A Decomposed Regression Model for Measuring Structural Changes in the Flour Milling Industry

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ABSTRACT

This paper presents a decomposed Poisson regression model based on count data that evaluates the size distribution, the changing number of flour mills for each size class, and the concentration of market power, simultaneously. This model also allows us to test dominant price leadership model.

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1. Introduction

The U.S. milling industry has experienced considerable structural change in size, location and number of plants during the last three decades. Between 1973 and 1999 the number of plants milling wheat flour steadily declined to 198 from 279. The number of the smallest size class mills with daily capacity under 1,000 hundredweight (cwt) declined from 125 to 34 during the same period, while the largest size class flour mills with daily capacity over 10,000 cwt increased from 24 to 61. At the same time, wheat-flour production increased substantially from 255 million cwt to 404 million cwt. Following railroad deregulation in the early 1980s, the advent of unit train technology in wheat shipments lowered the cost of shipping wheat relative to the cost of shipping flour and mill feeds (Wilson, 1995). Since then, flourmills were more commonly built at or near metropolitan centers.

Another important change in the U.S. milling industry is the increased concentration level of market power in geographically dispersed markets. In the early 1970s, market share for family owned or owned by local elevator companies accounted for more than 70 percent, while the remaining market was shared by vertically integrated food processors (such as Pillsbury, Nabisco, General Mills, and International Multi-Foods) and multi-unit flour millers (such as ConAgra, Cargill, ADM). By 1992, market share for the four largest multiunit flour millers accounted for nearly 70 percent, where Cargill dominates in California, ADM in the Midwest and Pacific Northwest, and

ConAgra in the East (Wilson, 1995). Significantly increased market power in geographically divided regional markets, when accompanied by entry barriers, would seem to enhance both prices and firm profits. Economies of scale in plant size and capital requirements would seem to have contributed to erecting barriers to entry (Wilson, 1995). However, historical data clearly indicates otherwise.

During the period of 1972-1990, there were 112 exits with an average daily capacity of 1,300 cwt, while there were 40 new entries with an average daily capcity of nearly 2,800 cwt (Wilson, 1995). Both a high birth and death rate for new plants suggest that economies of size and capital requirements are not formidable barriers to entry in the U.S. milling industry. Furthermore, the number of large sized mills with an average daily capacity of nearly 15,000 cwt increased to 61 in 1999 from 24 in 1973. As a result of an increased number of larger size mills, market share for the four largest flour millers declined to 57 percent by 1997 from 70 percent in 1992. The greater number of large sized plants and weak barriers to entry suggests that the wheat-flour price would tend toward a monopolistic or competitive price level. By measuring net income from flour milling as a percentage of total flour milling assets, Goldberg (1983) considered the U.S. flour milling industry as a very low profit industry. In addition, the marketing margin over the cost of wheat at the Kansas City wholesale price has actually declined, with minor fluctuation, from $4.82/cwt during the 1973-74 period to $1.92/cwt during the 1997-98 period (in 1990 prices). Therefore, together with a large number of independent mills and free entry and exit, historical data may actually suggest that wheat-flour has been produced under monopolistic competition.

Both product differentiation and excess capacity characterize monopolistic competition. Differentiated products distinguish the industry from pure competition, and no mutual interdependence separates it from differentiated oligopoly. Each milling firm makes no economic profits in the long-run and operates with excess capacity. Under monopolistic competition, the number of mills tends to be excessive, and each mill has an under-utilized scale of plant. In fact, a larger plant is generally so much more efficient than a small one that it is economical to build a larger plant and under-utilize it (Cohen and Cyert, 1975; Kamerschen and Valentine, 1977).

Finally, it is an open question whether society is better served by a large number of small mills competing under conditions of atomistic competition or by a smaller number of larger mills under monopolistic competition. In monopolistic competition, milling firms produce smaller rates of wheat-flour at higher average costs (hence sell their products at higher prices where average costs equal average revenue). The fewer, but larger mills can operate at lower cost than more numerous small mills, who have been forced by their higher costs either to merge or to go out of business. Under this circumstance, the economies of large scale may exceed the benefits that would result from atomistic competition (Shepherd, Futrell, and Strain, 1976).

