doi: 10.17221/128/2014 -AGRICECON

Recent areas of innovation activities in the Czech dairy industry

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Abstract: The aim of the article is to compare and identify differences between the innovations within the Czech dairy industry. Dairy products are the export pillars of Czech agrarian foreign trade, and the dairy industry was one of the most important recipients of public support on innovations from the Rural Development Programme (RDP). The core of this research is an analysis of sixteen projects, supported under RDP sub-measure I.1.3.2 from 2007 to September 2013. Data from the representative sample of approved projects have been converted into a set of questions and answers to enable them to be evaluated, both quantitatively and qualitatively. The dataset is analysed by means of a counterfactual analysis, descriptive statistics, and correlation analysis. The results show that innovations, and public support of innovations, enabled dairies to stabilise their profits, and to increase their competiveness, during the period of economic crisis. There were five types of innovation trends in the Czech dairy industry in recent years: (i) The processing and efficient use of by-products (whey, buttermilk); (ii) The production of new products with health benefits; (iii) Improved processing of dairy products with particular focus on long-life products having better sensory parameters; (iv) Improved efficiency of transport and storage of milk and dairy products; (v) Improved wastewater treatment. The real innovative effect was, however, very limited because individual companies were not looking for their own new added value, but were more focused on the implementation of already-existing innovations.

Key words: competitiveness, innovations, milk processing, technology

The food industry is one of the most important branches of the economy of the whole European Union (Bigliardi and Galati 2013), as well as of its' individual member states. It plays a significant role as an employer, and also for its' economic output. The food industry is a cornerstone of each EU country's agrarian market competitiveness (meanings of the term "competitiveness" are discussed in Kačírková 2015). In addition, the food industry plays a central role in the processing of agricultural raw materials and food supply for the population. In recent years, the food industry has been facing far-reaching technical developments (new technologies and patents, new scientific and technical approaches etc.) and economic changes (the liberalisation of regional markets and also the liberalisation of the global market, the global economic crisis, population growth, the growth of demand, the growth of purchasing power, food scandals, BSE crisis, consumers' behavioural changes, structural changes in the food industry and food retailing). The impact of these changes can be easily seen in the production and processing of food (Menrad 2004), as well as in society, and will have significant impacts on the entire processing chain of agricultural production (including milk production), and food processing (including the milk processing industry) right through to the distribution of food to the final consumers (Menrad 2004).

When considering innovation processes in the food industry, it must be recognised that the food industry is not a homogeneous sector. The food industry includes many agricultural products in addition to the processing of food products. Each area of food production (meat, milk, sugar, fruits, vegetables,

Supported by the Government of the Russian Federation (Grant No. 074-U01) and the University of Economics, Prague (Project No. MF/F3/4/2013).

doi: 10.17221/128/2014 -AGRICECON

cereals, flour etc.) is unique. The food industry is currently a rapidly developing sector. There is significant competition between individual entities operating in the market. The competition is not only at the level of individual companies and markets nor only in the area of economy activities, but in the case of the food industry competition is also a subject of high level policy decision making. The food industry is considered as being one of the most strategic sectors of every economy around the world, which is one reason why food markets in many countries are heavily protected.

A very good example of such policies and attitudes to the foodstuff sector can be clearly seen in the case of the European Union. The European agricultural and food market is unique because of the application of its Common Agricultural Policy (CAP) and its common trade policy. This means however, that European countries are often strongly criticised by their international partners. These reforming processes have resulted in more liberal European agriculture and food industries. This liberalisation process, both in relation to the EU's own internal market, and also in relation to the EU's external environment, puts pressure on individual stakeholders. They have to improve their competitiveness, both in relation to the EU's external and internal environment. An example can be seen in the milk industry. The milk industry is a rapidly developing sector – not only in the EU, but throughout the world. Moreover, in the case of the milk industry it can be expected that there will be significant growth of the market in the future. It must be pointed out that the milk industry is currently undergoing significant changes in the European Union. It is expected that in 2015 the common market organisation of the milk market will be withdrawn, and the European milk market will be working without any application of a quota system. The new market environment/conditions will have a direct impact on individual producers; all of them will have to compete for their place in the market. The global milk market is already very turbulent: in the period 1990–2012 alone, the global volume of milk production increased from about 500 million tonnes to more than 750 million tonnes. The European Union is one of world market's main drivers. The volume of its own production is more than 150 million tonnes, and up to the time of writing, its' significant production capacities have been limited by a quota system. From 2015 the quota system will be removed and European production capacities will no longer be restricted. This presents a good opportunity for many producers to develop their capacities, both in the area of primary production, and also in the area of food processing capacities.

A very important factor influencing individual producers' success will be innovations – without innovations it will not be possible to survive in conditions of a rapidly-developing market (Bigliardi and Galati 2013).

When considering innovation activities in the food industry (including the milk industry), it is necessary to highlight that the food processing industry is typically described as a relatively mature and slow-growing area of business (Sarkar and Costa 2008), which displays a relatively low level of research & development investment, and is quite conservative in the type of innovations it introduces to the market (Costa and Jongen 2006). This sector perceives its end-customers to be, to a large extent, wary of radically new products and changes in consumption patterns. Such perceived wariness, together with the necessary stringency of legal requirements related to safety, transforms food product and process innovation into a highly complex, time-consuming and risky endeavour, and hence one not to be lightly undertaken (Costa and Jongen 2006).

However, recent important changes in the nature of both food supply and demand, coupled with an ever-increasing level of competitiveness, have rendered innovation not only an unavoidable corporate activity, but also one that is increasingly vital for overall agribusiness profitability. Contemporary consumers demand unique flavours and singular foods, guilt-free convenience in cooking and eating, and an increasingly health-promoting diet closely tailored to their individual needs and preferences (Costa et al. 2001, 2007).

Notwithstanding, innovations which can be understood as new products, processes or services, are recognised as an important instrument for companies in the food industry to stand out from their competitors and to satisfy consumer expectations (Menrad 2004). In particular during the last decade, consumer requirements in the field of food production have changed considerably; in fact, consumers increasingly recognise that food contributes directly to their health (Young 2000; Mollet and Rowland 2002). Thus, foods are no longer only intended to satisfy hunger and to provide the necessary nutrients, but also and especially to prevent nutrition-related diseases and to improve physical and mental well-being (Robertfroid 2000; Menrad 2003).

