TECHNICAL EFFICIENCY OF BRAZILIAN EXPORTERS OF ANIMAL PROTEIN

Geraldo da Silva e Souza
Embrapa – Brasilia/DF/Brazil (geraldo.souza@embrapa.br)
Silvia Ferreira Marques Salustiano
Instituto Federal de Tocantins – Brasilia/DF/Brazil (Silvia.salu@gmail.com)
Tito Belchior Silva Moreira: Correspondent author
Universidade Católica de Brasília – Brasilia/DF/Brazil (tito@pos.ucb.br)

Abstract: The objective of this study is to evaluate the technical efficiency of Brazilian companies that operate in the international market of animal protein (beef, pork and poultry). The six business groups of interest are JBS – Friboi, BRF – Brasil Foods, Marfrig, Minerva, Minupar and Excelsior. We fit a production function for the oligopoly assuming a stochastic frontier model with technical effects affecting the inefficiency component. The data are from the consolidated balance sheet of the group for the period that starts in the first quarter of 2007 and ends in the third quarter of 2011. Overall, Brasil Foods shows the worst performance. The stocks of living animals (beef, pork and poultry) negatively affect the production function and the subprime crisis negatively affects the technical efficiency of production.
Key words: Meat industry in Brazil, Production and Technical efficiency, International market of animal protein.
Jel Classification: C33, C67, F23, M21

1. Introduction

The market of animal protein undergoes significant changes. Among them it is worth mentioning the increasing demand of emerging countries, the evolution of information systems and the elimination of tariff barriers. The elimination of trade restrictions in a scenario of inflation stabilization and growth of international capital flows implies that country (Brazil) with companies capable of producing more competitively will become more attractive for investment. Brazil is a major actor in the international meat market. Hence the importance of examining the technical efficiency of its firms and main groups of open capital operating in the meat market whose stocks are traded, or negotiated in the BOVESPA.

In 2004 Brazil surpassed Australia and became the largest exporter of beef in the world. Moreover there is a real possibility that Brazil will gain more space in the markets of European countries, which show preference for beef from animals raised on pasture without use of anabolic steroids. Also the US, a country with the highest meat consumption per capita in the world - 35 kg per year, virtually imports from Brazil all its canned meat from areas of FMD (See Agroanalysis, 2008).

According to OECD (2011) the increase in consumption of animal protein is expected to reach 25.7% in developing countries in the period 2007-2017. For the same period developed countries will increase their consumption by 6.3%. The increase in meat consumption is resulting mainly from income and population growth especially in the developing countries. The outlook in percentage terms for growth during 2007-2017 is expected to be 20.4% for chicken meat, 20.2% for pork and 17.6% for beef.

Brazil has 90 million hectares available for cattle occupation, more than 15% of the drinkable water world reserves and a suitable climate. These are the background bases underlying Brazil's outstanding meat production and its role as a major player in the international market. The expressive insertion in the international animal protein market calls for the country to monitor closely structural changes in the industry, and to implement logistic, technological and administrative changes, as needed, in order to maintain its leadership.

In the context of corporate finance, the objective of the present study is to identify factors that may affects the efficiency of production of the six major industrial groups in Brazil in the meat business. These are (1) JBS – Friboi, (2) BRF – Brazil Foods, (3) Marfrig, (4) Minerva, (5) Minupar and (6) Excelsior. These companies have open capital and operate with more than one type of meat. They are also active in other agribusiness areas. JBS-Friboi is the largest in the world of animal protein. Marfrig Foods is among the top ten.

Our discussion in the article proceeds as follows. In Section 2 we describe the stochastic frontier model we will use. Section 3 is on statistical results. Finally in Section 4 we summarize our findings and present our final conclusions.

2. Methodological Aspects

The model we consider is a production stochastic frontier. The data we use to fit this model as already emphasized refers to the period 2007:1 to 2011:3. The production function specification is taken from the Cobb-Douglas family and for the error structure we use a normal - half-normal model. The normal random error components have mean zero and variances depending on the firm effects. The inefficiency error components are independent of the random error components with variances depending on a set of technical effects. Indeed the means of the inefficiency components are monotone functions of a linear construct defined by the technical effects. In other words, as in Aigner, Lovell and Schmidt (1977), Kumbhakar and Lovell (2003), Coelli, O'Donnell and Battese (2005), Greene (2008), and Fried, Lovell and Schmidt (2008), our model has the representation

$$\ln\ q_i = x_i'\beta + v_i - u_i \qquad i = 1, ..., I,$$

where q_i represents log output of the *i-th* firm, x_i is a *K x 1* vector containing the logarithms of inputs, β is a vector of unknown parameters (input elasticities), the $v_i \sim N(0, \sigma_{vi}^2)$ are the random error components independent of the inefficiency error components $u_i \sim N^+(0, \sigma_{ui}^2)$. The total error component is $\varepsilon_i = v_i - u_i$. The log likelihood for the model is given by

$$\ln L(\beta, \delta, \gamma \,|\, y) = I \ln(\frac{\pi\sigma^2}{2}) + \sum_{i=1}^{I} \ln \Phi(-\frac{\varepsilon_i \lambda_i}{\sigma_{Si}^2}) - \frac{1}{2\sigma_{Si}^2} \sum_{i=1}^{I} \varepsilon_i^2$$

