Efficiency and Productivity Change in the Greek Dairy Industry

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Abstract
The objective of this paper is to measure the efficiency and the productivity change of Greek dairy firms, using non parametric approaches. This assessment is being achieved by the computation of the CRS and the VRS DEA models, the context dependent DEA approach and finally, the evolution of the Malmquist productivity index. These empirical analyses are based on data from 29 Greek dairy firms. This implementation provided helpful information regarding the efficiency ranking of the firms that operate in the Greek dairy industry. Findings that inefficient firms are over-invested and over-exposed to high risk operation practices provide suggestions for future reparative actions in order to improve efficiency. This goal does not require radial effort from firms to achieve intermediate targets. Finally, stagnated mean efficiency change does not imply stagnated efficiency change for individual firms, but it is the outcome of a large variance of efficiency change scores being achieved by dairy firms from period to period.

Keywords: *Efficiency, Context-depended DEA, Malmquist Productivity Index, Dairy Industry*

1. Introduction

The dairy market situation deteriorated dramatically during the 2007-2009 period. In 2007 European Union (EU) and world dairy market prices increased considerably leading to a relatively small increase in milk deliveries. However, in 2008, a drop in global demand connected with the economic crisis had a direct effect on EU market prices which dropped substantially affecting severely dairy producers' income. The market situation recovered in 2009 and continuously improved in 2010 (European Commission, 2010). According to the second "soft landing" report from the EC (2012), volatility, not to the extent observed during the 2008-2009 period, persisted in the dairy market until the end of 2010 and it receded in 2011 and 2012, leading to increased production and higher prices.

In general, the milk sector went through a period of turmoil, but since then the dairy market situation has improved and future prospects are broadly positive, although the market has not been stabilized. Increasing global demand, especially from emerging

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countries, such as India, China and Russia, and growing trade create new perspectives for the sector. In order to benefit from the opportunities offered by demand and trade growth, to stabilize the dairy market and to ensure a fair functioning of the dairy supply chain a strong and efficient dairy industry is required. Robust milk processing factories and retailers would mitigate the price fluctuations, alleviate the market situation and assist to the restructuring of the sector. An efficient and effective operation of the dairy industry is essential to raise the competitiveness of the dairy sector. In this context, the investigation of the economic performance and the efficiency of dairy firms would be beneficial for an insightful critical description of the dairy sector in total.

The purpose of this paper is to assess the efficiency and the productivity growth of the dairy industry in Greece. The technical efficiency level of 29 dairy firms is measured through the application of a context-dependent Data Envelopment Analysis (DEA) approach, while the total factor productivity change and its components is estimated using the Malmquist productivity index. The analysis is based on published data and provides an indicative picture of the performance, structure and productivity of the dairy industry in the country.

Dairy industry in Greece constitutes one of the most important and dynamic sectors of the country's economy and a traditional branch of the Greek food industry (Rezitis and Kalantzi, 2012), exhibiting significant development the last thirty years. The vast majority of the companies that operate in the industry are small, local, family diaries that produce various types of dairy products, indicating a rather fragmented industry (Feka et al., 1997). These small milk processing units that operate locally do not affect the demand seriously; few large dairy companies account for more than 90% of the accumulated dairy market share in Greece. Although there are studies that have estimated the efficiency level of dairy farms in Greece (Manos and Psychoudakis, 1997, Psychoudakis and Dimitriadou, 1999, Theodoridis and Psychoudakis, 2008), there is no attempt to assess the efficiency of the Greek dairy industry. As it concerns the dairy companies in EU, there exist studies which investigated the competitiveness and innovativeness of the industry (Drescher and Maurer, 1999; Bremmers et al., 2008; Poppe et al., 2008; Wijnands et al., 2010), but not the level of its efficiency. Hence, the contribution of this study to the existing literature can be summarized to the fact that, at least to our knowledge, this is the only study that estimates the technical efficiency level of dairy firms and attempts to explore the performance of the sector from the aspect of the dairy industry.

The paper is organized as follows: Section 2 presents the data used in the analysis; Section 3 describes the methodological approach. Section 4 contains the empirical results, Section 5 their implications and the final Section concludes the study.

