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ABSTRACT---
Stochastic frontier analysis is used to determine the relative efficiency of firms in the food industry in industrialized countries. Using panel data analysis, the firm-specific factors, firm-size, the corporate tax rate and number of years of operation and country-specific effects as potential sources of efficiency are investigated. Relevant implications are discussed.

---KEY WORDS---

Efficient financial performance, value-added measures, stochastic frontier analysis

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A Cross-Country Comparison of Efficiency of Firms in the Food Industry.

The food industry is characterized by differentiated products and economies associated with size, scope, and scale of operations. These characteristics differentiate the impacts of international commerce in processed foods from those associated with international specialization and the theory of comparative advantage. Rivalry among sellers in the marketplace encourages efficiency and competitive prices, so consumers benefit from the availability of a wider array of products (U.S. Department of Agriculture, ERS, September 1997).

This relative efficiency of firms in the food industry across various countries is an issue of considerable interest to managers engaged in or considering exporting their products. As businesses grow and local markets become saturated, interest in trade possibilities with other countries increases. Krugman (1995) indicates the possibility of capturing economies of scale in finely differentiated markets provides an incentive for most trade to be limited to firms within the food industry among similar developed countries. This has resulted in an increase in intra-industry trade in the food industry across industrialized countries and increased efficiency of firms in the industry.

The improvement in efficiency suggests that there are factors that result in efficiency variation across various firms or through time. Knowledge of factors that enhance the efficiency of firms is vital information needed by managers to ensure that firms earn profits. Levels of efficiency scores have been previously used to determine performance. Sedik et al. (1999) used efficiency scores to evaluate corporate farm performance in Russia from 1991 to 1995. Ylvinger (2000) used efficiency measures to estimate the relative industrial performance. Efficiency measurement is derived from the estimation of technical efficiency. Technical efficiency is "the ability to minimize input use in the production of a given output vector, or the ability to obtain maximum output from a given input vector (Kumbhakar and Lovell, 2000).

The main objective of this study is to determine the relevance of firm-specific and country specific factors as sources of firm efficiency in industrialized countries' food industry. To achieve this objective, a two stage analysis is employed. In the first stage, stochastic frontier analysis is used to derive the technical efficiencies of firms in the food industry in three industrialized countries, France, Britain and the United States. The technical efficiencies estimated in the second stage are regressed against a vector of explanatory variables, using panel data estimation techniques to determine the factors that affect technical efficiency. This panel data analysis represents the second stage.

Data and Methods

Unbalanced panel data spanning a ten year period from 1989 to 1998, for 148 firms in the food industry are used. These firms belong to the major group 20 of the Standard Industrial Classification (SIC) Code (Office of Management and Budget 1987). The data are derived from financial statements of firms compiled by Disclosure Incorporated (May 1999).

Panel data gives a more reliable evidence of efficiency measures of firm performance (Kumbhakar and Lovell, 2000). This is due to the fact that the nature of panel data facilitates tracking of the performance of each firm through a time period.

Theoretical Model

A two step analysis is employed. In the first step a production frontier model is estimated. A traditional production model assumes that producers optimize their production objectives. This ideal situation is not realistic since producers do not always attain their production objectives.

The technique employed in frontier analysis allows for an approach where producers do not necessarily attain their optimal production objectives. Producers thus have relative success in attaining their production objectives and this is the basis for measuring technical efficiency. Technical efficiency is defined in terms of the distance from the production frontier. The production frontier defines the upper boundary of production possibilities. The output levels arising from various combinations of input for each producer are located on or below the production frontier. Distance functions derived by Shephard (1953, 1970) give the functional characterization of the structure of the production technology when multiple outputs are produced from multiple inputs. Output sets are characterized by output distance functions, D(x,y), represented as

$$D_o(x, y) = \min\{\mu : y/\mu \in P(x)\}, \tag{1}$$

where x represents inputs and y represents outputs. When multiple inputs are used to produce a single output, the output distance is a single-output production frontier.