Where $\sigma_{Si}^2 = \sigma_{vi}^2 + \sigma_{ui}^2$ and $\lambda_i^2 = (\sigma_{ui}^2 / \sigma_{vi}^2) \geq 0.$ Here $\sigma_{vi}^2 = \exp(w_i\delta)$ and $\sigma_{ui}^2 = \exp(z_i\gamma)$ where w is a vector of firms dummy variables and z is a vector of technical effects. The linear constructs affecting the random and inefficiency error components are $w\delta$ and $z\gamma$ respectively where δ and γ are also unknown parameters. The technical efficiency of the *i-th* firm is, following Stata (2011),

$$E_i = E\{\exp(-u_i) \,|\, \varepsilon_i\}$$

$$E_i = \{\frac{1 - \Phi(\sigma_{*i} - \mu_{*i} / \sigma_{*i})}{1 - \Phi(\mu_{*i} / \sigma_{*i})}\} \ \exp\ (-\mu_{*i} + \frac{1}{2}\sigma_{*i}^2)$$

where μ_{*i} and σ_{*i} are defined by

$$\mu_{*i} = -\varepsilon_i \sigma_{iu}^2 / \sigma_i^2$$

$$\sigma_{*i} = \sigma_{iu}\sigma_{iv} / \sigma_i$$

Our article considers six meat firms. JBS – Friboi, Firm 1; BRF - Brasil Foods, Firm 2; Marfrig, Firm 3; Minerva , Firm 4; Minupar, Firm 5 and Excelsior, Firm 6. The model variables are obtained from the balance sheet of each company. The output is defined by the value of the net revenue in units of US$ deflated by the US producer price index. The proxy for capital is defined by the values of property, plant and equipment (PP&E), i.e., fixed assets, deduced of the industry output gap. The PP&E value is in units of US$ also

deflated by the US producer price index. The proxy for labor is defined by the value of labor cost in units of US$ deflated by the US producer price index. We also consider the lagged value of the stock of living animals (beef, pork and poultry) in units of US$ deflated by the US producer price index as a contextual variable for the production function. Firm dummies are denoted D1-D6 respectively. They affect the inefficiency error as well as a dummy (Dcrisis) identifying the period in which the Brazilian economy was affected by the subprime crisis. For the period 2008:3 until 20011:3 Dcrisis=1, otherwise Dcrisis=0. We use a logarithmic transformation for all continuous variables.

3 Empirical Results

The statistical results arising from the stochastic frontier model are given in Table 1.

The overall fit is good. The square of the correlation coefficient between observed and predicted values is higher than 98%. The estimated coefficients of capital (K) and labor (L) are statistically significant. The elasticity values are 0.3140 and 0.9552 respectively. The sum of the elasticities is significantly greater than 1. The hypothesis of constant returns of scale is rejected with a p-value < 0.0001. The fit indicates increasing returns to scale, as expected. Generally, export companies need economies of scale to access the international market. In the case of Brazil the industry of meat products is not different. The market therefore is not competitive.

The coefficient of lagged stock of living animals (Stock) is statistically significant and negative. As expected, when the stock of animals increases, production decreases.

Among the dummies for firms only D2 is statistically significant indicating a lower efficiency intercept for Firm2. The crisis period has a negative significant effect on technical efficiency.

Table 1 - Empirical Results: Stochastic Frontier Normal-Half-Normal Model. Stata 11 output listing.

INPUTS	Coefficients	Standard Error	Statistic z	p-value
K	0.3140	2.68e-06	1.2e+05	<0.0001
L	0.9552	0.00002	4.3.e+04	<0.0001
Stocks(t-1)	-0.1133	0.00002	-6048.38	<0.0001
Year_2007	0.2119	0.00001	1.9e+04	<0.0001
Year_2008	0.2297	8.68e-06	2.6e+04	<0.0001
Year_2009	0.1872	5.22e-06	3.6e+04	<0.0001
Year_2010	-0.2320	9.84e-06	-2.4e+04	<0.0001
Constant	0.9007	0.00004	2.5e+04	<0.0001

	Explanatory variables for technical inefficiency variance function			
D2	2.6845	0.3998	6.7100	<0.00001
DCrisis	0.6963	0.2993	2.3300	0.0200
Constant	-2.7387	0.2209	-12.4000	<0.0001
	Explanatory variables for the random error variance function			
Constant	-37.7303	295.2220	-0.1300	0.8980

Note: Elaborated by authors

Figure 1 – Evolution in time of scores of technical efficiencies by firm

(1) JBS – Friboi, (2) BRF - Brasil Foods, (3) Marfrig, (4) Minerva, (5) Minupar e (6) Excelsior.

