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Evaluation of Fattening Efficiency of Grazing Bulls through Panel Data Envelop Analysis

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ABSTRACT

The purpose of this paper was to assess fattening efficiency changes in grazing bulls, using panel data envelop analysis in two periods of time. The panel data were compiled by DEAP 2.1, which included the results of a 3-year period from 38 private farms (beef farms) in cooperatives of credits and services. The farms were on prairie savannahs, located on 21.4831 latitude, and -77.3174 longitude, less than 300 meters above sea level, province of Camagüey, mid-eastern Cuba. The output variable was total sold kg (TSKG), and the input variables were cost of Norgold (CN), fuel kg per ha (FKGXHA), fuel kg per livestock unit (FKGXLU), and unit of human labor force (UHL), which were highly correlated to the output variable. Table 2 shows that technical efficiency (TE), pure efficiency (PEC), and scale sufficiency (SEC), underwent 0.2%, 0.4, and 0.5%, respectively, by the third year of fattening. Technological change (TC) between the second and third years rose to almost 14%, and the total productivity factor (TPF) spiked as farmers became more skilled and experienced, with a 4.9% increase in comparison to the first year, and 13.7% in the second year.

Key words: *overall technical efficiency, scale, productivity factor*

INTRODUCTION

As for many other companies, the success of agricultural companies in bull fattening depends on several economic aspects, the weather, and other resources Huergo (2010), Mota *et al.* (2016), and Webb and Erasmus (2013). However, Oiagen *et al*. (2013) found that farmers needed to optimize their capacity to make deals, and they did not know the costs of production or did not keep a record of technical or financial indicators in a fattening study in Rio Grande do Sul, Pará and Rondonia.

Determining the efficiency of bovine fattening is a key element for which several studies based on data envelop analysis (DEA) have been made. They show the efficiency of systems (Gamarra, 2004; Ozden and Armagán, 2014). Nevertheless, other methods that can be used to analyze changes of fattening efficiency in time are also needed, like the methods suggested by Aydin, Yeşilyurt and Sakarya (2014), particularly in relation to problems with stable and regular feed supplies to confined bovines.

Dynamic analysis of small-scale bull fattening is essential. Several institutions studied by Guevara *et al*. (2017) have been included in this paper, so efficiency advances and setbacks may be evaluated and adjusted, depending on their evolution.

The purpose of this paper was to assess fattening efficiency changes in grazing bulls using panel data envelop analysis in two periods of time.

MATERIALS AND METHODS

The panel data results were collected using DEAP 2.1, including the three- year data compiled from 38 private beef cattle farms with grazing animals, in mid-eastern Cuba, municipality of Sibanicú, province of Camagüey. The farms were located on 21.235latitude, and-77.52639longitude, less than 300 meters above sea level, coinciding with Guevara *et al*. (2017). The local soils are inceptisols and mollisols (Hernández *et al.*, 1999).

The output variable was total sold kg (TSKG); the input variables were cost of Norgold (CN), fuel kg per ha (FKGXHA), fuel kg per livestock unit (FKGXLU), and unit of human labor force (UHL), which were highly correlated to the output variable ($P < 0.05$; Spearman Test).

Various changes were evaluated: global technical efficiency (TE), pure efficiency (PEC); scale efficiency (SEC) was measured by dividing TE by

PEC. The technological change or change in technological efficiency (TC) was determined; total change of the productivity factor (TCPF) was also determined by the product of CE=TC x TE. Additionally, the percentages of farms with decreasing scale yields (DSY), the farms that did not change, and the farms with increasing scale yields (ISY), were determined. Then, in the second year of study, the inefficient and efficient farms were compared based on the variables studied by Guevara *et al.* (2017) using the Mann-Whitney test. The significant variables are shown in this paper: number of enclosures (NE), units of human labor (UHL), livestock units (LU), average final weight (AFW), daily weight gain (DWG), sales of livestock units (SLU), and cost of Norgold (CN). In the third year of fattening, the most significant differing variables were Norgold per LU (NLU), average final weight (AFW), and sales of LU (SLU).

RESULTS AND DISCUSSION

The results shown in table 1 indicate changes in measurements of efficiency and productivity for every farm in the period studied.

TE ranged between 0.1915 and 1.095, with an average 2.4% increase, approximately. Most farms increased technical efficiency, the rest should improve their results.

