Technological innovations and total factor productivity in dairy industry

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Abstract. This study analyses the main factors influencing the development of companies in dairy industry. Particular attention is paid to technological innovations by exploring two groups of companies: applying membrane-cell technology and without applying it. The study has successfully used tools of production functions to determine the total factor productivity in microeconomics. It is determined the impact of technological innovation on overall factor productivity and corporate growth.

1. Introduction

The dairy industry is an important subsector of the food and drink industry with great social and economic impact. In recent years on progress of subsector has an adverse effect a set of macroeconomic factors: over-supply of milk in world market, reduction in Chinese imports, embargoes from the Russian Federation and others. These factors formed the tendency of significant reduction of redeemed price of milk in Bulgarian market. Undoubtedly this causes the compression of the raw material base of the sub-sector and reduces production. For the past 20 years, the number of dairies has fallen more than 2 times (from around 450 in 2000 to around 200 in 2017).

Under these conditions, managers are oriented more on technological process as a decisive factor for efficient use of scarce raw materials, improving quality and expanding product range dairies to avoid massive competitive pressure.

This will allow not only to increase exports through a specific price and specific niche positioning but also to increase sales in the country (Bulgaria is a net importer of milk and dairy products worth nearly USD 100 million per year).

2. Methods and methodology

Corporate growth is the growth of the core business unit of sub-sector – dairy sector. It is known that corporate growth can be measured by various parameters Konarev and Konstantinova [1]. In this case, the amount of the company’s net sales revenue will be used as a growth indicator. The main model for research of corporate growth of dairies is as follows:
\[ Cg = F(C, L, T_{fp}) \]

, where
\( Cg \) is corporate growth;
\( C \) – capital;
\( L \) – labor;
\( T_{fp} \) – total factor productivity.

Using this model, corporate growth is assumed to be the result of three main factors:
a) capital – additional investment costs;
b) labor – an increase in staff costs;
c) total factor productivity.

Total factor productivity is a complex factor – it includes all other factors beyond labor and capital. It is believed that the technological process – implementation of new technologies, new machinery, new combination of resources, new forms of organization, new methods of marketing, etc. is the most influential factor in this group of factors.

However, included in the total factor productivity are factors stimulating corporate growth, as well as factors restraining it such as reduction in the amount of raw material, decrease in market prices, loss of markets, increased competitive pressures, embargoes, oversupply on the world market and others.

In order to examine the dynamics of corporate growth in dairy industry, a random sample of 10 enterprises, divided into two groups:
Group I – companies applying membrane-cell technologies in production process;
Group II – companies that do not apply these technologies.
The analysis period is 2007 – 2016.
The choice of 2007 as the beginning of a period was driven by our desire to analyze corporate growth after the global economic crisis of 2008. The following model was used to determine total factor productivity Konstantinova and Konarev [2]:

\[ \frac{A^i_t - A^i_{t-n}}{A^i_{t-n}} = \frac{Y^i_t - Y^i_{t-n}}{Y^i_{t-n}} - Cd^i_t \frac{K^i_t - K^i_{t-n}}{K^i_{t-n}} - La^i_t \frac{L^i_t - L^i_{t-n}}{L^i_{t-n}} \]  

(1)

, where
\( A^i_t \) – total factor productivity of the i-th dairy company in year \( t \) (year 2016);
\( Y^i_t \) – net sales of i-th company in t-th year;
\( Cd^i_t \) – capital intensity of i-th company’s production for the relevant period (2007 – 2016);
\( L^i_t \) – total amount of labor costs of i-th company for the year \( t \);
\( La^i_t \) – labor intensity of i-th company’s production for the same period;
\( N \) – number of years of the analyzed period.

This model represents a modification of R. Solow’s model [3] for economic growth analysis at national level:

\[ Yt = At \cdot F(Kt, Lt), \]  

(2)

, where
\( Yt \) – the aggregate production of the country;
\( Kt \) – amount of physical capital used in production;
\( Lt \) – the amount of labor inputs;
\( At \) – total factor productivity.
This model was also used by other authors in Bulgaria and abroad Ganev, Todorov et al. [4, 5, 6] for national analysis. The motivation of the authors to modify the model (2) in a model (1) is aspiration to use this toolkit for successful research at the level of the individual business unit – the dairy company.

3. Results and discussion

Primary data from companies enables Table 1 to be compiled.