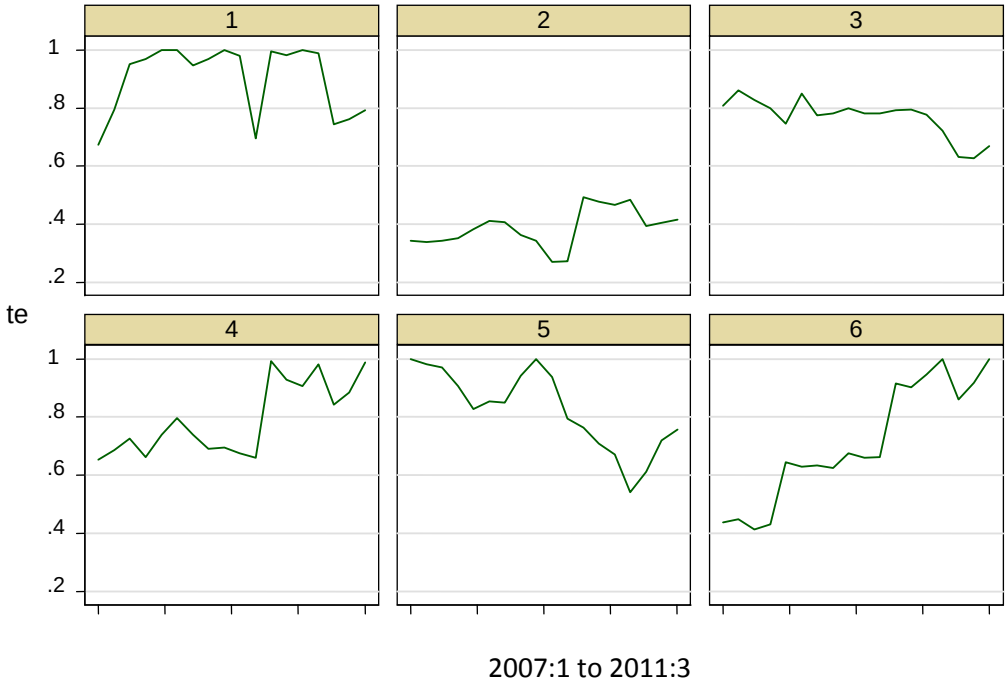

Figure 1 shows the evolution of technical efficiencies through time by firm. The worst performance is that of firm 2, BRF - Brasil Foods as indicated by the sign and significance of D2. It is possible to infer the impact of the subprime crisis on the Brazilian economy observing the economic growth between 2007 and 2011. The rates of economic growth were 6.9%, 5.17%, -0.6%, 7.53% and 2.73% respectively. The score of technical efficiency along the period analyzed was always lower than 0.60 for Firm 2 reaching minimum peaks in the 3th and 4th quarter of 2009, when the Brazil suffer the most with the subprime crisis.

Firm 1, JBS – Friboi is recovering from a relative low value in technical efficiency very likely also caused by the subprime crisis. It obtained its worst result in terms

of technical efficiency in the last quarter of 2009.

Firms 5 (Minupar) and 3 (Marfrig) show decreasing patterns of efficiency in the period. These firms began to recover in the last quarters of the period under analysis following the general trend observed for the oligopoly.

Firms 4 (Minerva) and 6 (Excelsior) show steady growths in efficiency in the period but they were also affected by the subprime crisis.

Conclusions

This article assesses production and technical efficiency of production of the major Brazilian companies operating in the international meat market (beef, pork and poultry). Production is described by means of a stochastic frontier model with a normal-half-normal error structure where the half-normal inefficient component has a variance function depending on exogenous categorical factors. The production function shows increasing returns to scale indicating imperfect competition. The six companies studied are publicly traded on the stock market of São Paulo (BOVESPA) and shows distinct patterns of growth of technical efficiency in the period 2007:1-2011:3. They are all negatively affected by the subprime crises. The company Brazil Foods shows the worst performance in the period with modest efficiency levels.

References

Agroanalysis (2008). Especial Globalização da Pecuária, **Agroanálise**, FGV, São Paulo, Vol. 28, n°11, p.20 - 40, nov.

Aigner, D.J.; C.A.K. Lovell and P. Schmidt (1977). "Formulation and Estimation of Stochastic Frontier Production Function Models". *Journal of Econometrics*, 6, 21 – 37.

Coelli, T. J.; Rao, D. S. P.; O'Donnell, C.J.; Battese, G. E. (2005). **An introduction to efficiency and productivity analysis.** Second Edition, Springer, 2005.

Fried, Harold O.; Lovell, C. A. Knox and Schmidt, Shelton S. (2008). **The Measurement of Productive Efficiency and Productivity Growth**. 1st Edition. Oxford University Press

Greene (2008). **Econometric Analysis**, 6th Edition, Prentice Hall, NJ.

Kumbhakar, S. C. and Lovell, C.A.K, (2003), **Stochastic Frontier Analysis**. 1st Edition, The Press Syndicate of the University of Cambridge.

OECD (2011). Organisation for Economic Co-operation and Development – Report: Agriculture subsidies. Available at http://www.oecd.org/searchResult/. Accessed on November 29, 2011.