The objectives of this paper are three-fold. Section 2 investigates the causes of structural change in terms of the number and size of wheat-flour mills in the U.S. flour milling industry. Economic variables that contribute to structural changes are identified. Using these variables, a multinomial logit model (MLM) is presented to characterize the changing size distribution of mills, while an aggregate Poisson regression model (PRM) is presented to measure the changing number of wheat-flour mills. The changing size distribution and number of wheat-flour mills occur simultaneously under any structural changes occurring in the U.S. milling industry. Therefore, section 3 presents a decomposed PRM model to characterize both the size distribution and the changing number of mills simultaneously. The model is then applied with data covering 1973-1998. The size selection and the number of wheat-flour mills for each size class are estimated under various economic scenarios characterized by changing labor and capital costs, and by changing output price. In Section 4, concluding remarks are offered.

2. Economic Factors Affecting Milling Structural Changes

Several different forces are responsible for structural changes in the U.S. milling industry. The major reason for expansion in plant size that has been hypothesized by many economists is to achieve economic efficiency in input use (Adelman, 1958; Farris and Padberg , 1964; Harwood , Leath and Heid, 1989). Chambers (1988), however, provided a broader theoretical foundation, explaining that expansion of plant size depends largely on the size of the elasticity of (total) cost with respect to output. To address these issues, let the cost function for a milling operation be represented in general as $C(x, y_j)$, where x is a vector of input costs and y_j is milling output from the jth size-class mill. Furthermore, let $y_j=k_iy_i$ $(i \neq j)$, where $k>0$ is the number of identical plants, each producing $y_i = y_j / k_i$. The toatl milling cost function can then be represented as: $C(x, y_j) = C(x, k_iy_i) = k_i^{\lambda(x, ki, yi)}C(x, y_i)$, where $\lambda(x, k_i, y_i)$ is the elasticity of the total cost function (Ferguson, 1969) or the elasticity of size (Chambers, 1988). When $\lambda(x, k_i, y_i) > 1$, the cost function identifies diseconomies of size, revealing that a multi-plant operation would be cost-effective. When $\lambda(x, k_i, y_i) < 1$, the cost function identifies economies of size, revealing that a larger sized operation, through either acquisition or a merger would be cost-effective. When $\lambda(x, k_i, y_i) = 1$, the cost function characterizes constant returns to size, that is, there are no economies or diseconomies of size.

Another factor explaining the increase in the size of milling operations is the increase that has taken place in the speed and range of transportation services bringing wheat to a milling plant (Mansfield, 1968). Improved unit-train technology has increased the radius of the wheat supply area around most plants, which leads to lower procurement costs as well as to larger milling volumes.

How large does a plant need to be to attain maximum economic efficiency? To answer this question, the U.S. wheat-flour milling industry is grouped into four size classes based on the size of daily active capacity. The four size classes include $0 \leq S_1 < 1{,}000$ cwt; 1,000 cwt $\leq S_2 < 5{,}000$ cwt; 5,000 cwt$\leq S_3 < 10{,}000$ cwt; and $S_4 \geq 10{,}000$ cwt. Furthermore, exit from flour milling is treated in a manner analogous to the merging of independent operations. Indeed, the ownership of most flour milling companies has changed mainly through acquisitions (Harwood, Leath and Heid, 1989). Results in Table 1 support that even though there have been structural changes among different size classes, no evidence exists of intrastructural changes within each size class.

Under monopolistic competition, free entry forces the firm to produce where total revenue equals total costs and economic profits equal zero. That is, $P_y y_j = C(x, y_j)$ or $y_j = C(x, y_j) / P_y$, where P_y is unit price of y. Therefore, the selection of mill size can be explained with normalized input prices. Among many others, both wage and corporate bond rates are considered in general economics to play a very significant role in explaining increases in plant size.