Gamarra (2004) made scale DEA analysis of double purpose grazing farms on the Colombian Caribbean coast, and found that only 8% were efficient. Oviedo and Rodríguez (2011) in Cundinamarca, only found 8.3% of efficient farms with stable scale yields (SSY), when DEA was oriented to inputs, using beef and breeding animals as output variables. The author suggested an improvement in the selling prices of fattened animals, also coinciding with Grunwaldt and Guevara (2011), who were able to achieve cost-effectiveness when the price of young-calf bulls was adequate, and feeds were produced by the farmers. Oaigen *et al.* (2013) also coincided in that some fundamental competitiveness factors were, access to technological innovation, price setting and organization of farmers.

In relation to TC, it had a broader variation range (0.899-1.406), with a 6.7% average, approximately. Most farms experimented increases in that time. Very few farms were technologically inefficient. Farm No. 30 might provide a very interesting case study due to elevated TC.

Regarding PEC, almost half the farms made progress, whereas a fourth underwent no changes mainly caused by the lack of proper labor force discipline.

The scale efficiency change (SEC) had the least variation after three years of bovine fattening; it showed no increases in one out of six farms.

That period also showed an increase in average TCPF, of approximately 9.2%; some farms had 40% increases and over, whereas others decreased in more than 10%. In addition to it, the TCPF increase was observed in 95% of farms. Farms No. 6, 19, 20, 35, 36, and 37 had the highest productivity factors.

Accordingly, since TCPF is the product of TE and TC, and the average TE was lower than the average TC, improvements in technological innovation was the factor leading to increased production on the farms.

Table 2 shows that technical efficiency (TE), pure efficiency (PEC), and scale sufficiency (SEC), decreased in 0.2%, 0.4%, and 0.5%, respectively, by the third year of fattening. Technology change (TC) between the second and third years rose to almost 14%, and the total productivity factor (TCPF) spiked, as farmers became more skilled and experienced, with a 4.9% increase in comparison to the first year, and 13.7% in the second year.

Aydin, Yeşilyurt and Sakarya (2014) made DEA to measure efficiency in 64 companies engaged in bovine fattening, in north-east Anatolia, Turkey. The output variables were carcass income, income on incentive bonuses, and income on fertilizers. The first variable was similar to the one used in the present study. However, the results were different from this study, with 22.79% inefficient farms in the first period, and 25% in the second. This increase was attributed to higher prices of fattening resources.

Although in the second year there were changes in the calculated efficiencies compared to the first year, marked differences were observed in the third year for TCPF and SEC, compared to TE, TC, and PEC (Fig. 1).

Table 3 shows the results in the third year; the number of farms with increased TCPF was higher in comparison to the second year. TC was observed to increase significantly in terms of farms, but only 34.2% of them underwent increases in relation to farms with decreased values, during the second year. However, 97.4% of farms had increases by the third year. Both instances pointed to the inexistence of farms with altered efficiency values.

Ozden and Armagán (2014), in Aydin, Turkey, considered several structural and sectorial problems associated with bovine fattening, which caused price rises and led to beef imports. DEA was used to determine an average of 0.87 for technical efficiency. Besides, increases had been influenced by farm size. The main barrier of this and other studies was that time changes were not shown, whereas DEA facilitated evaluation of system changes in time.

Tables 2 and 3 show the convenience of panel DEA to analyze the dynamics of different parameters linked to efficiency of beef producing farms. It was based on a critical approach to the changes in global technical efficiency, pure efficiency, technological efficiency, scale efficiency, and changes in the productivity factor.

In comparison to the first and third years, the second year had statistically significant differences ($P < 0.05$ and $P < 0.10$) on farms that increased their TCPF in relation to the ones that decreased in the same proportion. Table 4 shows that in the second year, the average final weight (AFW), daily weight gain (DWG), and sale of LU (SLU) were significantly higher ($P < 0.05$) for IC farms compared to DC farms. The variables number of enclosures (NE), units of human labor (UHL), livestock units (LU), and Norgold costs (CN), were significantly lower ($P < 0.05$ and $P < 0.10$), which corroborated better use of soil, animal, human, and financial resources for the same group (IC).

In the third year of fattening, the farms with increases (IC) were significantly higher than the decreasing farms (DC) in two variables: average final weight (AFW), and sales per livestock unit (SLU).

To increase the efficiency of all farms, including the farms with increasing values, it is important to improve production per animal. It depends on grassland management, and the production of feed supplements, in order to increase daily weight gain with slight cost increases, instead of using more imported concentrate supplements. This criterion coincided with Mora, Torres and Torres (2012), in a study made in the humid Colombian tropic.