2. Data

A sample of 29 dairy companies operating in the Greek dairy market was used for the empirical investigation. This sample size could be considered as a small fraction of the total number of the Greek dairies[3]; however the selected sample dairy firms satisfy

[3] As it has aforementioned Greek dairy industry includes a large number of small capacity cheese manufacturers.

the vast majority of the domestic demand for dairy products. Almost 33% of the sample firms are importing firms focused on evaporated milk, milk powder, yoghurt, butter and cheese products while 20% of them are Greek cooperatives, holding considerable market shares of the fresh milk market as well as the cheese and yoghurt market. The data used for the analyses were collected from the published annual balance sheets of the dairy companies under examination. The DEA models, which are being described in the following section, are based on data from the 2006-2007 period. The estimation of the productivity change (Total Factor Productivity - TFP) and its components, namely technical efficiency change and technical change (frontier shift), is based on observations from five continuous years, the 2003-2007 period. In the specification chosen in this study the relevant inputs and outputs are factors which affect directly the economic performance of each firm, as indicated in the relevant bibliography. Thus, such inputs include the operational cost at various types or versions, capital cost and depreciation, while as outputs include the revenue of the firms, mixed profit, and production quantities. Following the same approach, the inputs incorporated in the models are the *overall depreciation*, the *cost of sold products*, the *shared capital*, the *value of stock*, and the *short term liabilities*. The outputs being selected are the *revenue*, and the *mixed profit* of each firm. The summary statistics of the output and input variables are presented in Table 1.

Table 1: *Descriptive statistics of inputs/outputs*

	Mean	*Median*	*Standard Dev.*	*Min*	*Max*
Depreciation	17,510,043	4,064,940	27,081,785	328,006	123,579,000
Shared Capital	14,516,990	5,079,900	32,928,112	232,663	170,801,000
Cost of Sold Products	61,442,809	19,479,000	80,569,897	1,484,403	289,328,000
Stock	9,048,943	3,201,749	12,833,790	48,008	47,308,000
Short Term Liabilities	25,851,008	10,597,440	35,219,900	609,032	150,980,000
Revenue	85,838,152	32,092,212	120,066,891	2,151,890	466,458,000
Mixed Profit	27,513,097	7,495,000	53,363,056	413,545	221,202,031

3. Methodological Approach

Efficiency and performance are a core concept of economics research. The relationship between them has been analyzed from many points of view, using different techniques and investigating the determinants of efficiency. An established methodological approach for the measurement of efficiency is the non-parametric DEA, which is based on a finite sample of observed production units (Decision Making Units – DMUs), uses a linear programming method and does not require a pre-specification of a functional form. The basic version of the DEA model was initially proposed by Charnes et al. (1978). Since then, DEA has been applied extensively in performance evaluation of production units and nowadays is considered a well-established technique. The fundamental DEA models and their extensions can be found in Coelli (1995), Cooper et al. (2005), Zhu (2009) and Fried et al. (2008).

In this study an input-oriented CRS and VRS DEA model is applied. Input-oriented models maximize the proportional decrease in inputs while achieving the same level of production, and VRS DEA models assume that the units do not operate at an optimal scale and allow the estimation of the scale efficiency component.

Due to the fact that many small or medium sized diary firms operate on a local or regional level or adopt niche marketing strategies like ship provisioning and hotel catering, it is more appropriate to evaluate the DMUs not only against the best practice frontier, but by implementing the relative attractiveness approach, where the relative attractiveness is defined with respect to a particular best-practice context. According to Zhu (2009) in order to obtain the evaluation contexts an algorithm is developed to remove the original best-practice frontier to allow the remaining inefficient DMUs to form a new second best-practice frontier. When this new second-level best-practice frontier is removed, a third-level best-practice frontier is constructed, and so on, until no DMU is left (Morita and Zhu, 2010). This way, the DMUs are stratified into several levels of best-practice frontiers. Each best-practice frontier provides an evaluation context for measuring the relative attractiveness and progress of the units. This extension of the original DEA approach is called Context-Dependent DEA (Seiford and Zhu, 2003) and provides a measure of attractiveness and progress of the DMUs with respect to a given evaluation context. In this study, we consider the attractiveness and progress of the 29 sample dairy firms. This extension of the approach makes DEA more versatile and allows DEA to identify better options (Cook and Zhu, 2005).

