INNOVATIONS AND KNOWLEDGE TRANSFER FOR THE FOOD SUPPLY CHAIN SUSTAINABILITY: CHALLENGES IN THE CZECH DAIRY INDUSTRY

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Abstracts

A mobilisation of research, knowledge transfer and innovation to deal with the current challenges as raising world food demand while protecting natural resources is a priority area of the EU. The effective knowledge transfer and innovation activities in the agri-food supply chain may push all producers in the vertical to improve their competitiveness while saving resources. In the paper we examine the current level of innovation activities and knowledge transfer in milk processing industry in the Czech Republic, with a particular focus on the collaboration of firms with R&D organisations and other important agents, in order to assess the potential for enhancing sustainable dairy production. Most of the interviewed milk processors confirmed that sustainability objective did not rank high within firms' strategies while it showed a great potential for innovations. It is apparent from the conducted interviews with stakeholders as well as from the statistics that the level of cooperation for innovations is rather low among the Czech food and particularly dairy processors. The low cooperation level concerns not only research institution but also other agents including farmers. The lack of cooperation among producers can partly be accounted to property rights protection and the need to get advantage over the competition. The interviews and the statistics showed that companies with in-house R&D staff have higher absorption capacity and thus requirements concerning cooperation with research institutions and that these firms are not satisfied with what is offered in the country and seek support abroad. The current support programme increased the sector innovation activity, but at the same time used-up limited capacities of the national research base. Continuation of the support in the current way seems unsustainable.

Keywords

Sectoral system of innovation, absorption capacity, dairy processing industry

1. Introduction

The European agri-food market is increasingly challenged by the world market opportunities, however, under terms of competition. Getting rid of the government based buffers urges for making the European agri-food system far more efficient. It necessarily leads to more intensive utilisation of resources, including the natural ones which in contrary need more protection. A mobilisation of research, knowledge transfer and innovation to deal with these challenges have been emphasised as a priority area by the European Commission (EC, 2012, a). The respective system of policy tools accomplishing the Europe 2020 strategy tends (in their proposals) to boost the responsibility of the private sector for its success in the market and the agri-food chain development. Thus each part of the chain has to contribute to managing the market challenges and to keeping the chain vital. The effective knowledge transfer and innovation activities at any stage of the agri-food supply chain may push all producers in the vertical to improve their competitiveness while saving resources. "In a globalized world, lack of innovation can easily put companies and organizations out of business, regardless of resource endowments and accumulated capitals. Strategies to maximize shareholder value in the short run without strengthening innovative capacity of the entire industry can lead to loss of competitiveness and economic failure." (Grossman & Helpman, 1991)

The focus of the paper is on dairy processing industry since it combines struggle for efficient performance with positive environmental externalities linked to dairy cattle production. The

rather balanced distribution of dairy farming across Europe given by the quota system might convert into uneven layout with more and less successive regions in Europe after the quotas are abolished (European Commission, 2012, b; Kempen et. al., 2011; European Commission, 2009; Thiele, Hargens, 2006). It might have serious negative effects on the landscape, environment and rural areas. Most attention has been paid to the primary production so far (e. g. Ostermeyer, Appel, Balmann, 2011; Kempen et. al, 2011; Jongeneel et al., 2010). However, improving competitiveness of dairy industry might be equally crucial in averting shed of dairy cattle from regions like the Czech Republic.

In the paper we examine the current level of innovation activities and knowledge transfer in milk processing industry in the Czech Republic, with a particular focus on the collaboration of firms with R&D organisations and other important agents, in order to assess the potential for enhancing sustainable dairy production.

The paper is structured in 6 parts. In the next part we briefly review some theoretical consideration concerning innovations, knowledge acquirement and governmental support. The adopted approach and data sources are described in paragraph 3. An overview of the dairy sector and its position in the EU and R&D and innovation policies is given in paragraph 4. Paragraph 5 is devoted to results of the Community Innovation Statistics (CIS) and interviews with stakeholders. Finally, findings are discussed in the concluding paragraph (6).

2. Theoretical background

Theories around innovation usually distinguish two models: "linear" and "innovation systems" models. In the linear (macro-economic) model innovation is viewed as a scientific and technical sequential process driven by experts, where innovations are developed by scientists and taken up by practitioners e.g. Cohen and Levin (1989). In this discourse innovation originates through specialist research and development activity and scientific knowledge is the key driver of change (Smith, 2000).