Producers use inputs $x \in R^n_+$ to produce a scalar output $y \in R^n_+$ with technology

$$y_i = f(x_i;\beta)\exp\{v_i + u_i\}, \gamma_i = 1,......I \tag{2}$$

where â is a vector representing technology parameters estimated for I producers. Equation (2) is the production frontier (Fried et al. 1993). The disturbance term v_i is statistical noise and the non positive component of the disturbance, u_i measures technical efficiency. The log linear form of equation (2) is used in the estimation of the parameters. This is given as

$$z_i = x_i\beta + v_i + u_i, \tag{3}$$

where z = lny.

The theoretical model used for the second step, the panel data analysis, is an effects model of the general form,

$$y_{it} = a_i + g_t + b' x_{it} + e_{it}. \quad (4)$$

In this model, there are K regressors in x_{it} not including the constant term. From (4), five variants of the model are derived. These are the ordinary least squares model (OLS), one and two-factor fixed effects models (FEM), and one and two-factor random effects models (REM) (Greene, 1995, p.310). The five models are given below:

(i) The OLS model:

$$y_{it} = a \quad + b' x_{it} + e_{it}. \quad (5)$$

(ii)The One-Factor Fixed Effects Model:

$$y_{it} = a_i + b' x_{it} + e_{it}. \quad (6)$$

(iii) The Two-Factor Fixed Effects Model:

$$y_{it} = a_0 + a_i + g_t b \quad ' x_{it} + e_{it}. \quad (7)$$

$$y_{it} = a_i + b' x_{it} + e_{it} + u_i. \tag{8}$$

(iv) The One-Factor Random Effects Model:

$$y_{it} = a + b' x_{it} + e_{it} + u_i + w_i. \tag{9}$$

(v) The Two-Factor Random Effects Model:

In the FEM, differences across units are captured by differences in the group-specific constant term, á. The REM differs from the FEM in that for the REM the dummies or individual specific constant terms are randomly distributed over cross-sectional units. Therefore in the analysis of countries, the dummy variables are a collection of factors that pertain to the group of countries that the sample is drawn from. Generalized Least Squares (GLS) is necessary to estimate the REM (Green, 1995, p.289).

Two specification test statistics are used in the panel data analysis. A Lagrange multiplier (LM) statistic developed by Breusch and Pagan is used for testing the REM against the OLS model (Greene, 1995, p.291). The LM test for the REM is based on OLS residuals to check for evidence, or the absence of such evidence, that suggests that the error components model is favored. Large values of the LM statistic favor either the REM or the FEM over OLS model.

The other specification test, Hausman's (H) test is based on the fact that under the hypothesis of no correlation, both FEM and GLS are consistent but OLS is inefficient. Thus under the null hypothesis, the two estimates should not differ systematically. A large value of the H statistic argue in favor of the FEM over the REM.

Empirical Model

Step One

The empirical model used to estimate the production frontier is a random effects model. Return on Assets (ROA), a profitability ratio, has been identified by previous researchers as a performance measure. Given return on assets as the output variable, an efficient frontier is determined using marketing-mix variables and market-structure variables as input variables. The marketing-mix variables are sales force expenditure, advertising expenditure, promotional expenditure, and other marketing expenditure. The market-structure variables are industry concentration and capacity utilization. The empirical model for the first step of the analysis, therefore is given as:

$$ROA_{it} = \beta X_{it} + v_{it} - \mu_i . \qquad (9)$$

Pitt and Lee (1981) suggest that the log linear version of the stochastic frontier model, equation (2), can be estimated using panel data. In this case, the model is generalized to handle both time-series and cross-section units. This model is comparable to those proposed by Nerlove (1965) and Wallace and Hussain (1969) except that u_i is one-sided distributed. If the u_{it} terms are replaced by u_i, the model is given as:

$$z_{it} = x_{it}\beta + v_{it} + u_i, \qquad (10)$$

I=1,...,N, t=1,....T, where u_i is i.i.d. one-sided distributed with truncated normal density function

$$h(u) = \frac{2}{\sqrt{2\Pi}\sigma_u}\exp\left\{-\frac{u^2}{2\sigma_u^2}\right\}, u \le 0; \qquad (11)$$

and v_{it} is i.i.d. normal.