Assuming that $J^1=\{DMU_j, j=1,\ldots,n\}$ is the set of all n DMUs and interactively define $J^{l+1}=J^l-E^l$ where $E^l=\{DMU_k \in J^l \,|\, \theta^*(l,k)=1\}$ and $\theta^*(l,k)$ is the optimal value to the following input-oriented CRS envelopment model when DMU_k is under evaluation

Assuming that there are n DMUs which produce s outputs by using m inputs, the set of all DMUs is defined as J^l and the set of efficient DMUs in J^l is defined as E^l. Then the sequences of J^l and E^l are defined as $J^{l+1}=J^l-E^l$ (Morita and Zhu, 2010). The set of E^l can be found as the DMUs with optimal value φ_k^l of 1 to the following linear programming problem:

$$\theta^*(l,k)=\min_{\lambda_j,\,\theta(l,k)} \theta(l,k)$$

Subject to

$$\sum_{j\in F(J^l)} \lambda_j x_{ij} \le \theta(l,k)x_{ik}$$

$$\sum_{j\in F(J^l)} \lambda_j y_{rj} \ge y_{rk}$$

$$\lambda_j \ge 0, \quad j\in F(J^l)$$

Where x_{ij} and y_{rj} are i-th input and r-th output of DMU j. When $l=1$ the above model becomes the original input oriented CRS envelopment model, and E^1 consists of all the frontier DMUs. When $l=2$ the model provides the second-level best-practice frontier after the exclusion of the first, and so on. The following algorithm achieves the identification of these best-practice frontiers.

Step 1: Setting $l = 1$. Evaluate the entire set of DMUs, J^1, by the above model to obtain the first-level frontier DMUs, set E^1

Step 2: Excluding the frontier DMUs from future DEA runs. $J^{l+1} = J^l - E^l$.
(if $J^{l+1} = \varnothing$ then stop.)

Step 3: Evaluating the new subset of DMUs, J^{l+1}, by the same model to obtain the new set of DMUs E^{l+1} which is the new best-practice frontier.

Step 4: Letting $l = l + 1$ and going again to step 2.

Stopping rule: $J^{l+1}=\varnothing$, the algorithm stops.

The attractiveness of a $DMU_q = (x_q, y_q)$ from a specific level E^{l_o}, $l_o \in \{1,\ldots, L-1\}$ is being characterized by the following model

$$H_q^*(d) = \min H_q(d) \quad d = 1,\ldots, L-l_o$$

Subject to

$$\sum_{j \in F(E^{l_o+d})} \lambda_j x_j \leq H_q(d) x_q$$

$$\sum_{j \in F(E^{l_o+d})} \lambda_j x_j \geq y_q$$

$$\lambda_j \geq 0 \quad j \in F(E^{l_o+d})$$

The $H_q^*(d)$ is called (input-oriented) *d-degree* attractiveness of DMU_q from a specific level E^{l_0}

The progress measure for $DMU_q \in E^{l_0}$, $l_o \in \{2,\ldots,L\}$ is being determined by the solution of the following linear programming problem

$$G_q^*(g) = \min G_q(g) \quad g = 1,\ldots, L-1$$

Subject to

$$\sum_{j \in F(E^{l_o-g})} \lambda_j x_j \leq G_q(\beta) x_q$$

$$\sum_{j \in F(E^{l_o-g})} \lambda_j x_j \geq y_q$$

$$\lambda_j \geq 0 \quad j \in F(E^{l_o-g})$$

$M_q^*(d) \equiv 1 / G_q^*(g)$ is called (input-oriented) g-*degree* progress of DMU_q from a specific level E^{l_o}

The productivity growth of the dairy firms is estimated using the Malmquist Productivity Index, which is calculated as follows (Thrall, 2000):

Suppose each DMU_j ($j = 1, 2,\ldots, n$) produces a vector of outputs $y_j^t = (y_{1j}^t,\ldots,y_{sj}^t)$ by using a vector of inputs $x_j^t = (x_{1j}^t,\ldots,x_{sj}^t)$ at each period t, $t = 1, \ldots, T$. From t to $t+1$,

DMU_o's efficiency may change or (and) the frontier may shift. Malmquist productivity index is calculated via

(i) Comparing x_0^t to the frontier at time t, in the following input-oriented CRS envelopment model

$$\theta_0^t(x_0^t,\ y_0^t) = \min \theta_0$$

Subject to

$$\sum_{j=1}^{n} \lambda_j \chi_j^t \leq \theta_0 x_0^t$$

$$\sum_{j=1}^{n} \lambda_j y_j^t \geq \theta_0 y_0^t$$

$$\lambda_j \geq 0, \quad j=1,\ldots,n$$

where $x_o^t = \left(x_{1o}^t,\ldots,\ x_{mo}^t\right)$ and $y_o^t = \left(y_{1o}^t,\ldots,\ y_{so}^t\right)$ are the input and output vectors of DMU_o among others.

