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Full Length Research Paper

Efficiency analysis of sausage industry: Evidence from Greece

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The article analyzes the technical and scale efficiency of Greek sausage companies for the period of 1994 to 2007, by using a bootstrapped data enveloped analysis. The motivation for employing the bootstrapping approach stems from the need to improve the accuracy of the conventional DEA model. The results suggested that technical inefficiencies were present and increased over the considered period in the sample of firms. On the contrary, the scale efficiency analysis showed that the majority of sample enterprises were operating nearly optimal scale during the study period, while in the same time, the number of scale inefficient firms decreased by using increasing return technology. Results also revealed that small firm size was not a barrier for achieving technical and scale efficiency. The inefficiencies in Greek sausage industry were mainly due to managerial failure to fully exploit potential technology. Some policy applications derived from these findings. Management should apply new methods of decreasing costs and excess capital usage, while policy-makers should propose adequate improvement policies of performance.

Key words: Efficiency, data envelopment analysis (DEA), bootstrapping method, sausage industry.

INTRODUCTION

The production of sausage in Greece took on the features of a manufacturing industry since 1970. The majority of sausage manufacturers firms are small, private and family owned, which focuses on niche markets. The few large companies that exist have automated production processes in place, and control a significant part (approximately more than 65%) of the market, through organized distribution networks that cover all Greek regions. In the past several years, this industry experienced upsizing, with the average size of firms, defined as the firm's turnover, expanding by 23% between 2000 and 2005, while at the same time, the total number of firms in industry has been growing, by 8.1% (from 202 to 249). Also, the domestic sausages production accelerated in period of 1994 to 2007, with an average annual growth rate of 3.4%, as a result of increasing domestic demand which has increased with an average annual growth rate of 3.7% (ICAP, 2008).

The needs of the domestic market in sausage are covered mainly by domestic production (on average 89.5%), while imports and exports are limited. Nevertheless, a loss of market share of Greek sausage companies in period of 1994 to 2007 is concluded by the analysis of the key indicators of international trade (enlargement of import penetration in domestic market and drop in export extroversion of domestic production, ICAP, 2008).

It is noticeable that during the two last decades, radical changes of institutional settings occurred due to the three stages of integration of Greece into European Economic and Monetary Union (EMU). During the 1990's, exchange controls were abolished and capital movements were completely liberalized in the states member of European Union (including Greece). Since 1994, Greece experienced a period of coordinating economic policy and achieving economic convergence which was accomplished by assigning of the Greek state monetary policy decisions to European Central Bank (in 2001) and the adoption of euro as its currency (in 2002).

The question that arises is whether the loss of

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competitiveness of the Greek sausage companies was accompanied by an increase on inefficiencies of firms operating in this sector. Another significant point is the issue of performance during the Greece integration on EMU period. Also, it is investigated whether there are important efficiency divergences among the small, middle-size, and large firms. The answer to these questions requires the estimation of efficiency. So, the study begins by assessment of the relative performance of Greek sausage manufacturing plants from 1994 to 2007, using the smoothed bootstrap data envelope analysis (DEA) proposed by Simar and Wilson (1998, 2000). The motivation for adopting this method arises from the need to overcome the disadvantages of the standard DEA model and to improve the accuracy of its results, providing bias corrected technical and scale efficiency estimates, as well as confidence intervals.

Many previous empirical studies have focused on measuring the relative level of manufacturing efficiency, by using the DEA approach. Some studies have addressed the issue of efficiency in food industry (Basu and Kumar, 2008; Dimara et al., 2008; Ismail, 2009), and in meat production (Lambert, 1994; Yusuf and Malomo, 2007). A few efficiency analyses have been done in meat manufacturing sector (Ali, 2007; Goncharuk, 2009). For example, Ali (2007) analyzed efficiency and productivity in the Indian meat processing industry, over the period of 1980 to 2000, by using the standard DEA and estimating the Malmquist TFP index. On the other hand, Goncharuk (2009) estimated the efficiency of Ukrainian and foreign meatpacking companies, by utilizing a DEA model of super-efficiency.