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Moreover, the food industry has been facing technical and economic changes both in society and in manufacturing and food processing that in turn has had a significant impact on the entire food supply chain, right through to the distribution of food to the final consumers. This has forced companies to pay greater attention to food products which meet the consumers' demand for a healthy lifestyle (Bigliardi and Galati 2013).

Such demand requires a kind of product development that necessarily entails creating, or at the very least adopting, innovative technological solutions and new business models. On the other hand, recent general advances in areas such as biotechnology, nanotechnology and preservation technology offer an unprecedented number of opportunities for added-value applications in the food industry, many of which have the potential to adequately meet modern consumer demand (Juriaanse 2006).

In innovation research the food industry is traditionally regarded as a sector with low research intensity (Christensen et al. 1996; Garcia Martinez and Briz 2000; Grunert et al. 2005). Beckeman and Skjolkebrand (2007) assessed the degree of innovation in the food industry, stressing the fact that "very little innovation is taking place in the food industry". However, due to the fact that technology has moved from the production age, via the information age and towards the service age, the food sector has continued to grow, and still appears to be growing faster than previously.

However innovations, understood as new products, processes or services, are an important instrument for companies in the food industry to stand out from their competitors and to fulfil consumer expectations. According to the view of modern innovation research, companies almost never innovate in isolation, but their innovation activities are embedded in a network of different actors and "institutional" framework conditions. Therefore, it is not appropriate to analyse only the innovation activities of companies, but all activities in the entire innovation system, starting from knowledge generation through to the market introduction and the penetration of new products, processes or services, which should all be taken into consideration (Bigliardi and Galati 2013).

Given the large number of actors in the different areas involved in food supply, as well as their difficulties to single-handedly meet all the heterogeneous (and often contradictory) requirements of intermediate customers, end-users and legislators (Mikkelsen et al. 2005; Costa and Jongen 2006; Grunert et al. 2009), cross-boundary innovation management should thus be a widespread practice in food value-chains and networks.

Empirical substantiation of food companies engaging in open innovation strategies is, however, scarce (Knudsen 2007). Accordingly, peer-reviewed literature does not provide much empirical support for open innovation practices in the food sector, although firms in this industry do appear to be experimenting in different ways with open innovation strategies (Thomke and von Hippel 2002; Huston and Sakkab 2006; Vanhaverbeke and Cloodt 2006).

Food industry innovations are often aimed at developing important replacement products, following nutritional directions, or obeying food additive regulations. They are generally new or improved consumer products and services, and can be focused in one area of food technology (for example process engineering, product formulation, food qualities or consumer needs). Moreover, they have to combine technological innovation with social and cultural innovation, in order to produce food that satisfies the nutritional, personal and social needs of all communities. Innovations may occur throughout all parts of the food chain, and a possible classification of food innovations can be: (1) New food ingredients and materials, (2) Innovations in fresh foods, (3) New food processing techniques, (4) Innovations in food quality, (5) New packaging methods, and (6) New distribution or retailing methods (Jones and Jew 2007; Siro et al. 2008; Annunziata and Vecchio 2011).

To summarise these findings, it can be said that if we are analysing individual food companies, then there are four main categories of innovations: Product innovation, Process innovation, Market innovation, and Organisational innovation (Trienekens and Zuurbier 2008; Baregheh et al. 2012). Traill and Meulenberg (2002) suggest that food companies behave differently and choose the innovation types depending on their dominant orientation towards products or processes or the market, their ownership, size, market size and scope. Furthermore, some innovation activities are also dependent on cultural and geographical characteristics (Iliopoulos et al. 2012).

Research already conducted has proved that innovation activities in the food industry are strongly influenced by its' recent orientation on market and demand. Market orientation is, according to Iliopoulos et al. (2012), considered as the innovation strategy with the highest potential to succeed, and successful

doi: 10.17221/128/2014 -AGRICECON

companies try to integrate and balance their marketing and R&D activities.

Another very important role in innovation activities within the food sector is played by the institutional framework, cooperation and networking. According to the research on modern innovation, companies almost never innovate in isolation, but build their innovation activities on a vertical or horizontal cooperation to create a network of different actors. (Menrad 2004). Economies of scale and export orientation also play a significant role on the level of innovations (Karantininis et al. 2010). Evidence suggests that innovation activities can have a positive effect on the business performance of a food company, and vertical cooperation in particular increases exports of processed food products (Ghazalian and Furtan 2007; Mukhamad and Kiminami 2011).

The aim of the article is to compare and identify the differences between the innovations within the Czech dairy industry. Milk and dairy products are the export pillars of Czech agrarian foreign trade (Svatoš et al. 2013). Milk and dairy products are also an essential part of the human diet. The third argument for focusing on innovations in the dairy industry is that they are strongly supported by the Rural Development Programme. It is therefore highly topical to address the following questions: (1) What trends are the main innovation activities in the dairy industry currently following? (2) What are the most important objectives of the product and process innovations? (3) How does the profitability of innovative dairy companies differ from that of the average of the dairy industry? (4) Who are the key co-operation partners for innovations in the Czech dairy industry? (5) What is the form of the cooperation between applicant and research centre.

MATERIAL AND METHODS

The Czech Ministry of Agriculture approved a number of projects from 2007 to September 2013 from sub-measures I.1.3.2 of the Rural Development Programme (RDP) focused on financing innovative activities. The purpose of the grant could be the creation and introduction of a new technology, new process or product, or the improvement of an existing technology or product, leading to increased production efficiency and improved competitiveness. The database provides information about the applicants (including legal form and region), project name, project details, the assessment process, total investment expenditures, eligible investment expenditures, and the absolute and relative amount of the investment subsidy. Data from these projects were matched with financial statements obtained from the Bisnode Albertina Gold Edition database, which contains data from financial statements of companies in the Czech Republic, as well as an overview of the company headquarters, industry, number of employees and total turnover.

The evaluation of the economic effects of support is based on counterfactual analysis. For the counterfactual analysis it is necessary to have one sample of supported enterprises and another sample of enterprises with similar structural characteristics that were not supported by RDP in the same period. Because of specific features of supported applicants, and the relatively small sample of dairies with available complete financial statements (32), this paper leaves matching supported and not supported subjects out of consideration. Thus, the two samples are not the same size, nor have they similar structural features.