Other studies in tropical regions of Latin America showed higher results than this study. Castellón, Elías and Jordán (2014) set a supplement diet proportion: fiber feed 11:89 gains near 1 kg (0.976 and 0.829 kg/animal/day) where peanut hay contributed with 69 % DM and CP, and 67 % EM, thus proving the capacity to generate technology to produce beef using fibrous residues from agriculture. Guevara *et al*. (2016) in similar ecosystems, reported gains between 0.8-0.98 kg/animal/day using forest grazing based on *Leucaena leucocephala* for 10 years.

In Sudán, Baggara, Atta, El Khidir and Mohammed (2013) achieved gains of 0.77 kg/d, higher than this study, when they used a concentrate supplement at 2.5% of live weight, along with sorghum forage. These gains were acceptable and showed the variations observed in tropical animal fattening, which largely differed from the results in temperate regions, on high supplementation. It is assumed that the administration of more than 6 kg of concentrate supplements to large bull breeds (Holstein) and their crossings, daily gains between 1.1-1.3 kg/day can be achieved (Wadja *et al*., 2012), far higher than the ones achieved in this paper, using Zebu bovines feeding on average quality grass, with less than 1 kg of concentrate supplement. Diler *et al*. (2016), observed daily gains of 0.96 and 0.95 kg/day in light and heavy breeds; whereas Heinrichs *et al*. (2013) spent between \$0.75 and \$0.21 USD on feedstuffs in growing bovines between 6 months of age and reproduction animals, whereas the daily expenses in feed supplements was \$0.24 USD, approximately.

Conclusions

Envelop analysis of panel data to assess changes in fattening efficiency of grazing bulls facilitated a comprehensive and dynamic behavioral study of these systems. The fattening systems studied in the period were observed to decrease global technical, pure, and scale efficiencies. They also underwent an increase in technological and productive progress.

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Table 1. Changes in efficiency, technology, and productivity on the farms throughout the period

Farms	TE	TC	PEC	SEC	TCPF
1	0.999	1.023	0.984	1.015	1.022
2	0.996	1.024	0.982	1.014	1.019
3	0.990	1.107	0.982	1.009	1.096
4	0.915	1.034	0.934	0.980	0.946
5	1.022	1.029	1.006	1.015	1.051
6	1.095	1.177	1.097	0.999	1.289
7	1.036	1.076	1.016	1.020	1.115
8	1.020	1.025	0.993	1.027	1.046
9	1.030	1.024	1.002	1.028	1.054
10	1.029	1.023	1.001	1.028	1.052
11	1.053	1.023	1.000	1.053	1.077
12	1.039	1.017	1.000	1.039	1.056
13	1.043	1.064	1.030	1.013	1.110
14	1.008	1.087	1.007	1.001	1.095
15	0.985	1.022	1.000	0.985	1.007
16	1.034	1.013	1.024	1.010	1.048
17	1.003	1.079	0.999	1.004	1.082
18	1.038	1.016	1.028	1.010	1.054
19	1.051	1.225	1.047	1.003	1.287
20	1.033	1.155	1.025	1.008	1.193
21	1.000	0.899	1.000	1.000	0.899
22	1.011	1.028	0.993	1.018	1.039
23	1.072	1.017	1.011	1.060	1.089
24	1.047	1.015	1.038	1.009	1.063
25	1.021	1.065	1.009	1.012	1.087
26	1.030	1.023	1.001	1.029	1.053
27	1.065	1.077	1.044	1.020	1.146
28	1.037	1.080	1.024	1.012	1.120
29	1.035	0.997	1.028	1.007	1.031
30	1.000	1.406	1.000	1.000	1.406
31	1.043	1.057	1.018	1.025	1.103
32	1.002	1.016	1.000	1.002	1.018
33	0.994	1.016	0.985	1.009	1.010
34	1.046	1.018	1.001	1.045	1.064
35	1.000	1.277	1.000	1.000	1.277
36	1.035	1.222	1.021	1.013	1.264
37	1.026	1.201	1.000	1.026	1.232
38	1.040	1.027	0.992	1.048	1.068
Geometric mean	1.024	1.067	1.008	1.016	1.092
Minimum	0.915	0.899	0.934	0.980	0.899

Maximum	1.095	1.406	1.097	1.060	1.406
Increase %	76	95	55	84	95
Without change %	8	0	21	8	0
Decrease %	16	5	24	8	5