The current survey attempts to contribute to empirical analysis of industrial economics, by examining efficiency changes in industry, where similar studies are limited in comparison to other sectors. Contribution to literature is also the application of the innovative method of performance measurement proposed by Simar and Wilson (1998, 2000), which, to our knowledge, has not been applied in this context. From a policy perspective, this study provides insight on the best practices which facilitates the managers' effort to enhance efficiency, as well as the application of adequate policies by the institutions. The efficiency analysis of the Greek sausage sector is considered as a main issue and the application of adequate efficiency enhancement policies is needed to ensure the competitiveness increase and specific industry sustainable growth.

MATERIALS AND METHODS

Efficiency measures by using bootstrapped data enveloped analysis

The article applies a non parametric DEA approach to measure the relative efficiency scores of the sample Greek sausage manufacturing firms. In literature, two basic flavors of methods for measuring the efficiency exist. In the first one, technical efficiency ($\hat{\theta}_{CRS}$), proposed by Charnes et al. (1978), is appropriate for analyzing the performance when the technology exhibits constant returns to scale (CRS). On the other side, Banker et al. (1984), proposed the pure technical efficiency ($\hat{\theta}_{VRS}$) which is used in the case where technology exhibits variable returns to scale (VRS).

So in this study, in order to elucidate which of them is the most appropriate for analyzing the Greek sausage industry case, a non-parametric test proposed by Simar and Wilson (2002), for each year in the 14-year study period was performed. According to these results, in all 14 cases, the null hypothesis that the technology exhibits constant returns to scale was rejected. Therefore, the underlying technology for the sausage manufacturing firms of the given sample was variable returns to scale. The pure technical efficiency, under the assumption of an input orientation, is measured here, by solving the following linear program:

$$\hat{\theta}_{VRS} = \min\{\theta > 0 \mid y \leq \sum_{i=1}^{n} \lambda_i y_i, \theta x \geq \sum_{i=1}^{n} \lambda_i x_i, \sum_{i=1}^{n} \lambda_i = 1, \lambda_i \geq 0, i = 1...n\} \quad (1)$$

In Equation 1, the efficient level of input is defined by θx, which is the projection of an observed sausage industry (*x, y*) on to the efficient frontier, while θ is a scalar and λ is a non-negative vector of constants specifying the optimal weights of inputs/outputs. $\hat{\theta}_{VRS}$ gives the decrease of inputs, which an observed firm at location (*x, y*) could undertake, in order to become efficient. Firm is considered fully efficient when $\hat{\theta}_{VRS} = 1$, and inefficient otherwise. Pure technical inefficiency is usually interpreted as a result of inadequate management practices. Another measure is scale efficiency(*SE*) which is used to examine how close a sausage manufacturing firm is to potentially optimal scale (Färe and Grosskopf, 1985). *SE* is calculated as the ratio of the technical efficiency score $\hat{\theta}_{CRS}$ of a sample firm under CRS technology to those ones of pure efficiency $\hat{\theta}_{VRS}$ under variable VRS technology.

A similar test investigates the source of scale inefficiency which is the ratio (S) of the efficiency scores of a sample firm under non-increasing returns to scale ($\hat{\theta}_{NIRS}$) to those ones under variables return to scale ($\hat{\theta}_{VRS}$).

A sample firm is operating under increasing returns to scale (IRS), when *S* is significantly less than unity, while it is operating under decreasing returns to scale (DRS) , when S is equal to unity (Coelli et al*.,* 2005; Cooper et al., 2000). The standard DEA approach has come under criticism owing to the potential bias of efficiency estimates due to the sampling variation of the estimated frontier and the non measurement of random error and therefore, to the incorrect definition of overall deviation from the frontier as inefficiency. This research project addresses these inherent limitations of DEA, by applying the smoothed bootstrap approach of Simar and Wilson (1998, 2000). The complete bootstrap algorithm

Table 1. Descriptive statistics of the data.

Variable	Mean	Min.	Max.	Standard derivation
Total sales	13700	280	91894	21665
Capital cost	1204	13	8989	2085
Cost of raw and auxiliary materials	8348	117	65645	14156
Number of full-time employees	114	4	703	160

performed in this study is extensively described in Simar and Wilson (1998). This approach combines the advantages of both parametric and non-parametric methods, avoiding the problems of mis-specification of the production function and sample variation bias.

