the 15% level for a two-tailed t-test
<table>
<thead>
<tr>
<th>Model 1: Upstream</th>
<th>Statistically significant in all quarters of 1983 and first quarter of 1985. One-tailed test, $\alpha=.10$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: Downstream</td>
<td>Statistically significant in the first two quarters of 1995. One-tailed test, $\alpha=.10$</td>
</tr>
<tr>
<td>Model 2: Upstream</td>
<td>Not significant in any quarter.</td>
</tr>
<tr>
<td>Model 2: Downstream</td>
<td>Not significant in any quarter.</td>
</tr>
<tr>
<td>Model 2: Concentration</td>
<td>Negative in all quarters. Statistically significant in 34 of the 50 quarters. One-tailed test, $\alpha=.10$</td>
</tr>
<tr>
<td>Model 2 Capacity</td>
<td>Positive, but not significant in all quarters.</td>
</tr>
<tr>
<td>Utilization $[\bar{c}<em>{MM}/\bar{c}</em>{CR4}]$</td>
<td></td>
</tr>
<tr>
<td>Utilization $[\bar{c}<em>{MM}/\bar{c}</em>{CU}]$</td>
<td></td>
</tr>
</tbody>
</table>
References