This sample commences with the first year of the RDP programme, i.e. 2007. The last available year (2012) was the final opportunity to assess the progress made since 2007. So, only applicants, whose projects were finished and put into operation by the end of 2012, are considered as supported. Parameters used to measure the difference in size of successful project applicants and other dairies are the companies' total assets, and the value of their total output. The following basic financial profitability ratios are used to evaluate the financial impacts of supported innovations compared to not-supported applicants, because dairy companies (like any other profit-oriented companies) consider profit as the key financial indicator of competitiveness:

– Return on Assets (ROA) = Earnings before interest and taxation (EBIT)/Total assets (%)
– Return on Equity (ROE) = Net income after taxes/Equity (%)
– Return on Sales (ROS) = EBIT/Total revenues (%)

Differences are statistically verified through Welch *t*-test[1].

[1]Welch *t*-test tests if the difference in mean between two groups is equal to a hypothesized value. Assumes the populations are normally distributed. Due to central limit theorem the test may still be useful when the assumption is

doi: 10.17221/128/2014 -AGRICECON

The available project documentation is then analysed quantitatively and qualitatively. The simple statistics describe phenomenon to be considered as trends in innovation activities in the dairy industry. Descriptive statistics puts emphasis on:
– Type and form of cooperation between dairy and research centre.
– Types of innovations and their combination.
– Expected results of innovations.
– Technological properties of innovations with respect to consumers' preferences.

The quantitative analysis of data related to innovation processes and their financing are based on the application of the following set of statistical methods and indicators: Correlation analysis; Average values analysis; Median values analysis; Minimum and maximum values analysis; Standard deviation analysis; and Variation coefficient analysis. The analysis is conducted in Czech koruna (CZK). The expenditures for innovative activities are grouped into six basic categories: Total project expenditures; Expenditures for cooperation in development; Expenditures for research and development; Expenditures for marketing innovations; Expenditures for investments into already existing new technologies; and Co-financing.

Except for the analyses of individual types of expenditures, the relationships existing among individual types of supported innovative activities are also analysed. The idea is to identify the system existing among individual innovations applied. Sixteen basic innovative activities are used as the objects of the correlation analysis: 1 – New product/product innovations; 2 – Product for the final consumer; 3 – Positive impacts (especially) on the health of the consumer; 4 – Innovation especially focused on sensory features of product; 5 – Innovation focused on the life-span of the product; 6 – Microbiology cultures application; 7 – Physical methods application (temperature, cooling, sterilisation); 8 – The growth of demand; 9 – Marketing innovations (new packaging, graphics, marketing strategies); 10 – Processing of by-products; 11 – Research and development; 12 – Production in laboratory scale; 13 – Testing of product's parameters; 14 – Cooperation in product/package design; 15 – Innovation including purchase of new packaging machine; 16 – New technology of packaging processes and also the new type of package.

DESCRIPTION OF THE SAMPLE

In the period 2007–2013 (September), 53 projects were approved in the sub-measure I.1.3.2 of the Rural Development Programme focused on financing cooperation on innovations in the Czech food industry. Of the approved projects 41.5% came from dairy industry, 34% focused on innovations in meat processing industry. The third most frequently approved branch in the RDP was the processing and preservation of fruit and vegetables (13.2%). The remainder of the approved projects engaged in innovation of processing wine, hops and vinegar. The level of public support, defined as the ratio of public expenditures to total eligible project costs, ranged from 46% to 50%. The average eligible investment expenditure was 36.5 million CZK per project. The highest average eligible investment expenditure per project was in the dairy industry (42.4 million CZK). Support of cooperation on innovations in the food industry were significantly more capital-demanding than simple investments in modernisation (average eligible investment expenditures were 12 million CZK), because innovations needed expensive high-tech technologies that are usually tailored to the specific technical requirements of the applicant. Moreover, support of cooperation included payment for research and development by an external research team.

In total, there were 22 approved projects by 14 companies aimed at innovations in the dairy industry. The total eligible investment expenditures were 933.89 million CZK. The applicants represented the most important companies in the dairy industry with more than 40% share of the product sales. Some of the applicants were also agricultural companies processing their own products. The total sum of applicants' assets before support was 7562.93 million CZK in 2007. The share of eligible investment expenditures in total assets was therefore 12.3%, however, the variation of project significance in total assets varied from 1.6% to 325.5%. Most of the applicants were supported once or twice. Only one subject was supported six times and it increased its total assets by 1.53 times by 2012.

The authors had 16 projects available for analysis from the total 22 approved projects. The authors converted the data from the project documentation into a set of questions and answers which could be evaluated both quantitatively and qualitatively. The

violated if the sample sizes are equal, moderate size, and the distributions have similar shape. Test does not assume the population variances are equal.

doi: 10.17221/128/2014 -AGRICECON

Table 1. Size of innovative and other dairy companies before support in 2007

Indicator	Status	2007	Welch *t*-value	*p*-value
Total assets (1000 CZK)	innovative (N = 14) other (N = 24)	540 209.57 232 263.13	1.637	0.0611
Total output (1000 CZK)	innovative (N = 14) other (N = 24)	1 480 889.79 731 778.17	1.249	0.1150

Source: authors

sample of 16 projects covers 72.7% of approved projects, 63.9% total eligible investment expenditures, and 68.5% investment subsidies. The sample can therefore be considered as being a representative portfolio of the approved innovation projects. The average total eligible expenditures in the sample were 37.3 million CZK. The average subsidy rate was 49%. The eligible expenditures included investments in new technologies and technical equipment (95.4%), and expenditures on research capacities (4.6%). Expenditures on research capacities included the wages of the researchers and the costs of laboratory equipment.

Financial impacts of innovation

Table 1 shows the differences between size indicators between innovative and other dairy companies before support (2007).

Closer examination indicates that the innovative dairies were usually larger than other companies not receiving support. The Welch t-test shows significance at a = 0.1 only in total assets. Unlike straightforward modernisation of machinery, innovations require large investment expenditures. Innovations bring higher value-added to new products or processing technologies.

Table 2 contains information about the impacts of innovations on financial indicators. The number of innovative dairies in 2012 is lower (11) than in 2007 because one company had become bankrupt, and at the time of writing two companies had still not published financial statements for 2012.