(ii) Comparing x_o^{t+1} to the frontiers at time $t+1$, calculating

$$\theta_0^t(x_0^t,\ y_0^t) = \min \theta_0$$

Subject to

$$\sum_{j=1}^{n} \lambda_j \chi_j^t \leq \theta_0 x_0^t$$

$$\sum_{j=1}^{n} \lambda_j y_j^t \geq \theta_0 y_0^t$$

$$\lambda_j \geq 0, \quad j=1,\ldots,n$$

(iii) Comparing x_o^{t+1} to the frontiers at time t+1, calculating

$$\theta_0^{t+1}(x_0^t,\ y_0^t) = \min \theta_0$$

Subject to

$$\sum_{j=1}^{n} \lambda_j \chi_j^t \leq \theta_0 x_0^t$$

$$\sum_{j=1}^{n} \lambda_j y_j^t \geq y_0^t$$

$$\lambda_j \geq 0, \quad j=1,\ldots,n$$

(iv) Comparing x_o^{t+1} to the frontiers at time t, calculating

$$\theta_0^t(x_0^t,\ y_0^t) = \min \theta_0$$

Subject to

$$\sum_{j=1}^{n} \lambda_j \chi_j^t \leq \theta_0 x_0^t$$

$$\sum_{j=1}^{n} \lambda_j y_j^t \geq y_0^{t+1}$$

$$\lambda_j \geq 0, \quad j=1,\ldots,n$$

The Malmquist productivity index is defined as:

$$M_0 = \left[\frac{\theta_o^t\left(x_o^t, y_o^t\right)}{\theta_o^t\left(x_o^{t+1}, y_o^{t+1}\right)} \; \frac{\theta_o^{t+1}\left(x_o^t, y_o^t\right)}{\theta_o^{t+1}\left(x_o^{t+1}, y_o^{t+1}\right)} \right]^{\frac{1}{2}}$$

M_o measures the productivity change between period's t and $t+1$. If $M_o>1$ productivity improves, if $M_o< 1$ productivity declines and if $M_o=1$ productivity is stable (Lovell, 2003). The following modification of M_o makes it possible to measure the magnitude of technical efficiency and the movement of the frontier in terms of a specific DMU_o.

$$M_0 = \frac{\theta_o^t\left(x_o^t, y_o^t\right)}{\theta_o^{t+1}\left(x_o^{t+1}, y_o^{t+1}\right)} \bullet \left[\frac{\theta_o^t\left(x_o^t, y_o^t\right)}{\theta_o^t\left(x_o^{t+1}, y_o^{t+1}\right)} \; \frac{\theta_o^{t+1}\left(x_o^t, y_o^t\right)}{\theta_o^{t+1}\left(x_o^{t+1}, y_o^{t+1}\right)} \right]^{\frac{1}{2}}$$

The first term on the right hand side measures the magnitude of technical efficiency change between periods t and $t+1$. Obviously, $\frac{\theta_o^t\left(x_o^t, y_o^t\right)}{\theta_o^{t+1}\left(x_o^{t+1}, y_o^{t+1}\right)} \overset{>}{\underset{<}{=}} 1$ indicating that technical efficiency improves, remains or declines. The second term measures the shift in the EPF between period t and $t+1$ (Tone, 2004).

4. Results

The constant returns to scale (CRS) and the variable returns to scale (VRS) input-oriented DEA model was applied and the frequency distribution of the technical and efficiency estimates obtained are presented in Table 2. Under the VRS DEA model 9 out of the 29 dairy companies, i.e. 31% of the total sample, are fully technical efficient, 4 companies more than in the CRS DEA model; a result consistent with the theory that the VRS frontier is more flexible and envelops the data in a tighter way than the CRS frontier. In both models there is a considerable variation of the efficiency score, indicates that with the appropriate input adjustments, Greek diary companies could improve their performance and increase their competitiveness.