2.1 A Multinomial Logit Analysis

Structural changes within the U.S. flour milling industry consist of both size distribution and a changing number of milling operations. Transition probabilities associated with a Markov process (Chan, 1981; Farris and Padberg, 1964; Garcia, Offutt, and Sonka , 1987) and a multinomial logit analysis (Adelaja, Nayga, and Farooq, 1999; Kim, Lin, and Leath,1991) have been often used to explain structural changes in firm size distribution.

Following McFadden (1975), and Domencich and McFadden (1975), the selection probability of the *i*th milling size class is represented in a MLM as:

(1) $$Pi = \exp(D_i) / \sum_{j=1}^{m} \exp(D_j), \quad i = 1, 2, \ldots, m$$

where D_j is the estimated utility function U_j, such that $U_j = D_j + \varepsilon_j$, and all ε_j are independently and identically distributed with a Weibull distribution. The normalized MLM is then written as:

(2) $$P_i = \exp(d_i) / [1 + \sum_{j=2}^{m} \exp(d_j)], \quad i = 1, 2, \ldots, m$$

where $P_1= [1 + \sum_{j=2}^{m} \exp(d_j)]^{-1}$ and $P_i/P_1 = \exp(D_i\text{-}D_1) = \exp(d_i)$.

The odds of a milling firm operating an *i*th size mill over the size class 1 is given by:

(3) $$P_i/P_1 = \exp[\ a_{io} + a_{i1}\,(w/p) + a_{i2}\,(r/p) + \varepsilon_i\ ], \quad i = 2, 3, \ldots, m,$$

where *w* represents the hourly wage of production workers in the flour mill industry ($/hr), *r* represents corporate bond rates, and *p* represents a unit price of wheat-flour ($/cwt).

The hourly wages of production workers in the flour mill industry were obtained from the Bureau of Labor Statistics, U.S. Department of Labor. Corporate bond rates and wheat-flour price data were obtained from the Economic Research Service, U.S. Department of Agriculture, and daily milling capacity data for flour mills were obtained from the industry source Milling and Baking News, Milling Directory: Buyer's Guide. Table 2 shows the MLM maximum likelihood estimators (estimated using the SAS PHREG procedure with data covering 1973-98). Results indicate that as wage rates increase or the corporate bond rate declines, a significant number of independent small size mills are consolidated into a larger size milling operation through either acquisition or merger arrangements. Size class probabilities, estimated at mean values for each of the four size class equations are as follows:

(4) $[P_1 \;\; P_2 \;\; P_3 \;\; P_4] = [0.3148 \quad 0.2738 \quad 0.2368 \quad 0.1746]$.

However, transition probabilities explain only the size distribution of structural changes within the U.S. flour milling industry. To evaluate the effects on wheat-flour supply of changes in explanatory variables, information on the changing number of mills is also required, as discussed in the following section.

2.2 A Poisson Regression Model

Both a simple regression model (Farris and Padberg,1964; Reining,1988) and a conditional expected value equation (Chan, 1981) have been used to estimate the changing number of firms within an industry. The use of linear regression with count variables, however, would result in inefficient, inconsistent, and biased estimators. The Poission regression model (PRM) is one of a few models that deal with characteristics of count outcomes. We use a Poisson model to estimate changes in the number of mills to improve the economic analysis of milling-industry structural change.

Let N be a random variable indicating the number of flour mills that were counted during an interval of time. The PRM is then represented by the following functional relationship.