The results of the counterfactual analysis show that both innovative and other dairies started with a similar return on assets and return on sales in 2007, whilst the return on equity was higher in other companies than in the innovative. In 2012, all profitability indicators were higher in the sample of innovative dairies. Unfortunately, the only difference in return on sales has the statistical significance at $\alpha = 0.1$. Innovations, as well as public support of innovations, help dairies to stabilise their profits in hard times (as has been experienced since 2008), and to increase their competitiveness.

Results of qualitative analysis of projects

The projects of cooperation on innovations in the dairy industry can be divided into four phases:

(1) Cooperation. Co-agreement of the rights to use utility models in order to protect the idea and recipe of the intended product, and know-how

Table 2. Results of the counterfactual analysis

Indicator	Status	2007	*t*-value (*p*-value)	2012	*t*-value (*p*-value)
Return on assets (%)	innovative other	9.686 10.585	0.314 (0.622)	7.736 5.376	–0.893 (0.190)
Return on equity (%)	innovative other	14.283 21.611	0.727 (0.733)	14.391 3.315	–0.956 (0.173)
Return on sales (%)	innovative other	4.616 4.238	–0.262 (0.398)	4.014 –5.661	–1.356 (0.094)

Note: Innovative companies N = 11, other companies N = 24

Source: authors

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that will establish cooperation in the implementation of the project. Handing over of testimonials and materials to support nutrition and health claims. Preparation of graphic design, product design, consultancy, preparation of marketing strategies. The cooperation on linked marketing innovations is not as common as the cooperation on technology or product innovations. Only six projects included cooperation expenditures on new design of new product or package.

(2) Research and development. Laboratory attempts to create new formulas, determination of specific technological procedures, technical standards of the product. Laboratory and operating experiments, design of production documents, evaluation of physical/chemical properties, microbiological quality, nutritional quality and soundness.

(3) Technology. Design of the production line, and project documentation appropriate for the technological level of the project. Identification, specification and ordering of individual devices. Construction changes and other preparations for the installation of the proposed equipment. Installation of equipment.

(4) Production. Bringing the production line into operation, test run of the new product, and verification of the technological process according to the technical standards. Packaging and testing of the product's durability and resilience. Creation of production know-how, and its handover to the manufacturers.

In all cases, the cooperation between the applicant and the research centre consisted of consultation and advisory services, identification of problems and suggestion of possible solutions, complete methodology of work, and the preparation of the technological process. An integral part of cooperation is research and development, trial production in laboratory conditions, and testing properties/operating parameters of the new product and technology. The research centre and the dairy work together to try finding energy-saving technological solutions in order to reduce costs and meet environmental challenges.

There were two important partners of applicants in the dairy industry in the Czech Republic: (i) Institute of Chemical Technology Prague, (ii) MILCOM a. s.

The Institute of Chemical Technology Prague was the most frequently contracted partner for innovations in the dairy industry (in more than 60% cases). It is a state university specialising in all areas of chemical research. The specialists at the Institute design optimal use of research findings *inter alia* protection of intellectual and industrial property rights (IPR), patent applications, licence agreements, as well as publishing scientific results.

MILCOM a. s. is a private enterprise. It is an important partner for all food producers, and particularly for dairy companies developing new products, technologies and reliable food diagnostics. It offers quality services in the fields of dairy processing and packing technology, food research, and laboratory products.

The applicants were also able to choose other partners, such as the Food Research Institute Prague[2].

The overall aim of innovations in the dairy industry is to increase the competitiveness of dairy companies. Almost all projects (15 of 16) also targeted higher sales. One project focused on a more efficient storage system, and concentrated primarily on cost savings. Higher competitiveness of dairies should be recognised by higher profits supported by more efficient processing or storage (100 % projects).

There are four basic types of innovations, which have been identified and defined by Eurostat in their "Community innovation survey"[3]. For the assistance of the reader, these are reproduced below, *verbatim*:

(a) Product innovation. Product innovative enterprises are those who introduced, during the period under review, new and significantly improved goods and/or services with respect to their fundamental characteristics, technical specifications, incorporated software or other immaterial components, intended uses, or user friendliness. Changes of a solely aesthetic nature and the simple resale of new goods and services purchased from other enterprises are not considered as innovation.

(b) Process innovation. Process innovative enterprises implemented new and significantly improved production technologies or new and significantly improved methods of supplying services and delivering products during the period under review. The outcome of such innovations should be significant with respect to the level of output, quality of products (goods or services) or costs of

[2]Previously named the "Research Institute of Food Industry"

[3]http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/inn_esms.htm(accessed July 8, 2014).

doi: 10.17221/128/2014 -AGRICECON

production and distribution. Purely organisational or managerial changes are not included.

(c) Marketing innovation. Marketing innovative enterprises implemented a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

(d) Organisational innovation. Organisational innovative enterprises implemented a new organisational method in the enterprise's business practices, workplace organisation or external relations. [Unfortunately, the authors of this paper have no information about any organisational innovations of the applicants.]

Product and process innovations together are called "Technological innovations".

Tables 3 and 4 show the types of innovation and expected results of innovations in the sample. Types of innovations as well as expected results are often combined in the same project.

The in-depth study of the sample shows five types of innovation trends in the dairy industry in recent years.

(1) Processing and efficient use of by-products (whey, buttermilk).
(2) Production of new products with health benefits.
(3) Improved processing of dairy products with a special focus on long-life products with better sensory parameters.
(4) Improved efficiency of transport and storage of milk and dairy products.
(5) Improved wastewater treatment.

The five results of innovation activities are often interconnected. For example, processing of whey may be followed by the development of new products with health benefits with focus on better sensory parameters (1 + 2 + 3).

Table 3. Types of innovation in the dairy industry

Type of innovation	Share (%) in the sample (N = 16)
Product innovation only	0
Process innovation only	18.75
Marketing innovation only	0
Product and process innovation (without marketing innovation)	6.25
Product and marketing innovation (without process innovation)	0
Process and marketing innovation (without product innovation)	18.75
Product, process and marketing innovation	56.25

Source: authors

A significant proportion of the projects focused on the processing of by-products (6 of 16). Five projects were concerned with the processing of whey. Whey (milk serum) is the liquid remaining after milk has been curdled and strained. It is a by-product of the manufacture of cheese or casein and has a number of commercial uses. The most difficult barrier to a more efficient use whey so far has been the low dry matter content. Another problem is the different composition of whey from different manufacturing facilities within one company. It is also necessary to remove any fat before processing the whey. The process is further complicated by the presence of acid whey, which is a by-product produced during the making of acid types of dairy products (cottage cheese, strained yogurt). It is therefore very important to develop the technology of whey pre-treatment.