***Table 2**: Efficiency rate scores under the CRS and VRS DEA Model*

Efficiency rate	***CRS DEA model***		***VRS DEA model***	
	No of Firms	***%***	***No of Firms***	***%***
$0.9 \leq E \leq 1$	8	27.6	12	41.4
$0.8 \leq E \leq 0.89$	2	6.9	2	6.9
$0.7 \leq E \leq 0.79$	5	17.2	7	24.2
$0.6 \leq E \leq 0.69$	6	20.7	2	6.9
$0.5 \leq E \leq 0.59$	4	13.8	3	10.3
$0.4 \leq E \leq 0.49$	4	13.8	3	10.3

The descriptive statistics of both the CRS and VRS DEA models' results are presented in Table 3 and provide more concise information about the industry. The mean efficiency score for the CRS and VRS DEA model is 0.73 and 0.81, respectively indicating that a 27% and 19% equiproportional decrease of inputs is possible, given the level of outputs and the production technology.

***Table 3:** Descriptive statistics of CRS and VRS DEA Models*

Efficiency score	***CRS DEA model***	***VRS DEA model***
Mean	0.73	0.81
Median	0.72	0.80
Standard Deviation	0.19	0.19
Minimum	0.40	0.44
Maximum	1.00	1.00
No of Efficient Firms	5	9

Moreover, the calculation of slacks showed that for a number of DMUs there are considerable non-radial input excesses with unique exception the cost of sold products input. Table 4 and Table 5 present the inputs excesses calculated for each firm and their relevant summary statistics.

The scale efficiency estimation also provided useful information for the industry in total. The sum of the intensity variables (λs) shows that the majority of the dairies, that is 69% of the total sample, operate under increasing returns to scale, 14% exhibit decreasing returns to scale and 17% show constant returns to scale, indicating that the majority of the dairy firms in the Greek market operate below their optimal scale. These findings provide hints that the firms could increase their efficiency by increasing their size.

Table 4: *Inputs Slacks (%)*

DMU No	Depreciation	Shared Capital	Cost of Sold Products	Stock	Short Term Liabilities
1	0.00	90.97	16.53	0.00	0.0
2	0.00	0.00	0.00	0.00	0.0
3	0.00	53.04	0.00	22.63	32.0
4	0.00	0.00	0.00	0.00	0.0
5	0.00	0.00	0.00	0.00	0.0
6	48.34	58.93	0.00	0.00	30.8
7	0.00	0.00	0.00	0.00	0.0
8	15.74	0.00	0.00	27.40	35.9
9	29.17	29.14	0.00	7.04	29.8
10	35.91	0.00	0.00	0.00	62.3
11	27.14	0.00	0.00	38.10	43.9
12	0.00	0.00	0.00	0.00	0.0
13	0.00	35.13	11.36	16.57	0.0
14	16.22	36.75	0.00	22.93	19.5
15	44.89	38.34	0.00	0.00	15.5
16	6.10	0.00	0.00	19.14	32.1
17	0.00	0.00	0.00	0.00	0.0
18	55.23	0.00	0.00	35.93	38.3
19	38.14	24.44	0.00	20.30	1.0
20	44.68	10.95	0.00	0.00	16.3
21	0.00	59.32	18.01	33.18	0.0
22	55.99	0.00	0.00	45.59	42.8
23	16.70	2.30	0.00	20.52	0.0
24	51.56	35.43	0.00	65.76	0.0
25	19.68	0.00	0.00	19.42	30.4
26	0.00	0.00	0.00	0.00	0.0
27	0.00	0.00	0.00	0.00	0.0
28	0.00	0.00	0.00	63.06	19.4
29	0.00	0.00	0.00	0.00	0.0

Table 5: *Descriptive statistics of inputs' slacks (%)*

	Depreciation	Shared Capital	Cost of Sold Products	Stock	Short Term Liabilities
Mean	17.43	16.37	1.58	15.78	15.52
Median	6.10	0.00	0.00	7.04	0.99
SD	20.64	24.78	4.83	19.54	18.42
Minimum	0.00	0.00	0.00	0.00	0.00
Maximum	55.99	90.97	18.01	65.76	62.34