(5) $\mu_i = E[N_i \mid (w_i/p_i), (r_i/p_i)] = \exp[b_0 + b_1(w_i/p_i) + b_2(r_i/p_i)]$,

where $\Pr(N_i \mid (w_i/p_i), (r_i/p_i)) = \exp(-\mu_i)\,\mu_i^{N_i} / N_i!$ and the subscript *i* represents the *i*th observation. The PRM has a very restrictive theoretical characteristic, that is, its conditional mean should equal its conditional variance. However, researchers can often encounter an overdispersion problem with some count variables having a variance greater than the mean which leads to inefficient estimators. Correcting this overdispersion problem leads to use of the negative binomial regression model (NBRM) such that:

(6) $\tilde{u}_i = \exp[b_0 + b_1(w_i/p_i) + b_2(r_i/p_i) + \acute{\varepsilon}]$,

where $\acute{\varepsilon}$ is a random error assumed to be uncorrelated with the explanatory variables. The NBRM allows for the conditional variance to exceed the conditional mean. However, in practice, the NBRM has its own problem in application. Its Hessian matrix is more complex, and therefore, use of SAS GENMOD to estimate a negative binomial regression model often results in a non-negative definite Hessian matrix. Hellerstein (1995) proposed the use of a Quasi-Newton algorithm, which is a member of a family of variable metric algorithms (Avriel, 1976). The Quasi-Newton algorithm is also complex, but its software is not readily available. Since we are only interested in the expected value of the count variable, rather than the distribution of the count variable, and the estimates from the PRM are unbiased and consistent, but inefficient (Gourieroux et al , 1984.; Long 1997), we use the PRM here for economic analysis.

Using SAS GENMOD to estimate the Poisson regression model, the maximum likelihood estimators are presented in Table 2. Results indicate that as wage rates increase or the corporate bond rate declines, the total number of flour mills declines through acquisition or merger arrangements. During the period of 1973-99, wage rates and the corporate bond rate have declined by 13 percent and by 76 percent, respectively, while the total number of flour mills have declined by 81 mills.

The total number of flour mills is estimated to be 232 mills when using mean values for the explanatory variables. The distribution of flour mills for each size class are estimated using the MLM size-class probabilities in equation (4). Both MLM and PRM estimates are presented in Table 3. Using the observed number of flour mills for each size class (f_i) and the corresponding (estimated) expected number of flour mills (e_i) at mean values, the χ^2–statistic, in the form of $\chi^2 = \Sigma(f_i - e_i)^2/e_i$, is calculated to be 0.1817. This result indicates that the estimates of the MLM performs well in explaining the size distribution of the structural changes within the U.S. flour milling industry, while the estimates of the PRM model performs well in estimating the changing number of flour mills.

3. A Decomposed Poisson Regression Model for Structural Change

In the previous section, the size-class distribution and the changing total number of flour mills have been analyzed separately with multinomial logit and Poisson regression models, respectively. Since both the size-class distribution and the changing number of flour mills occur simultaneously in the process of the changing structure of the U.S. flour milling industry, it would be more efficient to evaluate both the size distribution and the number of mills for each size class simultaneously.

Let $N_i(j)$ be the *i*th observation of the *j*th size class for flour mills, and $D_i(k)$ be the *i*th element of the *k*th unit vector associated with the *k*th size class. The Poisson regression model that reflects both structural changes in the size-class distribution and the total number of flour mills of the *j*th size class is then represented as:

$$(7) \qquad N_i(j) = \exp\left[\alpha_0 + \sum_{k}^{m} \beta(k)D_i(k)(w_i/p_i) + \sum_{k}^{m} \gamma(k)D_i(k)(r_i/p_i) + \sum_{k}^{m-1} \delta(k)D_i(k)\right], \qquad j = 1, 2, \ldots, m$$

where α, β, γ, and δ are parameters, and

$$D_i(k) = \begin{cases} 1 & \text{if } k = j \\ 0 & \text{otherwise.} \end{cases}$$

With this joint structural/number of flour mills relationship, as wage rates increase, milling firms would achieve greater economic efficiency by consolidating and eliminating duplication of operation. Consequently, the number of larger size mills would increase, while the number of smaller size mills would decline. Therefore, the parameter $\beta(j)$ associated with smaller size mills is expected to be negative, while it is positive for larger size mills. Similarly, declining corporate bond rates would reduce capital costs associated with acquisitions or mergers so that the parameter $\gamma(j)$ is expected to be positive for smaller size mills, while it would be negative for larger size mills.