In the Czech Republic, whey is commonly used for feeding animals. Dairies are now trying to take advantage of the high nutritional value of whey components. The aim of the innovations is to find a new technology for processing whey, and consequently use

Table 4. Expected results of innovations in the dairy industry

Expected results of innovations	Share (%) in the sample (N = 16)
1. Processing and efficient use of by-products	37.5
2. Production of new products with health benefits	37.5
3. Improved processing of dairy products with a special focus on long-life products with better sensory parameters	81.25
4. Improved efficiency of transport and storage of milk and dairy products	12.5
5. Improved wastewater treatment	12.5
Combination 1. + 2.	12.5
Combination 1. + 2. + 3.	12.5
Combination 1. + 3.	25
Combination 1. + 4.	12.5
Combination 2. + 3.	37.5
Combination 3. + 4.	18.75
Combination 2. + 3. + 5.	6.25

Note: No other combinations exist.

Source: authors

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processed whey to improve the nutritional benefits of sour or other milk products. Those applicants who improved whey processing either buy processed whey from the processing industry, or try themselves to add processed whey into milk products. The output of whey pre-treatment and processing is a more concentrated and stabilised whey which can be added into milk products, thus ensuring better storability and transportability. The quality of the stabilised, condensed whey is also increased by enhanced filtration in order to remove cheese powder. Moving whey processing into a special space separated from the preparation of raw materials for the production of cheese will achieve greater safety in cheese production. The use of reverse osmosis increases the amount of dry matter, and the permeate may be fully exploited as water for industrial use. Whey is not only a by-product, but also has a positive nutritional value. Thus, processing and the efficient use of by-products are often connected.

Another by-product that is processed in dairies is buttermilk. Traditional buttermilk is the liquid left over from churning butter from cultured or fermented cream. Raw buttermilk is adjusted to the desired fat content, pasteurised, condensed through an evaporator, dried and usually packed in large bags. Buttermilk is then used in the food processing industry, particularly in bakeries, after emulsification. The innovation lies in new methods of buttermilk storage before processing, the process of emulsification and new types of packages, not only for wholesale, but also for the retail market. The effective way of buttermilk storage in tanks keeps it cooled and safe, and improves the subsequent processing of the buttermilk. In order to increase sales it is possible to sell both condensed buttermilk in tins, and dried buttermilk in bags.

The manufacture of new products with health benefits is a valuable innovation that follows trends in consumers' demand for a healthier way of life. The production of new products with health benefits, and improved processing of dairy products with a special focus on long-life products with better sensory parameters, is the second most frequent combination of innovation activities in the sample (37.5% projects). Improvements to the nutritional properties of dairy products can be achieved by the fortification of products with microbial cultures, or by nutrient-friendly processing. Specific innovations have been developed in the segment of food for special medical purposes (special nutritionally complete liquid meals with high energy content and low lactose, intended as dietary supplements during malnutrition associated with illness). New products with health benefits often go together with improved processing of dairy products, together with a special focus on long-life products with better sensory parameters because healthy, long-life and tasty products in attractive packaging are in great demand.

The first attribute for attractive dairy products is to have a positive nutritional value. Dairy products can be fortified with probiotic cultures, most often by *Bifidomacterium, Lactobacillus acidophilus and Lactobacillus casei* which are combined with classic dairy and yoghurt cultures. Innovations are based on new probiotic cultures, such as *Enterococcus faecium*, that may have a positive impact on human organism. However, some microbiologists concern regarding the safety of probiotics that contain bacterium *Enterococcus faecium* (Lund and Edlund 2001).

Probiotic cultures adjust intestinal micro-flora through the suppression of undesirable microorganisms, and may have a positive impact on cholesterol level when increasing HDL and decreasing LDL cholesterol. Moreover, the positive nutritional value can be also increased by adding processed whey with a significant share of whey proteins (whey proteins consist primarily of α-lactalbumin and β-lactoglobulin). Whey protein is often sold as a nutritional supplement to bodybuilders. Fortified products can also help people to prevent serious complications (carcinoma of the large intestine, cardiovascular complications etc.).

Dairies work towards longer shelf-life of milk and milk products. Almost all projects focused on long-life milk products (15 of 16). The shelf life of milk and milk products can be extended in the following ways:
(a) Addition of artificial preservatives.
(b) Addition of microbial cultures.
(c) Physical influences (heat, cold).
(d) Special packaging.

The addition of microbial cultures is not combined with physical conservation. Dairies, like other branches in the food industry, try not to use artificial preservatives, therefore no project considered this kind of preservation. Four projects used microbial cultures to extend the life of milk products. These projects solved the life extension of milk products by the utilisation of lactic acid bacteria. Conservation arises naturally, because it is a fermented product containing lactic acid. Eleven projects used physical techniques to extend the shelf life of milk products;

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Table 5. Individual innovation projects expenditures characteristics (in million CZK)