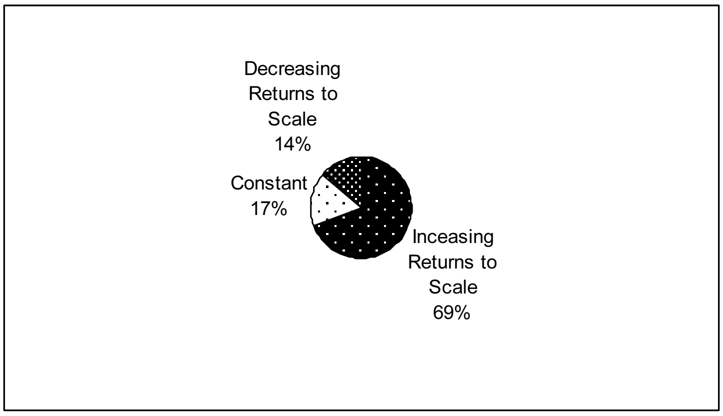

Figure 1. *Scale efficiency estimation of Dairy Firms*

The application of the context-dependent DEA methodology grouped the DMUs under examination to five levels as it appears at the following table.

Table 6: *Context-dependent levels*

Levels	*DMU No*	*CRS Efficiency Scores Range*
Level 1	2,4,12,17,29	1
Level 2	1,5,7,15,18,20,21,26,27,28	1-0.69918
Level 3	3,6,10,11,13,19,23,24	0.98822-0.57498
Level 4	8,9,16,22,25	0.44347-0.79935
Level 5	14	0.45719

The measurement of the attractiveness is calculated by selecting level two as the evaluation background (context) and level one as the one to be evaluated against the selected context and vice versa for the progress. The same procedure was followed with the DMUs from the other levels, accepting the fact that inefficient DMUs are more likely to improve their performance and achieve intermediate targets, rather than reaching the frontier level of efficient DMUs immediately. Table 7 presents the results of these estimations. It is quite interesting that in many cases there is significant difference in both the attractiveness and progress scores amongst DMUs of the same level, as well as between levels, even though in every case the context and the evaluated level are "abutting". These scores provide hints that the improvement of efficiency is not an easy target to be reached, even though these targets are usually characterized as intermediate.

Table 8 shows the average annual growth rate of productivity (TFP) and its components, namely efficiency change (TEC) and technical change which captures shifts in the frontier of technology (TC), over the whole investigated period. The results indicate that over the 2003-2007 period the dairy companies experienced an increase in the productivity, with the unique exception of 2007 where productivity declined by 1.9% .

The efficiency change component fluctuates below or above unity; however, its values are very close to one in each year, except 2007, indicating that there is no apparent trend. For the year 2007 efficiency change increases on average, but it is counterbalanced by the downward shift in the production frontier. The same trend occurs for the frontier shift, indicating that there is no continuous progress for the frontier technology.

Table 7: *Attractiveness and progress scores*

Level I DMU No	***Attractiveness score (Level II Context)***
12	1.651347
17	2.278315
4	7.024519
29	10.43168
2	13.10234

Level II	***Attractiveness score (Level III Context)***
28	1.971641
5	1.987055
21	2.029992
1	2.216762
26	2.365988
20	2.424651
15	2.435617
18	3.367354
27	3.485084
7	4.505573

Level III	***Attractiveness score (Level IV Context)***
6	1.474735
11	1.697265
24	1.792279
19	1.833627
23	1.889906
13	2.154092
10	2.203104
3	3.93652

Level IV	***Attractiveness score (Level V Context)***
9	14.26336
25	16.96738
16	19.44336
8	24.85944
22	24.96543

Level II	***Progress Score (Level I Context)***
27	1.008654
21	1.077743
1	1.102946
7	1.112609
26	1.136744
18	1.391235
20	1.396607
15	1.431446
5	1.523528
28	1.750151

Level III	***Progress Score (Level II Context)***
13	1.085135
23	1.099704
10	1.104356
3	1.126219
24	1.129656
11	1.166454
6	1.218972
19	1.250339

Level IV	***Progress Score (Level III Context)***
8	1.038186
9	1.020159
16	1.014581
22	1.028015
25	1.053103

Level V	***Progress Score (Level IV Context)***
14	1.199862

The technical change component exhibits a decrease of 14.7% in 2007 offsetting the efficiency improvement occurred at the same year. In general, the results of the decomposition of TFP show that each year its components move in opposite directions. The analytical results of the empirical analysis show that there is a large range between min and max scores, implying that amongst dairy firms there is considerable variation of productivity and efficiency change, in addition to frontier shift.