Data and sample

Data on inputs and output were collected for 35 Greek sausage firms for the period of 1994 to 2007. Our sample consists of all the large companies operating in this sector, as well as medium and small size firms. In this study, three inputs and one output was employed. The selection of output and input variables followed previous studies.

The output variable is total sales (Ali, 2007; Badunenko, 2010; Kravtsova, 2008; Yang and Chen, 2010; Lu et al., 2010) while input variables are the cost of capital, estimated as the sum of depre-ciation and interest (Ali, 2007; Badunenko, 2010), the cost of raw and auxiliary materials (Ali, 2007; Goncharuk, 2009; Kravtsova, 2008) and the number of full-time employees (Yang and Chen, 2010; Lu et al., 2010; Ali 2007; Goncharuk, 2009). It is worth noting that the DEA convention, stating that the minimum number of DMU should be greater than three times the number of inputs plus outputs, was satisfied. Our dataset was compiled from both primary and secondary sources.

First, a questionnaire survey was conducted from December 2008 until February 2009 by Panteion University of Athens to obtain information that was not readily available, such as the cost of raw and auxiliary materials and the number of employees.

During this process, 56 Greek sausage manufacturing firms were randomly selected, operating in different regions of Greece, were contacted, and 25 of them provided us with the relevant information (a response rate of 44.6%).

At the same time, data from 10 firms that have either been purchased or merged with other firms or have been closed, was drawn in the same time period from the annual industrial bulletin statistics of the Ministry of Development, as well as from the annual balance sheets of companies reported in the Greek Government Gazette. Thus, the panel data set used here was unbalanced, including 410 observations. This is due to late entries and early exits from the market.

The descriptive statistics of database employed, in efficiency scores measurement, are presented in Table 1.

Note that the monetary variables were deflated by the producer price index and expressed in thousands of euro at constant 1999 prices.

EMPRICAL RESULTS

Pure technical efficiency estimates

The original and bootstrapped VRS technical efficiency scores are presented in Table 2. These findings revealed that the original DEA average efficiency score for the entire period was equal to 0.87, while only few firms (6 out of 40) had produced their outputs on the best practice frontier and were considered to be efficient during the period of 1994 to 2007.

Figure 1 also provides the bootstrapped VRS efficiency estimates. It is important to note that the bias estimation was larger than the standard deviation and hence, the bias corrected efficiencies must be preferred compared to the original ones (Simar and Wilson, 2000).

The findings showed that the bias corrected pure technical efficiency of an “average” Greek sausage firm ranged from 0.83 to 0.73 from 1994 to 2007, indicating that the same output, for different years of the study, could have been produced by using 17 to 27% less than the observed inputs, if the firm was efficient.

By analyzing specific years of the study period, a clear trend of decreasing efficiency was observed (Figure1). The average efficiency scores diminished during the period of 1994 to 1998 (except for the year 1995), followed by a considerable rise in 1999 and in 2000, while in the period 2001 to 2007, there was a persistent decrease (except for the year 2005).

A similar declining trend of efficiency is confirmed by the frontier analysis within balanced panel including 20 firms. Also, significant differences in efficiency scores of an average firm within unbalanced and balanced panel were not observed over the considered period. Table 3 shows the average level of bias corrected pure technical efficiency scores by size categories. The results indicated that in most years, relatively larger firms have similar performance to smaller ones, while the middle firms with 50 to 249 employees performed slightly better.

Scale efficiency measures

Information on scale efficiency scores of the analyzed Greek firms is reported in Table 3. The most striking result was that in the fourteen years under consideration, an "average" firm of the sample displayed high scale efficiency (0.95). In terms of size, large firms, middle-size and small films on average, were slightly different in scale efficiency, as they had the average scale efficiency scores of 0.94, 0.96 and of 0.96 respectively in the period of 1994 to 2007 (Table 3). The nature of return to scale (RTS) is presented Table 4. From these results, in period

Table 2. Bias corrected estimates of technical and scale efficiency scores.