Individual Projects	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Total project expenditures	22 000 000	93 100 000	52 800 000	94 020 000	12 820 000	39 089 200	15 540 000	9 100 000	
– cooperation in development	4 500 000	2 100 000	2 000 000	2 020 000	1 000 000	2 000 000	1 390 000	1 200 000	
– research and development	3 800 000	2 100 000	2 000 000	2 020 000	1 000 000	2 000 000	800 000	600 000	
– marketing innovations	700 000	0	0	0	0	0	590 000	600 000	
– Investments into technologies	17 500 000	91 000 000	50 800 000	92 000 000	11 820 000	37 089 200	14 150 000	7 900 000	
Co-financing	11 000 000	45 988 000	24 912 000	43 249 200	6 325 000	19 374 600	6 795 000	4 550 000	
The share of subsidies	50.0%	50.0%	47.8%	46.0%	49.3%	49.6%	50.0%	50.0%	
– The share of expenditures for cooperation in development	20.45%	2.26%	3.79%	2.15%	7.80%	5.12%	8.94%	13.19%	
– The share of expenditures for research and development	17.27%	2.26%	3.79%	2.15%	7.80%	5.12%	5.15%	6.59%	
– The share of expenditures for marketing innovations	3.18%	0.00%	0.00%	0.00%	0.00%	0.00%	3.80%	6.59%	
– Investments into new technologies	79.55%	97.74%	96.21%	97.85%	92.20%	94.88%	91.06%	86.81%	
Individual Projects	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Average**
Total project expenditures	19 870 000	19 600 000	15 540 000	2 180 000	36 850 000	23 300 000	53 600 000	91 100 000	600 509 200
– cooperation in development	1 000 000	1 000 000	1 000 000	1 080 000	2 000 000	600 000	2 600 000	2 000 000	27 490 000
– research and development	1 000 000	1 000 000	1 000 000	640 000	2 000 000	600 000	1 500 000	1 000 000	23 060 000
– marketing innovations	0	0	0	440 000	0	0	1 100 000	1 000 000	4 430 000
– Investments into technologies	18 870 000	18 600 000	14 540 000	1 100 000	34 850 000	22 700 000	51 000 000	89 100 000	573 019 200
Co-financing	9 935 000	9 800 000	7 770 000	1 085 338	18 425 000	11 650 000	26 800 000	45 550 000	293 209 138
The share of subsidies	49.8%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	49.5%
– The share of expenditures for cooperation in development	5.03%	5.10%	6.44%	49.54%	5.43%	2.58%	4.85%	2.20%	4.58%
– The share of expenditures for research and development	5.03%	5.10%	6.44%	29.36%	5.43%	2.58%	2.80%	1.10%	3.84%
– The share of expenditures for marketing innovations	0.00%	0.00%	0.00%	20.18%	0.00%	0.00%	2.05%	1.10%	0.74%
– Investments into new technologies	94.97%	94.90%	93.56%	50.46%	94.57%	97.42%	95.15%	97.80%	95.42%

Source: authors

doi: 10.17221/128/2014 -AGRICECON

nevertheless, the conservation of milk without drastic heat treatment is still a big problem in the dairy industry. Dairies most often extend the shelf life of milk products by means of ultra-high temperature processing (UHT), pasteurisation or drying.

Innovation in packaging is not only a big question in the dairy industry. Packaging is a very important object for innovation activities because it has safety, handling, information and sales functions. The combination of product, process and marketing innovation is the most significant type of innovation (56.25% projects). Dairies try to use new packages which protect the contents, extend the life of milk products, attract consumers, and make the contents easy to store and transport. New packages are also environmental-friendly. The shelf-life of milk products can be extended by passive packaging that provides sufficient protection for the products, or by active packaging elements containing bactericidal substances or substances having a bactericidal action (nisin, purax, natamycin etc.) to suppress contamination.

Products for further processing are packed in industrial bulk packages (tanks, bags). Alternatively, products for retail consumers are packed in attractive active or passive packages (Tetra Pak®, Pure Pak®, Bag-in-Box™, Doypack®, tin, glass, capsule, plastic film, foil, cup with welded foil and plastic cap, repeatedly opening and closing package). Packaging for medical purposes is designed to be user-friendly, and can be directly and easily connected with a nutrition probe. Only 5 of 16 projects introduced a new package not previously used by the company.

The information function of packages in storage systems can be improved by special bar codes. Twelve projects (12 of 16 projects) included marketing innovations based on new packaging. Cooperation on the new design of a product and/or package is jointly contracted between the dairy, research centre and graphic design studios. The average share of marketing expenditures in the total eligible expenditures was 6.2% in the sample of six projects where marketing cooperation was included.

A special field of innovations in the dairy industry is the improvement of wastewater treatment (2 of 16 projects). The production of milk and dairy products results in a specific type of waste water, having a higher fat content and thus having significantly more demanding requirements for its disposal. At present, the industrial wastewater from the production of dairy products is pre-treated by mechanical cleaning in the plant. Afterwards, the pre-treated wastewater is pumped for further cleaning in the sewage treatment plant. The aim of this improvement to wastewater handling is to make modifications to achieve lower values of wastewater (biochemical oxygen demand, chemical oxygen demand, undissolved substance, extractable substances).

Results of quantitative analysis of projects

The following Table (5) provides an overview of the characteristics of individual innovation projects' expenditures. The data in the table shows that there are the significant differences between the individual projects. Despite more than 600 million CZK being spent during the analysed time period, for the innovation projects in milk processing sector, the money was not distributed equally. Almost 50% of all expenditure was allocated to the first four projects (out of 16).

Table 6. The selected characteristics of innovation projects' expenditures (in CZK)

	No.	Average	Total value	Median	Minimum	Maximum	Deviation	Variation coefficient
Total project expenditures	16	37 531 825	600 509 200	22 650 000	2 180 000	94 020 000	30 936 308	82.4269
– cooperation in development	16	1 718 125	27 490 000	1 695 000	600 000	4 500 000	936 933	54.5323
– research and development	16	1 441 250	23 060 000	1 000 000	600 000	3 800 000	845 174	58.6417
– marketing innovations	16	276 875	4 430 000	0	0	1 100 000	397 923	143.7195
– investments into technologies	16	35 813 700	573 019 200	20 785 000	1 100 000	92 000 000	30 629 166	85.5236
Co-financing	16	18 325 571	293 209 138	11 325 000	1 085 338	45 988 000	14 967 895	81.6776

Source: authors

doi: 10.17221/128/2014 -AGRICECON

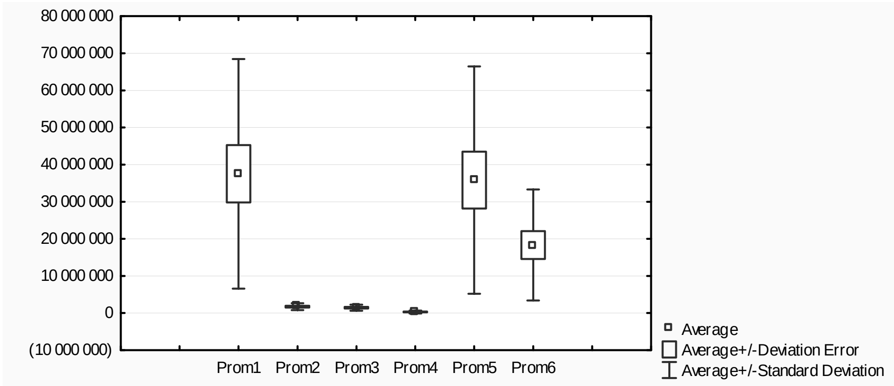

Figure 1. The selected characteristics of innovation projects expenditures' structure (in CZK)

Note: Prom1 – total project expenditures, Prom2 – cooperation in development, Prom3 – research and development, Prom4 – marketing innovations, Prom5 – investments into technologies, Prom6 – co-financing

Source: authors

Another serious problem is the structure of these expenditures. The majority of sources were spent for investments into new, already available technologies (more than 95% of the available budget), only 4.6% of all expenditures were spent for the companies' own innovation programmes (only 3.8% of expenditures were spent for research and development, and only 0.74% of available expenditures were spent on marketing activities innovations).