**Table 1.** Increase of the main indicators of the dairy companies for the period 2007 – 2016 (in thousands of BGN)

| Group I: using membrane technology | Companies     | Revenue (ΔY) | Capital (ΔK) | Labor (ΔL) |
|------------------------------------|---------------|--------------|--------------|------------|
| 1. OMK AD                          | 32 202        | 26 629       | 6 712        |
| 2. Dimitar Madzhyarov EOOD         | 14 008        | 8 308        | 726          |
| 3. Polidey-2 OOD                   | 12 412        | 4 547        | 527          |
| 4. Rodopeya Belev EOOD             | 5 331         | 3 761        | 561          |
| 5. Kostovi EMK OOD                 | 887           | 632          | 136          |
| **Total for the group**            | **68 840**    | **46 883**   | **8 665**    |

| Group II: without application of membrane technology | Companies     | Revenue (ΔY) | Capital (ΔK) | Labor (ΔL) |
|------------------------------------------------------|---------------|--------------|--------------|------------|
| 1. Shipka 99 AD                                      | 10 241        | 9 627        | 530          |
| 2. Elite 95 EOOD                                      | 10 042        | 24 767       | 596          |
| 3. Bour Chvor EOOD                                   | 13 512        | 8 687        | 1 824        |
| 4. Milk Group EOOD                                   | -             | -            | -            |
| 5. Rojen – Milk OOD                                  | 70            | 623          | 77           |
| **Total for the group**                              | **34 498**    | **43 702**   | **3 027**    |

The analysis shows that only one of the ten companies analyzed did not achieve corporate growth – Milk Group EOOD. It is necessary to point out that labor is measured through wage and social security costs, the capital – through the balance sheet of the total amount of equity and debt capital, and revenue – through net sales revenue.

After defining the basic parameters of the model (1), including the capital and labor productivity of each of the companies surveyed for analyzed period is compiled Table 2:

**Table 2.** Contribution of capital and labor to corporate growth

| Group I: using membrane technology | Companies     | Revenue (ΔY) | Capital (ΔK) | Labor (ΔL) |
|------------------------------------|---------------|--------------|--------------|------------|
| 1. OMK AD                          | 0.9517        | 0.7480       | 0.2179       |
| 2. Dimitar Madzhyarov              | 0.7011        | 0.3678       | 0.0456       |
The data from Table 2 make it possible to determine the contribution of total factor productivity to corporate growth, using the model of authors presented in modification (1):

\( \Delta A/A = 1.0285 - 0.6584 - 0.1587 = 0.2114 \);

b) For a second group of companies that do not apply membrane-cell technology in their business:

\( \Delta A/A = 1.7474 - 3.0002 - 0.2338 = -1.4866 \).

The results for the first group of companies indicate that analyzed nearly 10-year period (2007 – 2016) corporate growth to the whole group is 102.85%. It was formed in the following way:
- “capital” factor – 65.84%;
- labor factor – 15.87%;
- total factor productivity – 21.14%.

The second group of companies achieved higher corporate growth – 174.74%. However, this growth is extremely capital-intensive, which is confirmed by the empirical parameters of the model for the influence of the individual factors, as follows:
- “capital” factor – 300.02%;
- labor factor – 23.38%;
- total factor productivity – 148.66%.

As mentioned total factor productivity is a complex factor, which include, as factors that stimulate growth and factors that retain it. In this case, large investments in the second group of dairies have supported corporate growth.

First and second group of companies worked under the same economic conditions during the analyzed period. In principle, it can be assumed; that on them are equally influences both stimulating and restraining factors that form the overall factor productivity.

The only difference that exists between them is the application of membrane cell technology in production. This gives the authors reason to conclude that the application of membrane-cell technology has had a positive impact on the corporate growth of dairy companies.

Technological progress through the introduction of these technologies in the first group (companies) has not only blocked a number of growth factors but has increased this growth by
21.14%. The opposite is the result for a second group of companies, that to overcome the restraining factors and implement growth were forced to use additional significant capital that is out of reach for most dairies.

4. Conclusions

The presented study gives the following main conclusions:

1. Membrane cell technologies stimulate corporate growth in the dairy industry.
2. Business model that managers should implement to boost the development of milk processing companies has accelerated deployment of process, including membrane-cell technology.
3. Factoring analysis of corporate growth over the survey period (2007 – 2016) shows that capital expenditures are the main factor of growth. The impact of labor, measured through employers’ wage and social security costs, is relatively low. These results are quite disturbing, considering limited capital and labor resources, and high expectations of technological progress.
4. The three-factor model proposed by the authors can be successfully used in the theory and practice of analyzing, planning and forecasting the development of dairy companies.

References

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