Relatively recently, the conceptual framework has moved towards a model in which innovation is conceived as a co-evolutionary learning process occurring in the social networks of an array of actors (Dosi 1982, Edquist 1997, Hartwich 2010). This way of understanding looks at the wide environment of the market structures that contribute to define competencies, incentives and dynamics properties of the innovative process. (Malerba, 2005, Dragan & Shucksmith, 2008). In the consequence, the innovation mechanisms differ across sectors. As a framework to the sectors´ approach Malerba (2005) established the term *sectoral system of innovation.* The sector is understood as "a set of activities which are unified by some related products groups for a given or emerging demand and which share some basic knowledge" Malerba (2005). Sectoral system could be seen as composed by three main building blocks: i) knowledge and technology, ii) actors and networks and iii) institutions. Inspired by the evolutionary theory and learning process Malerba (2005) underlines the organizational content of the sectoral innovation system "different agents know how to do different things in different ways". The set of agents carries out market and non-market interactions for the creation, development and diffusion of new sectoral products. These agents are individuals and organizations at various levels of aggregation, with specific learning processes, competencies, organizational structure, beliefs, goals and behaviours. They interact through processes of communication, exchange, cooperation, competition and command. Their interaction is shaped by institutions. As Malerba shows on the example of five different sectors the content of three main building blocks is usually common within the sector but differs substantially across the sectors. Understanding them becomes a prerequisite for any policy addressed to a specific sector.

Absorptive (or absorption) capacity (Cohen and Levinthal 1990) calls attention to the internal capabilities of firms to enhance their technological capacity by assimilating and exploiting

external knowledge. The internal capabilities include R&D (in-house research) and non-R&D variables like managerial system, labour skill and market competences (Tidd 2000). Hervas-Olivier et al. (2012) point out that focus on absorption capacity is particularly relevant in low-tech industries where there are by definition low expenditures in R&D and thus of little power for explaining the acquirement of external knowledge. They found empirically that (a) firm's absorption capacity influences positively its engagement in cooperation with research institutes and universities and (b) the human resources (staff with university degree) and organization's innovation routines together with the experience in networks are the key factors of firm's cooperation with research institutions. [1]

The role of government support and relation of public sector and private industry within the systems is discussed by many authors. Hartwich (2010) brings to mind the OECD experience from Australia, the Netherlands and Russia that "it was particularly policies of linking private industry and public R&D organizations that allowed companies to leverage government funding sources for research and innovation and develop new technology knowledge together with specialized R&D organizations […]". Another example comes from the New Zealand´s Dairy Industry. In the same study Hartwich (2010) quotes that "part of the substantial growth of the sector and its gains in efficiency and competitiveness is due to innovations that stem from the collaboration between certain institutions in the public and private sectors and on the level of the industry. In particular it assumed that government policy and funding of research has supported the development of innovation."

A number of studies were made to identify the incentives for individuals and organizations to build a partnership with research. Hagedorn, Link and Vonortas (2000) summarise that empirical evidence supports the notion that firms join the partnership in order to further their competitive strategic goals; i.e. to gain access to complementary research resources enabling them either to diversify horizontally in new products or creating technical capacity for vertical integration. Hartwich and Tola (2007) based on studying public–private research partnerships in 12 Latin American countries, specified five factors of a successful partnership: i) a common interest, ii) a positive cost–benefit relationship for each partner, iii) deriving benefits from the contribution for each partner, iv) equilibrium between the partners' benefits, and iv) non-conflictive benefits. Later a catalyzing agent or a partnership broker was added to this list (Hartwich, Gottret, Babu & Tola, 2007). Brokerage functions are often performed by government agencies and funding bodies such as sector development committees, councils for science and technology, or commodity development boards.

There is a wide range of policies how to encourage the public and private sectors to join the partnership. Hartwich (2010) identified six measures stimulating innovation partnerships in the New Zealand ´s Dairy Industry: i) Private funding of R&D through contract as a preliminary step to partnerships; ii) Private funding of R&D through levy: On the basis of governmental decree or voluntary agreement, industry members contribute a certain input (often a percentage of their income from sales) to a common fund. The fund, usually administered by a parastatal agency over which industry members have mandatory control, allocates resources according to priorities set for sectoral development and innovation; iii) Government funding schemes for public science and R&D (public knowledge providers) that stipulate collaboration with the private sector and/or other technology providers; iv) Government funding schemes for the private sector that compel/stipulate collaboration with other private sector entities and/or technology providers including science and R&D organizations; v) Technology providers voluntarily collaborate with the sectoral entrepreneurs and other technology providers; and vi) Bringing partners together and identifying their common interest: Some development agencies provide special incentives to bring public and

[1] They argue that regardless of the non-R&D variables and the networking, R&D employees is a key indicator of the firm's access to universities-RTOs (Hervas-Olivier et al. 2012, 71).

private organizations in production and R&D together at one table to discuss areas of common interest and technological innovation opportunities in light of existing and emerging businesses and markets. This support does not focus on funding of specific R&D projects, but on brokering partnerships under the assumption that partners will have sufficient access to funds to later operationalize the partnership.