Firms	1994-2000			2001-2007			1994-2007							
	TE	PTE	SE	TE	PTE	SE	TE			PTE			SE	DEA
	Mean						Mean	UB	LB	Mean	UB	LB	Mean	
F1	0.80	0.84	0.95	0.79	0.80	0.98	0.79	0.86	0.73	0.82	0.91	0.73	0.96	0.91
F2	0.74	0.76	0.97	0.74	0.79	0.94	0.74	0.79	0.68	0.77	0.83	0.70	0.96	0.83
F3	0.72	0.75	0.95	0.80	0.86	0.93	0.76	0.78	0.68	0.81	0.84	0.72	0.94	0.84
F4	0.71	0.76	0.94	0.77	0.76	1.00	0.74	0.79	0.68	0.76	0.82	0.69	0.98	0.82
F5	0.79	0.82	0.96	0.83	0.85	0.99	0.81	0.88	0.74	0.83	0.92	0.73	0.98	0.92
F6	0.81	0.82	0.99	0.66	0.74	0.90	0.74	0.79	0.68	0.78	0.84	0.70	0.95	0.84
F7	0.74	0.76	0.97	0.72	0.74	0.98	0.73	0.79	0.67	0.75	0.82	0.67	0.97	0.82
F8	0.79	0.79	0.99	0.82	0.85	0.97	0.80	0.86	0.74	0.82	0.90	0.73	0.98	0.90
F9	0.76	0.80	0.95	0.80	0.83	0.96	0.78	0.84	0.72	0.81	0.89	0.72	0.96	0.89
F10	0.83	0.84	0.99	0.70	0.75	0.94	0.76	0.82	0.71	0.79	0.86	0.72	0.96	0.86
F11	0.80	0.81	0.99	0.73	0.74	0.98	0.77	0.84	0.71	0.78	0.87	0.71	0.98	0.87
F12	0.72	0.74	0.97	0.76	0.79	0.96	0.74	0.79	0.68	0.77	0.84	0.68	0.97	0.84
F13	0.73	0.76	0.95	0.82	0.84	0.98	0.77	0.82	0.70	0.80	0.86	0.71	0.97	0.86
F14	0.77	0.83	0.93	0.68	0.72	0.94	0.72	0.77	0.67	0.77	0.83	0.70	0.94	0.84
F15	0.72	0.77	0.95	0.79	0.83	0.94	0.76	0.82	0.68	0.80	0.87	0.71	0.94	0.87
F16	0.76	0.79	0.97	0.80	0.84	0.95	0.78	0.83	0.72	0.82	0.89	0.73	0.96	0.89
F17	0.76	0.80	0.94	0.70	0.76	0.93	0.73	0.79	0.67	0.78	0.86	0.68	0.94	0.86
F18	0.72	0.77	0.93	0.78	0.79	0.99	0.75	0.79	0.69	0.78	0.85	0.70	0.96	0.85
F19	0.76	0.83	0.92	0.74	0.79	0.94	0.75	0.81	0.70	0.81	0.89	0.71	0.93	0.89
F20	0.75	0.82	0.92	0.84	0.84	1.00	0.80	0.88	0.72	0.83	0.93	0.73	0.96	0.93
F21	0.76	0.79	0.96	0.79	0.84	0.95	0.77	0.83	0.72	0.81	0.89	0.73	0.95	0.89
F22	0.77	0.78	0.98	0.78	0.84	0.93	0.77	0.83	0.71	0.80	0.88	0.71	0.96	0.88
F23	0.80	0.83	0.97	0.66	0.70	0.95	0.75	0.81	0.68	0.78	0.85	0.70	0.96	0.85
F24	0.74	0.78	0.95	0.78	0.80	0.97	0.76	0.81	0.70	0.79	0.86	0.70	0.96	0.86
F25	0.75	0.81	0.93	0.82	0.90	0.91	0.77	0.80	0.70	0.83	0.88	0.72	0.93	0.88
F26	0.77	0.79	0.98	0.79	0.81	0.97	0.78	0.85	0.70	0.79	0.87	0.71	0.98	0.87
F27	0.77	0.78	0.99	0.75	0.80	0.94	0.77	0.82	0.72	0.79	0.84	0.72	0.98	0.84
F28	0.75	0.83	0.91				0.75	0.81	0.70	0.83	0.90	0.75	0.91	0.90
F29	0.77	0.82	0.94				0.77	0.83	0.71	0.82	0.90	0.73	0.94	0.90
F30	0.76	0.79	0.97				0.76	0.83	0.71	0.79	0.89	0.70	0.97	0.89
F31	0.64	0.75	0.86	0.80	0.85	0.94	0.73	0.78	0.68	0.80	0.87	0.72	0.91	0.87
F32	0.70	0.73	0.96	0.73	0.77	0.94	0.72	0.79	0.64	0.76	0.83	0.66	0.95	0.83
F33	0.93	0.89	1.00	0.72	0.75	0.95	0.75	0.80	0.69	0.77	0.84	0.68	0.97	0.84
F34				0.77	0.80	0.97	0.77	0.82	0.71	0.80	0.88	0.69	0.97	0.88
F35				0.78	0.78	1.00	0.78	0.85	0.70	0.78	0.87	0.67	1.00	0.87
Mean	0.76	0.79	0.96	0.76	0.79	0.96	0.76	0.81	0.70	0.79	0.86	0.71	0.96	0.86
Min	0.64	0.73	0.86	0.66	0.70	0.90	0.72	0.77	0.64	0.75	0.82	0.66	0.91	0.82
SD	0.05	0.03	0.03	0.05	0.05	0.03	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03