This decomposed Poisson regression model is estimated using SAS GENMOD. Parameter estimates are presented in Table 4. The sign of all estimators are consistent with a priori expectation. The effects of explanatory variables on the number of mills for size class S_1 ($0 \leq S_1 < 1{,}000$cwt) are almost twice as significant as the effects of the explanatory variables for size class S_4 ($S_4 > 10{,}000$ cwt), and in the opposite direction. Meanwhile, the effects of explanatory variables on the number of mills for size class S_2 (1,000 cwt $\leq S_2 <$ 5,000 cwt) are nearly half the effect for mills in size class S_4, also in the opposite direction. These results may indicate that wheat-flour mills of size classes S_1 and S_2 are merged to a larger size flour mill. The estimated mill numbers for each size class at mean values for explanatory variables are presented in Table 3. The χ^2–statistic is computed to be 0.2222, which indicates that the estimated decomposed PRM model parameters presented in Table 4 explain the structural changes within the flour mill industry very well (both its size-class distribution and its changing number of flourmills over time).

Wage rate, corporate bond rate, and wheat-flour price elasticities for the number of mills in each size class are represented in equations (8) through (10), respectively.

(8) $\eta_w(j) = [\partial\, N(j) / \partial\, w][w / N(j)] = \beta(j)\,[w / p] \lesseqgtr 0, \quad j = 1, 2, \ldots, m$

(9) $\eta_r(j) = [\partial\, N(j) / \partial\, r][r / N(j)] = \gamma(j)\,[r / p\,] \lesseqgtr 0, \quad j = 1, 2, \ldots, m$

(10) $\eta_p(j) = [\partial\, N(j) / \partial\, p][p / N(j)] = -\,[\beta(j)(w/p) + \gamma(j)(r/p)] \gtreqless 0, \quad j = 1, 2, \ldots, m.$

Results indicate that the wage rate and corporate bond rate elasticities vary across the size of plants. The flour price elasticity for the number of mills equals a negative of the sum of wage and corporate bond rate elasticities. Therefore, no changes in the number of flour mills are expected as all three variables increase or decrease by the same proportion. These elasticity relationships are estimated at mean values for explanatory variables and presented in Table 5.

Elasticities for size classes S_1 through S_4, along with the estimated number of flour mills for each size class, are used to compute a weighted average elasticity for the decomposed PRM. For the aggregate PRM, estimated model parameters presented in Table 2 are used to estimate $\boldsymbol{\eta}_w$, $\boldsymbol{\eta}_r$, and $\boldsymbol{\eta}_p$. Results show that weighted average elasticities for the decomposed PRM are slightly lower than, but very similar with those for the aggregate PRM.

3.1 Simulation Results

Under monopolistic competition, a firm would operate its flour mills where average costs equal average revenue. As either the wage rate or corporate bond rate increases, a firm would be expected to raise its flour price. To demonstrate that an increase in costs does not necessarily reduce the number of flour mills for a firm, we evaluate results for the following three scenarios. Scenario I simply assumes that the wage rate increases by 20 percent from the 1998 level, and that all other variables remain unchanged. Scenario II assumes that both the wage rate and corporate bond rate increase by 20 percent and the flour price remains unchanged. Finally, Scenario III assumes that both the wage rate and corporate bond rate increase by 20 percent and the flour price increases by 10 percent. Estimated elasticities presented in Table 5 and the observed number of mills for each size class during 1998 are used for the simulation analysis. Results are presented in Table 6.

Results from Scenario I indicate that the number of flour mills for smaller size classes, S_1 and S_2, decline as the wage rate rises, while those for the largest size class S_4 would increase, and the total number of flour mills would decline by 4 mills. Smaller firms merge or go out of business, and larger firms would consolidate and eliminate duplication of operations to reduce production costs.