Table 2. Yearly changes in efficiency, technology, and productivity

Years	TE	TC	PEC	SEC	TCPF
Second year	1.05	0.999	1.012	1.037	1.049
Third year	0.998	1.139	1.004	0.995	1.137

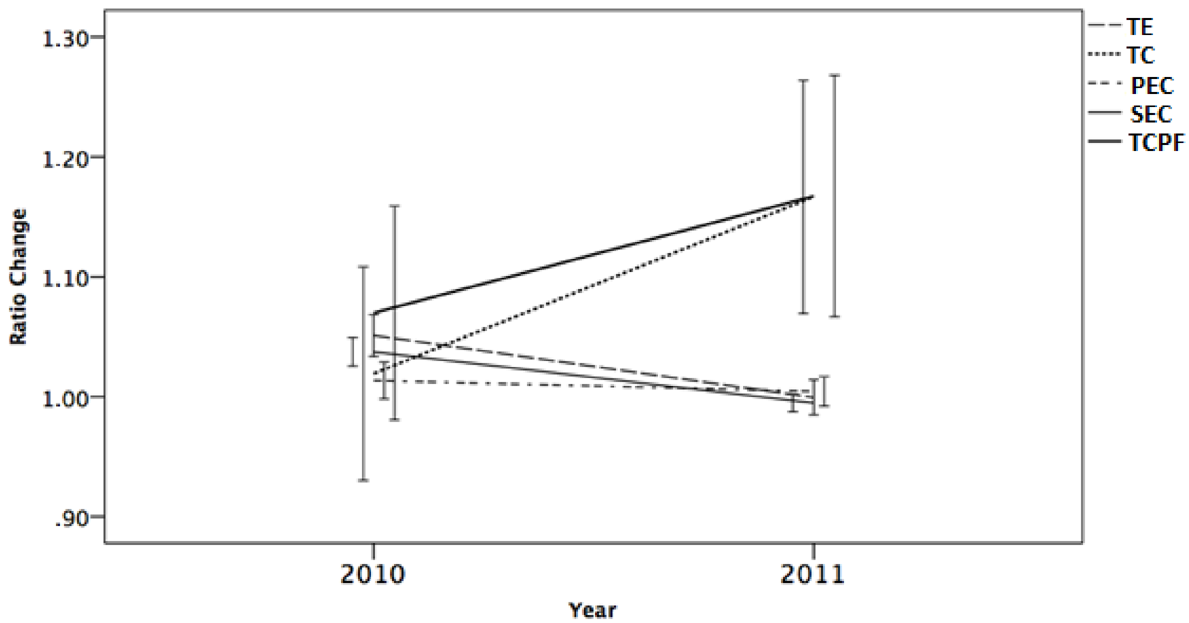

Fig. 1. Changes in efficiency, technology, and productivity in each year

Table 3. Number of farms according to changes in efficiency in the second and third years of fattening

Year	UPC	Components									
		TE		TC		PEC		SEC		TCPF	
		DTE	INC	DTE	INC	DTE	INC	DTE	INC	Losses	Growth
Second year	38	4	31	25	13	11	19	1	32	11	27
Third year	38	18	17	1	37	10	16	22	9	6	32

Table 4. Descriptors and significant statistics per production variables for increasing/decreasing farms, according to TCPF in every year

Second year	Decreased (DC)		Increased (IC)		Total	
	Mean	SE±	Mean	SE±	Mean	SE±
Number of enclosures (NE)*	1.9	0.25	1.2	0.08	1.42	0.10
Units of human labor (UHL)*	1.55	0.25	1.07	0.07	1.21	0.09
Livestock units (LU)	35.36	7.24	23.30	2.85	26.79	2.99
Average final weight (AFW, kg)*	369.09	2.07	376.48	1.71	374.34	1.45
Daily weight gain (DWG, kg)*	0.48	0.01	0.52	0.01	0.51	0.01
Sales of LU(SLU, $)*	2952.73	16.59	3011.85	13.66	2994.74	11.58
Cost of Norgold (CN, $)**	2324.22	475.78	1531.11	187.04	1760.70	196.66
Third year						
Norgold per LU(NLU, kg)**	0.55	0.01	0.53	0.00	0.53	0.00
Average final weight (AFW, kg)*	365.83	7.24	381.44	1.94	378.97	2.16
Sales of LU(SLU, $)*	2926.67	57.93	3051.50	15.55	3031.79	17.27

* ($P < 0.05$) and ** ($P < 0.10$) ANOVA