TE, PTE and SE stands for overall, pure technical, and scale efficiency estimates respectively, LB stands for lower bound of the confidence interval, UB for upper bound of the confidence interval, DEA stands for original VRS efficiency estimates.

of 1994 to 2007, approximately 28.3% of the sample firms were operating at constant return to scale (CRS), while a considerable portion of firms was scale inefficient. Nearly 70.5% of the sample firms were operating at increasing return to scale (IRS). Only the 1.2% of the firms considered was operating at decreasing returns to scale (DRS). Moreover, an increasing trend in the share of scale efficient firms was present (from 10% of all firms in 1994 to 28.3% in 2007). As a result, the share of scale inefficient firms due to IRS was decreased (from 80% in 1994 to 76% in 2007).

Inputs slacks

Figure 2 shows the average share of sample firms whic

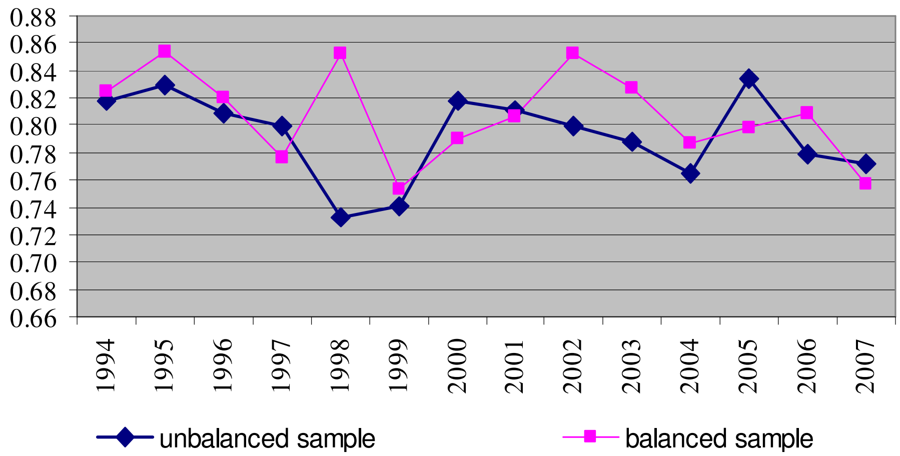

Figure 1. Bias corrected estimates of the average VRS technical efficiency for period of 1994 to 2007.

Table 3. Averages of efficiency and number of firms by size categories.