Scenario II assumes that both the wage rate and corporate bond rate rise by 20 percent, while all other variables remain unchanged. As the corporate bond rate rises, capital costs associated with acquisition of smaller firms would be higher so that the number of mills for the size class S_4 would decline, while those for the smaller size classes S_1 and S_2 would increase. However, the declining number of large mills due to a rising corporate bond rate would be offset by the increasing number of larger mills due to a rising wage rate. Similarly, the increasing number of mills for smaller size mills due to a rising corporate bond rate would be offset by the declining number of smaller mills due to a rising wage rate. As a result of these offsetting effects on the number of mills for each size class, the effects of both a rising wage rate and corporate bond rate on the total number of flour mills are insignificant. The total number of flour mills changes by one from 201 mills to 202 mills.

Finally, Scenario III assumes that both the wage rate and corporate bond rate increase by 20 percent and the flour price increases by 10 percent. Results indicate that the potential effects on the number of flour mills of increasing wheat-flour price are also insignificant. This result may be well supported by the fact that when production costs increase under monopolistic competition, the firm sets its price where average costs equal average revenue. Therefore, as the wage rate and corporate bond rate increase, the firm would simply raise its milled flour price. Results from Scenario III indicate that there would be no significant changes in the number of flour mills across size classes. The number of mills for the size class S_3 increases by one, while those for the size class S_4 declines by one, so that the total number of mills would be unchanged under Scenario III.

The practical implications of these results tell us that the full effects of a changing structure of the U.S. milling industry need to account for the decomposed effects of the changing economic variables. Given that both changing size distribution and the resulting number of flour mills in each size class occur simultaneously, evaluating either the size distribution or the changing number of flour mills in each size class, more than likely will lead to misleading results. Furthermore, each economic variable affects flour milling firms for each size class differently in opposite directions, meaning that effective structural change analysis is best addressed by decomposing the effects of market parameter changes to isolate the full structural change effect.

4. Conclusions

This paper extends previous work in modeling structural changes in the U.S. flour milling industry. To date, the changing size distribution and number of flour mills in each size class have been evaluated separately. Transition probabilities associated with a Markov process or a multinomial logit model has been used to evaluate the size distribution of industry firms, while a regression model has been used to evaluate the changing number of firms for each size class. This research presents a decomposed Poisson regression model based on count data to evaluate both the size distribution and the changing number of flour mills for each size class, simultaneously. Specifically, we model the importance of different effects of changing economic forces on the size distribution as well as the number of flour mills for each size class.

Empirical results indicate that both the wage rate and corporate bond rate explain the changing structure of the U.S. milling industry very well. The wage rate and corporate bond rate elasticities of the number of mills in each size class vary across the size of plant, generally in opposite directions. The wage rate elasticity of the number of mills increases as the size of plant increases. However, the corporate bond rate elasticity declines as the size of plant increases.

Simulation analyses exhibit that the full effect of both a rising wage rate and corporate bond rate on the total number of flour mills is insignificant due to the offsetting effects of these economic factors on the number of mills for each size class. The declining number of larger mills resulting from a rising corporate bond rate would be offset by the increasing number of larger mills due to a rising wage rate. Similarly, the declining number of smaller mills due to a rising wage rate would be offset by the increasing number of smaller mills resulting form a rising corporate bond rate. As a result of these offsetting effects on the number of mills for each size class, the total number of flour mills remains unchanged even when the wage rate, corporate bond rate, and flour price rise.

Finally, increased market power would distort resource allocation by producing smaller outputs at higher costs than would occur under a perfectly competitive market. This would suggest that it may be desirable to conduct an empirical market power test, such as that suggested by Varian.

Table 1. Size class statistics for wheat-flour milling, 1973-99.

	Size classes for flour milling[1] (daily active milling capacity (cwt))			
	S_1	S_2	S_3	S_4
Mean (cwt)	300	2,665	6,717	14,643
Standard deviation	21	112	379	660
Coefficient of variation	0.0704	0.0421	0.0564	0.0451

Size classes: $0 \leq S_1 < 1{,}000$ cwt, $1{,}000\text{cwt} \leq S_2 < 5{,}000$ cwt, $5{,}000 \text{ cwt} \leq S_3 < 10{,}000$ cwt, and $S_4 \geq 10{,}000$ cwt.