The efficiency component is time-invariant and v_{it} and u_i are assumed to be independently and identically distributed. Both generalized least squares and maximum likelihood procedures were used to determine which model best suited the data being used. The likelihood function of this model has been derived by Pitt and Lee (1981) as:

$$\ln L = N\ln 2 - \frac{NT}{2}\ln(2\Pi) - \frac{N(T-1)}{2}\ln\sigma_v^2 - \frac{N}{2}\iota_n(\sigma_v^2 + T\sigma_u^2)$$
$$-\frac{1}{2\sigma_v^2}\sum_{i=1}^{N}(y_i - x_i\beta)'\left(I_T - \frac{\sigma_u^2}{\sigma_v^2 + T\sigma_u^2}\iota\iota'\right)(y_i - x_i\beta) \qquad (13)$$
$$+\sum_{i=1}^{N}\ln\left[1-\Phi\left(\frac{\sigma_u}{\sigma_v(\sigma_v^2 + T\sigma_u^2)^{\frac{1}{2}}}\sum_{t=1}^{T}(y_{it} - x_{it}\beta)\right)\right]$$

where Ö(x) is the standard normal cumulative density function evaluated at x. A preliminary analysis of the generalized least squares and maximum likelihood procedures reveals that the maximum likelihood procedure is a better procedure for the data because it produces efficient estimates.

Step Two

Panel data analysis using efficiency levels based on the efficient frontier estimated in step one of the analysis as the independent variable, firm-specific characteristics as the independent variables and country and time dummies as the effects variables are used to determine the influence of firm-specific, country-specific effects and time effects on efficiency. The empirical model of the general form is

$$Eff_{it} = \alpha_i + \gamma_t + \beta Size_{it} + \beta TAX_{it} + \varepsilon_{it}. \quad (14)$$

In this model, there are two regressors, intercept terms and a random disturbance term. Dummy variables or the effects variables represented by á$_i$ and ã$_i$, are used to account for country-specific and time factors respectively, that are unique to various parts of the panel but cannot be explained by the regressors. The random disturbance term captures factors not accounted for in the regression which have an effect on y_{it}. The regressors are the firm-specific factors, total assets and corporate tax. Total assets is denoted as SIZE, while corporate tax is denoted as TAX. Dummy variables in the one-factor model represent countries, while in the two-factor model they represent countries and time. The time dummy variables represent the number of years of operation of each firm, while the country dummies represent the country of origin. The five variants of the effects model, the OLS model, the one and two factor Fixed Effects models and the one and two factor Random Effects model, are each estimated.

Results and Discussion

One Factor Models

The results for these models are shown in Table V. The LM test was significant for the REM. This indicates that the dummy variables for country add explanatory power to the model. Also, the REM was favored over the FEM since the H statistic was not significant. Therefore the firm-specific effects are randomly distributed across the countries being analyzed. This means that inferences pertain to industrialized countries as a whole and not to the individual countries. Therefore, without considering time effects, firm-specific factors are important in explaining efficiency in industrialized countries.

Two Factor Models

Dummy variables for country and time effects were significant. This inference was made from a significant LM statistic shown in Table V. Furthermore, the H statistic was significant (Table V). Therefore the FEM was favored over the REM.

Firm-specific measures are found to be relevant in explaining the efficiency of firms in the food industry. Furthermore, the factors characteristic to the various countries and the number of years of operation are important in explaining differences in firm efficiency across each country.

Implications of this Research

This study reveals the firm-specific factors which managers can employ when making decisions to improve the efficiency of their firms. It also indicates country-specific factors are important determinants of firm efficiency in the food industry, which is useful information for managers faced with formulating strategies for both domestic and foreign operations. Efficiency comparison across countries could clearly reflect the performance of foreign operations and their contribution to total corporate profits. This can be used as a guide to foreign operations that need improvement.