	Pure technical efficiency								Scale efficiency							
	Size firms categorized by the number of employees															
	0-49		50-249		> 250		Total		0-49		50-249		> 250		Total	
	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M
1994	20	0.82	8	0.80	2	0.88	30	0.82	20	0.93	8	0.97	2	0.87	30	0.92
1995	21	0.82	11	0.81	2	0.87	34	0.82	17	0.96	11	0.97	2	0.87	30	0.93
1996	20	0.77	10	0.83	2	0.58	32	0.78	21	0.96	10	0.99	1	1.00	32	0.98
1997	19	0.80	10	0.81	2	0.85	31	0.81	20	0.95	10	0.93	2	0.90	32	0.93
1998	18	0.78	11	0.73	2	0.69	31	0.76	19	0.94	12	0.97	2	0.96	33	0.96
1999	16	0.73	9	0.78	9	0.76	34	0.74	18	0.96	9	0.99	4	0.97	31	0.98
2000	17	0.82	8	0.83	6	0.83	31	0.82	16	0.93	8	0.97	6	0.96	30	0.95
2001	14	0.81	8	0.80	6	0.80	28	0.81	17	0.98	8	0.95	6	0.96	31	0.96
2002	13	0.83	9	0.80	6	0.82	28	0.82	14	0.94	8	0.90	7	1.00	29	0.93
2003	15	0.76	9	0.83	6	0.80	30	0.79	13	0.98	9	0.97	6	0.93	28	0.96
2004	12	0.74	7	0.86	6	0.72	25	0.77	15	0.97	7	0.95	6	0.97	28	0.96
2005	12	0.86	8	0.83	6	0.85	26	0.85	12	0.97	8	0.97	6	0.98	26	0.97
2006	12	0.82	9	0.71	5	0.83	26	0.78	12	0.94	9	0.99	5	0.91	26	0.95
2007	13	0.76	7	0.71	5	0.75	25	0.74	13	0.96	7	0.96	5	0.94	25	0.95
M	16	0.79	9	0.80	5	0.79	29	0.79	16	0.96	9	0.96	4	0.94	29	0.95

N stands for the number of firms, M stands for the average of efficiency score.

had input slacks equal to zero or above, in the period 1994 to 2007. These results have been derived using original DEA. According to these, a majority of the sample enterprises had inputs slacks greater than zero, during the considered period, indicating the existence of productive factors overcapacities in sample firms.

The inputs-slacks expressed as a percentage of the input level, are shown in Figure 3. An interesting finding was that all inputs had to be decreased, in order for the sample firms to become pure and technically efficient.

Capital might be decreased, on average, by 19.5%, while labour and raw and auxiliary materials by 14.4and 8.6% respectively.

The relatively small slack-input for intermediate consumption observed in the sample firms supports the ascertainment about the small inefficiency of this input factor. Another interesting finding is that during the liberation of market period from 1994 to 2000, all inputs slacks were decreased, while during the Greek integration period to EMU (2001 to 2007), the former drop of inputs slacks had been replaced by a clear increasing trend of all inputs excesses, from 2001 through 2006,

Table 4. Frequency of scale efficient and scale inefficient firms with inefficiency due to decreasing or increasing returns to scale (1994 - 2007).

	Scale efficient		Scale inefficient						Total	
Year	N of SE (%)		N of SI due to DRS (%)		N of SI due to IRS (%)		N of SI (%)		N (%)	
1994	3	10.0	3	10.0	24	80.0	27	90.0	30	100.0
1995	8	26.7	0	0.0	22	73.3	22	73.3	30	100.0
1996	19	59.4	1	3.1	12	37.5	13	40.6	32	100.0
1997	6	18.8	0	0.0	26	81.3	26	81.3	32	100.0
1998	6	18.8	0	0.0	26	81.3	26	81.3	32	100.0
1999	10	32.3	0	0.0	21	67.7	21	67.7	31	100.0
2000	7	23.3	0	0.0	23	76.7	23	76.7	30	100.0
2001	7	22.6	0	0.0	24	77.4	24	77.4	31	100.0
2002	6	20.7	0	0.0	23	79.3	23	79.3	29	100.0
2003	7	25.0	0	0.0	21	75.0	21	75.0	28	100.0
2004	10	35.7	1	3.6	17	60.7	18	64.3	28	100.0
2005	10	38.5	0	0.0	16	61.5	16	61.5	26	100.0
2006	11	42.3	0	0.0	15	57.7	15	57.7	26	100.0
2007	6	24.0	0	0.0	19	76.0	19	76.0	25	100.0
Mean	8	28.3	0	1.2	21	70.5	21	71.6	29	100.0

SE stands for scale efficient, SI stands for scale inefficient, DRS stands for decreasing returns to scale, IRS stand for increasing returns to scale, N stands for number of firms.