Table 2. Coefficients for a multinomial logit model (MLM) and an aggregate Poisson regression model (PRM) of the U.S. flour mill industry

	MLM			Aggregate PRM
Variable	*ln* (P_2/P_1)	*ln* (P_3/P_1)	*ln* (P_4/P_1)	*ln* (N)
Constant	-0.2271 (-1.0746)[1]	-0.1924 (-0.9101)	-0.9659 (-4.5706)	5.5674 (72.1166)
w/p	0.9150 (6.3897)	1.1137 (7.7761)	1.9547 (13.6501)	-0.3870 (-7.4138)
r/p	-80.0143 (-5.3854)	-117.2085 (-7.8888)	-152.0589 (-10.2344)	25.4360 (4.5737)

1. Estimated z-values are in parentheses.

Table 3. Observed and estimated number of mills in each size category (at mean values for explanatory variables) : 1973 – 1998.

	Size classes of flour mills[1]				
	S_1	S_2	S_3	S_4	Total
Observed number of mills	76	62	54	40	232
Estimated by MLM & Aggregate PRM	73	63	55	41	232
Estimated by Decomposed PRM	72	62	54	40	228

1. Size classes are defined in footnote 1, Table 1.

Table 4. Estimates of a decomposed Poisson regression model foot the number of mills by size class for wheat-flour milling industry.

α (constant)	3.4835
	(18.1243)[1]
Normalized wage variable (w/p)	
$\beta(1)$	-1.2307
	(-13.5391)
$\beta(2)$	-0.3038
	(-2.9931)
$\beta(3)$	-0.0914
	(-0.8324)
$\beta(4)$	0.6984
	(5.2789)
Normalized corporate bond rate (r/p)	
$\gamma(1)$	96.9022
	(9.5673)
$\gamma(2)$	26.3078
	(2.4441)
$\gamma(3)$	-8.9228
	(-0.7796)
$\gamma(4)$	-48.2588
	(-3.7202)
Dummy variables	
$\delta(1)$	1.0158
	(4.3503)
$\delta(2)$	0.6736
	(2.7607)
$\delta(3)$	0.6748
	(2.6874)

Estimated z-values are in parentheses.

Table 5. Wage rate, corporate bond rate, and flour price elasticities of the number of flour mills for each size class measured at mean values.

	η_w	η_r	η_p
Aggregate PRM:	-0.3763	0.2550	0.1213
Decomposed PRM:			
S_1	-1.1968	0.9715	0.2253
S_2	-0.2954	0.2637	0.0317
S_3	-0.0889	-0.0895	0.1784
S_4	0.6792	-0.4838	-0.1954
Weighted Average [1]	-0.3602	0.2724	0.0878

1. A weighted average computed with the elasticities for S_1 through S_4 and the estimated number of mills for each size class presented in Table 3.

Table 6. Estimated number of flour mills under three different economic scenarios.

Size	N(*j*) (1998)	ΔN(*j*) due to Δ *w*	ΔN(*j*) due to Δ *r*	Δ N(*j*) due to Δ *p*	Sub-total	Estimated N(*j*)
Scenario I[1]:						
S_1	34	-8			-8	26
S_2	52	-3			-3	49
S_3	54	-1			-1	53
S_4	61	8			8	69
Total	201	-4			-4	197
Scenario II[2]:						
S_1	34	-8	7		-1	33
S_2	52	-3	3		0	52
S_3	54	-1	-1		0	54
S_4	61	8	-6		2	63
Total	201	-4	3		1	202
Scenario III[3]:						
S_1	34	-8	7	1	0	34
S_2	52	-3	3	0	0	52
S_3	54	-1	-1	1	-1	53
S_4	61	8	-6	-1	1	62
Total	201	-4	3	1	0	201

Scenario I assumes that wages increase by 20 percent and all other prices remain unchanged. Scenario II assumes that both the wage rate and corporate bond rate increase by 20 percent and the wheat-flour price remains unchanged. Scenario III assumes that both the wage rate and corporate bond rate increase by 20 percent and the wheat-flour price falls by 10 percent.