Information about cross country efficiency in the food industry is also useful information for investors who seek to hold diversified portfolios in other countries. A knowledge of performance based on efficiency will guide in their investment decisions.

This research can be used for policy purposes. Information of relative efficiency across countries serve as a measure by which policy concerning international trade can be made. Choices of more efficient foreign investments can be made for increased revenue. Policy can also be formulated for countries with less efficient firms in order to improve performance.

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Table 1. Definition of Variables

Variable	Definition
Advertising Expenditure	Media Expenses Divided by Revenue
Sales Force Expenditure	Sales Force Expenses Divided by Revenue
Promotion Expenditure	Promotion Expenses Divided by Revenue
Other Marketing Expenditure	Other Marketing Expenses Divided by Revenue
Industry Concentration	Percent of Sales by Four Largest Firms in the SIC Group
Capacity Utilization	Asset Turnover Ratio (Sales/Assets)
Return on Assets	Net Income/Assets

Table II. Descriptive Statistics for France

Variable	Mean	Minimum Value	Maximum Value	Number of Observations
SIZE	13883644.20	6409989.00	19435824.00	10.00
TAX	0.36	0.32	0.43	10.00
EFFICIENCY	0.22	0.17	0.31	10.00

Table III. Descriptive Statistics for Britain

Variable	Mean	Minimum Value	Maximum Value	Number of Observations
SIZE	2629095.71	83570.00	7866360.00	51.00
TAX	0.29	0.10	0.37	51.00
EFFICIENCY	0.23	0.11	0.50	51.00

Table IV. Descriptive Statistics for the US

Variable	Mean	Minimum Value	Maximum Value	Number of Observations
SIZE	4486198.28	498624.00	13833534.00	87.00
TAX	0.39	0.28	1.02	87.00
EFFICIENCY	0.25	0.14	0.79	87.00

Table V. Regression Coefficients

Variable	Base OLS	One Factor FEM	One Factor REM	Two Factor FEM	Two Factor REM
Intercept[a]	0.05 (2.18)[b]		0.32E-04 (0.00)	-0.27E-01 (-0.97)	-0.64 (-0.19)
SIZE	-0.69E-09 (-0.45)	0.27E-08 (1.33)	0.14E-08 (0.77)	0.28E-09 (0.14)	0.20 (0.11)
TAX	0.05 (8.21)	0.68 (9.32)	0.66 (9.18)	0.76 (10.40)	0.70 (10.00)
FRANCE		-0.06 (-1.32)		-0.03 (-0.95)	
BRITAIN		0.03 (1.24)		0.04 (3.98)	
UNITED STATES		-0.03 (-0.92)		-0.02 (-3.65)	
1989				-0.04 (-2.47)	
1990				-0.04 (-2.39)	
1991				-0.03 (-1.49)	
1992				-0.00 (-0.14)	
1993				0.04 (2.15)	
1994				0.02 (1.24)	

Table V. Regression Coefficients (continued)

Variable	Base OLS	One Factor FEM	One Factor REM	Two Factor FEM	Two Factor REM
1995				0.02 (0.95)	
1996				0.02 (0.94)	
1997				0.01 (0.80)	
1998				0.02 (0.82)	
N	148				
R^2	0.32	0.38		0.47	
F (Regression)	33.75[c]	22.36[d]		8.56[e]	
H statistic[f]			3.19		8.35
LM statistic			7.23[f]		9.84[g]

[a] No intercept for the one-factor FEM model (Greene, 1995, p.289).
[b] t statistics are in parentheses.
[c] F(2,145) at the 0.95 probability level is 3.00.
[d] F(4,143) at the 0.95 level is 2.37.
[e] F(14,133) at the 0.95 level is 1.67.
[f] Chi square statistic for 1 degree of freedom at the 0.95 level is 3.84.
[g] Chi square statistic for 2 degrees of freedom at the 0.95 level is 5.99.