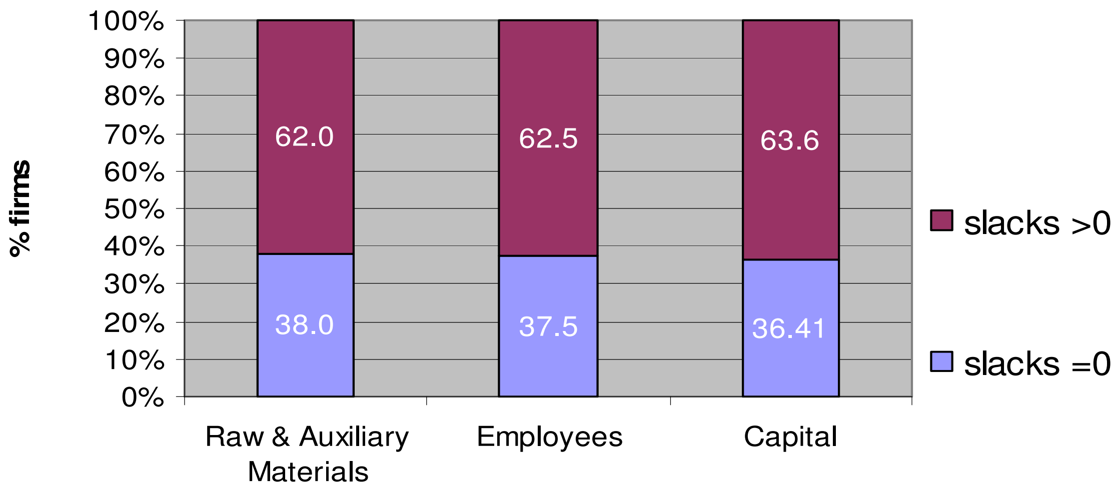

Figure 2. Distribution of three slack inputs over the period of 1994 to 2007.

followed in 2007 by an intense decrease of capital,labour and raw and auxiliary materials excess.

DISCUSSION

Decreasing competitiveness in Greek sausage manufacturing industry was accompanied by a managerial failure to fully exploit potential technology during the period of 1994 to 2007, which tended to enlarge over time. The liberation of markets during the 1990's and the Greece's integration to European and Monetary Union, since 2001, did not intercept the declining course of technical efficiency on Greek sausage industry. Similar evidence is reported by Vasiliev et al. (2008) which studied the issue of grain farms performance in Estonian over the period of 2000 to 2004, and found that the Estonia accession to European Union did not influence the performance of grain farmers.

Despite the increasing trend of technical inefficiencies,

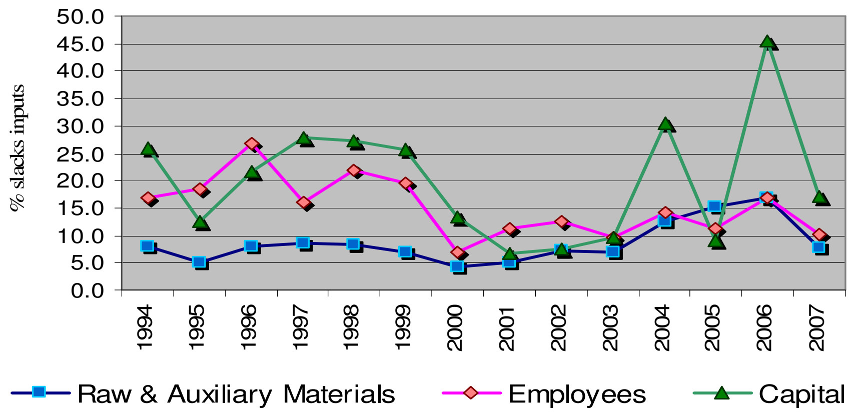

Figure 3. Ratio between DEA input slacks for VRS technical efficiency and average input level.