Table 6 summarises the results from the previous table (Table 5). It is possible to see the significant differences between the average values of individual types of expenditures and the median, minimum and maximum values. It is also apparent that the values of standard deviation and variation coefficient are very high if compared to individual projects mutually. The value of variation coefficient in particular provides information about the significantly different size of individual projects. While some projects had a decisive impact on the business activities of individual companies, in other cases it was very limited. Figures 1 and 2 illustrate the differences between categories of individual expenditures. Again, it is possible to see that the majority of expenditures for innovations was spent on investments into already-existing technology – the companies' own innovations are only minor. It is also very important to point out that, from the statistical point of view, no relationships are apparent between the individual types of expenditures, at neither the 5% nor 10% significance level. Individual

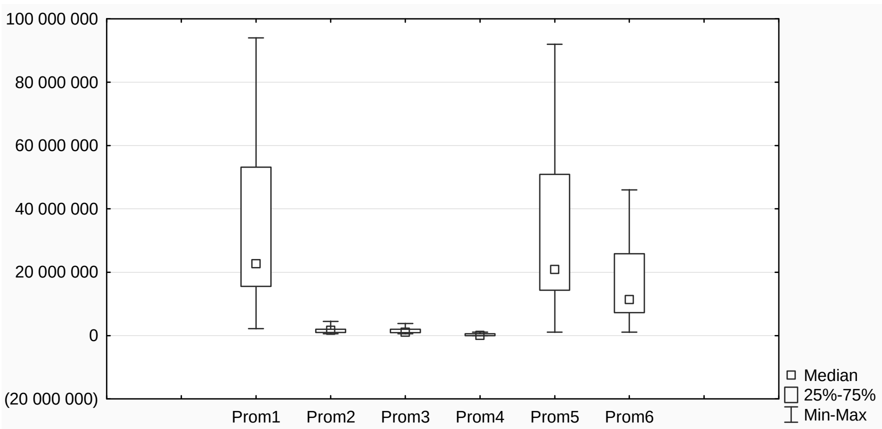

Figure 2. The selected characteristics of innovation projects expenditures' structure (in CZK)

Note: Prom1 – Total project expenditures, Prom2 – cooperation in development, Prom3research and development, Prom4 – marketing innovations, Prom5 – Investments into technologies, Prom6 – Co-financing

Source: authors

doi: 10.17221/128/2014-AGRICECON

Table 7. Individual processes supported by innovation projects' expenditures and their mutual relations

Correlation matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.000	0.289	0.333	**0.620**	0.333	0.149	0.035	0.333	0.447	0.067	0.333	0.333	0.333	**0.600**	**0.620**	0.244
2	0.289	1.000	0.372	**0.590**	–0.124	0.277	–0.324	–0.124	0.462	**–0.620**	–0.124	–0.124	–0.124	0.372	**0.590**	0.324
3	0.333	0.372	1.000	0.372	0.200	0.447	–0.313	0.200	0.447	–0.067	0.200	0.200	0.200	**0.733**	0.372	**0.592**
4	**0.620**	**0.590**	0.372	1.000	**0.537**	0.277	0.022	**0.537**	**0.832**	–0.289	**0.537**	**0.537**	**0.537**	0.372	**1.000**	0.324
5	0.333	–0.124	0.200	**0.537**	1.000	0.149	0.383	**1.000**	0.447	0.200	**1.000**	**1.000**	**1.000**	0.200	**0.537**	0.174
6	0.149	0.277	0.447	0.277	0.149	1.000	**–0.856**	0.149	0.333	0.149	0.149	0.149	0.149	0.447	0.277	–0.078
7	0.035	–0.324	–0.313	0.022	0.383	**–0.856**	1.000	0.383	–0.078	–0.035	0.383	0.383	0.383	–0.313	0.022	0.164
8	0.333	–0.124	0.200	**0.537**	**1.000**	0.149	0.383	1.000	0.447	0.200	**1.000**	**1.000**	**1.000**	0.200	**0.537**	0.174
9	0.447	0.462	0.447	**0.832**	0.447	0.333	–0.078	0.447	1.000	–0.149	0.447	0.447	0.447	0.447	**0.832**	0.389
10	0.067	**–0.620**	–0.067	–0.289	0.200	0.149	–0.035	0.200	–0.149	1.000	0.200	0.200	0.200	0.200	–0.289	**–0.522**
11	0.333	–0.124	0.200	**0.537**	**1.000**	0.149	0.383	**1.000**	0.447	0.200	1.000	**1.000**	**1.000**	0.200	**0.537**	0.174
12	0.333	–0.124	0.200	**0.537**	**1.000**	0.149	0.383	**1.000**	0.447	0.200	**1.000**	1.000	**1.000**	0.200	**0.537**	0.174
13	0.333	–0.124	0.200	**0.537**	**1.000**	0.149	0.383	**1.000**	0.447	0.200	**1.000**	**1.000**	1.000	0.200	**0.537**	0.174
14	**0.600**	0.372	**0.733**	0.372	0.200	0.447	–0.313	0.200	0.447	0.200	0.200	0.200	0.200	1.000	0.372	0.313
15	**0.620**	**0.590**	0.372	1.000	0.537	0.277	0.022	0.537	0.832	–0.289	**0.537**	**0.537**	**0.537**	0.372	1.000	0.324
16	0.244	0.324	**0.592**	0.324	0.174	–0.078	0.164	0.174	0.389	**–0.522**	0.174	0.174	0.174	0.313	0.324	1.000

1 – New product/product innovations, 2 – Product is for final consumer , 3 – Especially the positive impact on health of consumer, 4 – Innovation especially focused on sensory features of product , 5 – Innovation focused on duration of product, 6 – Microbiology cultures application, 7 – Physical methods application (temperature, cooling, sterilization), 8 – The growth of demand, 9 – Marketing innovations (new packaging, graphics, marketing strategies), 10 – Usage of secondary courses, 11 – Research and development, 12 – Production in laboratory scale, 13 – Testing of product's parameters, 14 – Cooperation in product/package design , 15 – The part of new technology is also packing unit, 16 – New technology process of packaging is realized and also the new type of package is realized

Source: own calculations

doi: 10.17221/128/2014 -AGRICECON

projects are independent, and there was probably no system supporting the process of money distribution. Individual projects were so different that it was even very difficult to evaluate them. It was not possible to apply any type of input/output analysis.