Table 8: *Total Factor Productivity Change Composition*

Year	***TC***	***TEC***	***TFPC***
2003/2004	1.010±0.083	0.999±0.139	1.011±0.176
2004/2005	0.991±0.077	1.020±0.115	1.009±0.120
2005/2006	1.076±0.166	0.982±0.186	1.054±0.262
2006/2007	0.853±0.141	1.165±0.188	0.981±0.156

5. Discussion

The fact that up to now there is not still an important amount of works on the implementation of the DEA methodology at the dairy industry in total, does not allow for the formation of reference in relation to the efficiency indexes of such an important industry of the food sector. This first attempt in the Greek market indicates that the efficiency scores vary significantly, suggesting that firms could improve their economic performance through efficiency improvement. Due to fact that the Greek market operate as an integral part of the EU market, where important dairy firms operate, there is a necessity for further research on efficiency of dairy firms in this international free economic zone. Table 9 provides useful information on this issue, comparing the descriptive statistics of the efficiency scores between firms producing dairy products inside the country, with those which import them mainly from northern European countries. The results show significant differences, with importing firms to prevail on both CRS and VRS DEA models. The calculation of slacks indicates that inefficient dairy firms are over invested and significantly exposed to short-term liabilities. The latter is a typical phenomenon of the Greek market, due to chronic market distortions, which not only have a negative impact on firms' competitiveness, but increase also the operational risk of them.

Table 9: *Descriptive statistics of firms producing dairy products in Greece and importing them from abroad*

	Dairy firms producing in Greece (CRS)	***Dairy firms importing in Greece (CRS)***	***Dairy firms producing in Greece (VRS)***	***Dairy firms importing in Greece (VRS)***
Mean	0.67	0.89	0.75	0.94
Median	0.66	0.92	0.77	0.99
Standard Deviation	0.18	0.12	0.19	0.09
Minimum	0.40	0.67	0.44	0.76
Maximum	1.00	1.00	1.00	1.00

The implementation of the Context-depended DEA model demonstrated the significant differences on attractiveness scores of level 1, having level 2 as context, as well as of level 4, having level 5 as context. Significant variance appears also on progress scores of level 2, having level 1 as context, as well as of level 5, having level 4 as context. These variations verify that firms placed at level 2 and level 5, need to put substantial effort to achieve better market performance, compared to the firms, placed into intermediate levels.

The fluctuation of efficiency change indexes provides evidence that during the examined period the Greek dairy industry appears to be stagnated. Nevertheless, dairies exhibit significant range of efficiency scores between time periods, verifying that important changes occur in the utilization of the existing technology in dairy industry and, consequently, this generates continuous adjustments on firms' efficiency ranking. It is obvious that there is considerable interest in conducting further research on this topic, in order to develop a reference set which will provide constructive information regarding dairy market operation.

6. Conclusions

The milk processors and the dairy industry in general must be prepared to deal with the longer term developments and challenges of the dairy sector. Increasing competition on dairy markets both within the EU and worldwide, new rules established by the so-called Milk Package designed to reinforce the producers' role in the supply chain, the end of the quota system in EU and the anticipated export opportunities, highlight the need to improve the performance and to increase the productivity of the dairy industry. The future prospects of the dairy sector are interesting and now there is more justifiable industry confidence in the future. An efficient and competitive milk processing industry is essential for maintaining sustainable milk production.

This article applies DEA approach on Greek dairy industry and provides findings regarding the efficiency ranking of the most important dairy companies in Greece. The fact that the average efficiency score is 0.73 and 0.81 under the CRS and VRS DEA model suggests that there is space for improvement regarding the allocation of the available resources. Proofs that inefficient firms are over-invested and over-exposed to high risk operation practices provide suggestions for launching a road map aiming to minimize the excessive use of these specific inputs. Special attention requires the fact that there is considerable difference in efficiency scores between firms producing diary products in the country and firms importing these products from the main milk producers of the EU, such as Germany and France. Quite promising though is the issue that there are no considerable slacks for the *cost of sold products* input variable, which incorporates all the parameters of operational cost. This implies that special attention should be paid on the efficient utilization of the existing infrastructure. Stagnated level of efficiency change does not denote stagnated efficiency change for individual firms, but it is the outcome of a large variance of efficiency change scores achieved by dairy firms from period to period. In a nutshell, this paper implements an advanced methodological approach for the assessment of the efficiency of such an important sector both for Greece and EU. The results of this empirical research provide not only hints, but offers clear remarks, about the improvement of the competitiveness of the sector.

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