the majority of Greek sausage companies were close to operating at optimal scale, indicating that there is a very slight space to achieve input savings, through the adjustment of their operational scale. The relatively small-scale production of the Greek sausage industry and Greece in general, was the main reason why a minor number of firms had used decreasing return technology (DRS), or in others words, why they had to decrease their size for achieving scale efficiency. So, several firms managed to be scale efficient by expanding their size. That is why upsizing behavior occurred in the study period in Greek sausage industry. This finding implies that the source of scale inefficiencies may explain one important structural change: why upsizing or downsizing behavior is observed in an industry. Former examination of the relationship between the source of scale inefficiencies and upsizing or downsizing behavior reveals similar evidence in the literature. For example, Vasiliev et al. (2008), and Ceyhan and Hazneci (2010) found that upsizing was a rational conduct because all scale inefficient firms have continually operated under increasing return portion of technology, while other research projects conducted in developed economies explained downsizing behavior as a result of decreasing return portion of technology (Badunenko, 2010). Looking at the low pure technical efficiency in comparison to scale efficiency, it is clear that inefficiencies in Greek sausage industry were mostly due to inadequate management practices (pure technical inefficiency), than to inappropriate size of firms (scale inefficiencies). Inefficient managerial decisions led mostly to capital excess usage in Greek sausage plants. Probably, the failure of manager is based on that they used the subsidies provided by EU for purchase of machinery without taking into account the firm size. This conclusion is supported by the findings of Vasiliev et al. (2008).

The investigation of impact of structural attributes on performance observed in Greek sausage industry over the study period suggests that the small firm size was not a barrier for achieving efficiency.

A similar relationship between size and technical efficiency was also revealed in other areas in developing countries (Vasiliev et al., 2008; Granér and Isaksson, 2009; Ceyhan and Hazneci, 2010).

However, many previous studies found that the technical efficiency increases with the size of the firm (Badunenko, 2010). These mixed results may be explained by the literature. Relatively large firms were usually more efficient because they pursued a cost leadership strategy, having the opportunity to enjoy economies of scale due to large production volumes or/and economies of scope, as they could meet the needs of the mass market, competing, also, on differentiation (quality, brand and customization). On the other hand, relatively small sausages enterprises could be efficient too, because they managed to gain a completive advantage in focused narrow market segments (Fotinopoulou and Keramidou, 2006). Depending on the needs of the selected market segments and the resources and capabilities of each firm, several small firms could offer low prices and enjoy advantages of conductive low costs, through the use of low cost family labour, productive flexibility, or other cost economies, attained often in illegal ways (paying less than the minimum wage, or even tax evasion).

CONCLUSION

This article provides an application of the DEA bootstrapping procedure in the sausage industry, in order to estimate efficiency scores. The analysis of pure technical efficiency scores (PTE) showed an increase trend of inefficiencies over the study period, due to the managerial failure to fully exploit potential technology. The high growth trend of sausage domestic production, as well as the Greece's integration in European Economic Monetary Union could not change this situation. However, several firms succeeded in improving their performance and adapting their size. So, upsizing was found to be a rational conduct, which explains why the number of scale inefficient firms has been decreasing over the considered period. The analysis of slacks inputs suggests that the main source of inefficiencies was based mostly on the high capital slack and less use of labour. The subsidies provided by EU might stimulate purchase of machinery without regard to firm size. Furthermore, the findings revealed that firm size did not have any effect on the efficiency of our sample firms, as relatively smaller firms enjoyed advantages of conductive low costs, mostly through the use of low cost family labour. Therefore, the loss of competitiveness of the Greek sausage companies during the 2000' was accompanied by an increasing trend of productive factors overcapacities in them. On the policy implication side, management has large space to enhance their competitiveness by paying more attention to reduction of the input of capital and applying new methods to promote staff's efficiency. This can be done by adopting similar practices, to those of best performers in the sample. Policy-makers have to take into account the impact of European Union subsidiaries on firm efficiency in sectoral level, so as to propose adequate policies for improvement sector's efficiency and competitiveness of Greek manufacture.

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