Table 7 provides a brief overview of individual innovative activities supported by private and public expenditures. As already mentioned, individual activities were not supported according to any system, they were supported only on the basis of the individual companies' proposals. However, no system appeared to be in place regarding the money distribution process, although some relationships were identified at the level of individual supported innovative activities. On the basis of correlation analyses – it is possible to identify several important relationships between individual types of innovative activities. It can be seen that some activities are accompanying each other: the following correlations are apparent (for key identifying individual innovation types please refer to the note below Table 7): innovation 1 is correlated to innovations 4, 14 and 15; innovation activity 2 is correlated to innovations 4, 10, 15; innovation 3 is correlated to innovations 14 and 16; innovation 4 is correlated to innovations 1, 2, 5, 8, 9, 11, 12, 13 and 15; innovation 5 is correlated to innovations 4, 8, 11, 12, 13 and 15; innovation 6 is correlated only to innovation 7; innovation 8 is correlated to innovations 4, 5, 11, 12, 13 and 15; innovation 9 is correlated to innovations 4 and 15; innovation 10 is correlated to innovations 2 and 15; innovation 11 is correlated to innovations 4, 5, 8, 11, 13 and 15; innovation 12 is correlated to innovations 4, 5, 8, 11, 13 and 15; innovation 13 is correlated to innovations 4, 5, 8, 11, 12 and 15; innovation 14 is correlated to innovations 1 and 3; innovation 15 is correlated to innovations 1, 2, 4, 5, 8, 9, 11, 12 and 13; and innovation 16 is correlated to only innovations 3 and 10. On the basis of these correlation analyses can be seen that, at least while there is no system at the level of total expenditures distribution, at the level of individual activities/proposals – a system apparently exists. The specific type of innovation is usually accompanied by the set of other innovations as can be seen in the case of many examples provided by Table 7.

CONCLUSIONS

This article aims at a comparison and the identification of differences in the innovation activities within the dairy industry, as an important food producer in the Czech Republic. Because the cooperation on innovation activities in the food industry is supported by the RDP, it was necessary to obtain in-depth information about the targets of innovations and cooperation between dairies and research centres.

The counterfactual analysis of the supported and the other (not supported) dairies clearly shows that innovative dairies are usually medium or large companies with sufficient capital power to buy expensive technology. Innovations, and public support of innovations, have enabled dairies to stabilise their profits during a period of crisis, and to increase their competiveness. It is important suggestion of further support of innovations.

The application of descriptive statistics and quantitative analyses of a representative sample of sixteen supported projects under sub-measure I.1.3.2 of the RDP has identified the main types, and results of, innovation activities in the Czech dairy industry. The combination of product, process and marketing innovation is the type of innovation most frequently supported. Dairies seek to offer consumers new products, processed with innovative, energy-efficient technology, and packed in attractive packaging. The innovation activities target five areas: Processing and the efficient use of by-products (whey, buttermilk); Production of new products with health benefits; Improved processing of dairy products with a particular focus on long-life products having better sensory parameters; Improved efficiency of transport and storage of milk and dairy products; and Improved wastewater treatment. The dairies put most emphasis on long-life products with better sensory parameters without artificial preservatives. The shelf-life of milk and milk products has been extended through special packaging, addition of microbial cultures, or physical influences (heat, cold). The addition of microbial cultures was not combined with physical conservation techniques.

The production of new products with health benefits, and improved processing of dairy products with particular focus on long-life products having better sensory parameters, was the second most frequent combination of innovation activities. Health improvement is usually made through fortification of products by microbial cultures or by nutrient-friendly processing. Processed whey also helps to improve health benefits due to the significant share of whey proteins.

Another important finding is that dairies tried to be not only energy-efficient, but also become

doi: 10.17221/128/2014 -AGRICECON

zero-waste facilities. They achieved this through the use of by-products from milk processing (whey, buttermilk). Moreover, some dairies focussed on environmental-friendly technologies and have improved their wastewater treatment because this helps to solve the problem with specific waste water with a higher fat content.

The key cooperation partners for innovations in the Czech dairy industry were the State Institute of Chemical Technology Prague and the private company MILCOM a.s. Cooperation is the first phase of the innovation process and consists of a complex group of activities, sometimes including marketing innovation. Expenditures on research capacities accounted for only about 5% (4.6%) of total investment expenditures. The remaining investment expenditures (95%) were allocated to purchasing technical equipment. The cooperation between applicant and research centre consists of consultation and advisory services, identification of problems and the suggestion of possible solutions, complex methodology of work, and the preparation of any technological process. An integral part of cooperation was research and development, trial production under laboratory conditions, and testing the properties/operating parameters of the new product and technology.

The quantitative analysis of the sample shows unequally distributed support. Four projects (out of 16) accounted for more than 50% of all expenditures. There is a significantly different size of individual projects. Some projects had a decisive impact on the business activities of individual companies, whereas some other projects were quite small and their impact on a company's competitiveness was very limited.

It is necessary to be very critical in relation to the process of spending public money. Even if individual projects are focused on support of innovation activities, the real innovative effect is very limited because individual companies were not looking for their own new added-value, but were particularly focused on the implementation of already-existing innovations. This process cannot be considered as being really innovative – because without the implementation of new technologies – individual companies would not be able to survive in competitive market.

Acknowledgement

This paper was prepared with financial support from the project "Socio-economic practices of sustainable development in the new industrialization". The project is supported funded by the Government of the Russian Federation, Grant 074-U01 and conducted within the National Research University of Information Technologies, Mechanics and Optics (ITMO), in St Petersburg, Russia.

Support for this paper came also from the internal research project of the University of Economics, Prague "Measuring the economic efficiency in the agri-food sector using productivity indices", project no. MF/F3/4/2013.

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Received: 18th August 2014
Accepted: 3rd October 2014

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