References

Adelaja, Adesoji, Rodolfo Nayga, Jr., Zafar Farooq (1999). "Predicting Mergers and Acquisitions in the Food Industry," Agribusiness, Vol. 15: 1-23.

Adelman, Irma (1958). "A Stochastic Analysis of the Size Distribution of Firms," journal of the American Statistical Association, Vol. 53: 893-904.

Avriel, Mordecai (1976). *Nonlinear Programming: Analysis and Method*. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Bureau of Labor Statistics (1999), U.S. Department of Labor, October.

Chambers, Robert G. (1988). *Applied Production Analysis: A dual approach*, Cambridge University Press, NY.

Chan, Luke (1981). "A Markovian Approach to the Study of the Canadian Cattle Industry," Review of Economics and Statistics, Vol. 53: 107-116.

Cohen, K.J. and R.M. Cyert (1975). *Theory of the Firm: Resource Allocation in a Market Economy*, Second edition, Printice-Hall, Inc., Englewood Cliffs, NJ.

Domencich, T. and D. McFadden (1975). *Urban Travel Demand: Behavioral Analysis*. Amsterdam, North-Holland Publishing Co.

Farris, Paul and D. Padberg (1964). "Measures of Market Structure Change in the Florida Fresh Citrus Packing Industry," Agricultural Economics Research, Vol. 16: 93-102.

Ferguson, C.E. (1969). *The Neoclassical Theory of Production and Distribution*. New York: the Syndics of the Cambridge University Press.

Garcia, Philip, Susan E. Offutt, and Steven T. Sonka (1987). "Size Distribution and Growth in a Sample of Illinois Cash Grain Farms," American Journal of Agricultural Economics Vol. 67: 471-476.

Goldberg, Ray A. (1983). "Economics of the Flour milling Industry," Research in Domestic and International Agribusiness Management, Vol. 4: 145-195.

Gourieroux, C., A. Monfort, and A. Trognon (1984). "Pseudo Maximum Likelihood Methods: Applications," Econometrica, Vol. 52: 701-720.

Harwood, J. L., M. Leath, and W. Heid (1989). The U.S. Milling and Baking Industries, AER-611, Econmic Research Service, USDA.

Hellerstein, Daniel M. (1991). "Using Count Data Models in Travel Cost Analysis with Aggregate Data," American Journal of Agricultural Economics, Vol. 73: 860-866.

Kamerschen, David and Lloyd Valentine (1977). *Intermediate Microeconomic Theory*, South-Western Publishing Co., Cincinnati, Ohio.

Kim, C.S., William Lin, and Mack Leath (1991). "The Changing Structure of the U.S. Flour Milling Industry," Agricultural Economics Research, Vol. 43:18-25.

Long, J. Scott (1997). *Regression Models for Categorical and Limited Dependent Variables*, Sage Publications, Inc., Thousand Oaks, CA.

Mansfield, Edwin (1968). *The Economics of Technological Change*, W.W. Norton & Company, Inc. New York, NY.

McFadden, Daniel (1975). "Conditional Logit Analysis of Qualitative Choice Behavior," Frontiers in Economics, P. Zarembka (ed.), New York, Academic Press: 105-142.

Shepherd, G.S., G. A. Futrell, and J. R. Strain (1976). *Marketing Farm Products: Economic Analysis*, Sixth edition, the Iowa State University Press, Ames, IW.

Sosland Companies Inc.(1973-99). *Milling Directory/Buyer's Guide*, Sosland publishing Company, KS.

Varian, H. R. (1984). "The Nonparametric Approach to Production Analysis." Econometrica, Vol. 52: 579-97.

Wilson, William W. (1995). "Structural Changes and Strategies in the North American Flour Milling Industry," Agribusiness, Vol. 11: 431-439.