Hartwich argues that these six mechanisms can result in a variety of forms of partnerships, ranging from ad-hoc contacts for information exchange to formal projects that promote the development or application of a technology, and even strategic links for developing long-term research and development and innovation programmes.

3. Methodology and data

The approach follows the concept of sectoral system of innovation outlined by Malerba (2005). As it was explained above, this approach investigates three components which shape the sector performance: actors, knowledge and technology and institutions (Table 1). We further distinguish internal factors and surrounding environment (external factors); external factors include actors providing knowledge and institutions affecting the transfer of knowledge, while internal factors refer to capabilities of food (dairy) industry firms acquire and utilise knowledge (technological advances).

Table 1 Research scope and sources of information

Industry (food, dairy)		Actors	Knowledge and technology	Institutions	CIS	R&D statistics	Business statistics	Interviews	Literature review
Innovation performance					x		x	x	x
Internal factors	Innovation activity				x				
	R&D expenses					x			x
	Absorption capacity				x				
	Networking							x	
External factors	Research institutions							x	
	Suppliers of technology								x
	Interest groups							x	
	Market structure						x		
	Policies							x	x

Source: Own survey

Analysis is fed from five sources of information: Community Innovation Statistics, R&D statistics, business surveys, interviews with actors and literature. The use these sources for analysing individual components of the approach is showed in Table 1, too.

The Community Innovation Statistics (CIS) are produced in all 27 Member States of the European Union[2]. In the Czech Republic, the CIS have been collected since 2001. In this paper we use micro-data from the surveys 2003, 2005, 2008 and 2010 provided by the Czech Statistical Office. The survey covers about 5000 firms of which about a half are small and medium enterprises (SME)[3]. The number of food processing firms ranges from 176 (in 2008) up to 281 (in 2005). Concerning milk processing companies their number oscillates around 20 (16 in 2010 - 25 in 2003). Although the number of dairy plants might seem low, the sample represents processing of 62 % and 70 % of raw milk produced in the country in 2010 and

[2] Based on Oslo Manual (OECD, 2005)
[3] Enterprises with less than 250 employees

2008 respectively. In turn it means that the CIS samples have captured the most dominant dairy processors.

The share of SMEs is higher in the food industry sub-sample (more than two thirds), while it is similar to the whole sample (a half) in the dairy sector. Thus the dairy processors are on average substantially bigger than the food industry companies in terms of sales (revenue) and employment (Table 2).

Table 2 Basic characteristics of the CIS sample

	Item	Unit	2003	2005	2008	2010
Food Industry	Number of companies		261	281	176	215
	Average sales	CZK millions	663	567	**834**	**689**
	Average employment		224	182	248	**202**
	SME (EMPL<=250)	%SME	66%	73%	66%	73%
Dairy Industry	Number of companies		25	22	17	17
	Average sales	CZK millions	1025	1149	**1763****	**1517****
	Average employment		278	295	330	**345***
	SME (EMPL<=250)	%SME	52%	50%	47%	59%

Note: ** significant at α=0.05, * significant at α=0.1
Source: CIS, own calculation

The R&D statistics is a survey based on the OECD Frascati manual (OECD, 2002) collecting information on R&D expenditure, employment and sources of funding. It covers around 85%[4] of economic subjects in the country there are about 50 food processing enterprises of which 10 are dairies.

Table 3 Specification of interviewed innovation actors

#	**Character**	**Business form**	**Specialization**	**Size1)**
1	Specialised research institute	Private	Applied research; laboratory and technical service, supply of fermentation cultures, and consulting	small
2	Institute of Chemical Technology (ICT University)	Public	Basic and applied research in chemistry and bio-technologies (Department of Dairy, Fat and Cosmetics)	
3	Association of dairy processors	Association	Interest organisation, providing market and technological information to members	≈ 50% of milk deliveries
4	Dairy group of the Food Industry Chamber	Association	Interest organisation	≈ 50% of milk deliveries
5	Milk processor	Joint stock comp.	Milk processing (+organic)	Large
6	Milk processor	Joint stock comp.	Milk processing	Large
7	Milk processor	Joint stock comp., foreign owner	Milk processing	Medium, expanding
8	Milk processor	Joint stock comp.	Milk processing	Medium
9	Agri-food holding	Joint stock comp.	Milk processing, other food processing, farm production, agricultural services, (+organic)	Small dairy, expanding

Note: [1)] The categories Large, Medium and Small identify the relative size with respect to other agents in the country.
Source: own classification

The information on market structure and productivity have been obtained from two business surveys: the Structural Business Statistics of the Eurostat[5] and the CreditInfo statistics based

[4] It refers to the response rate, see www.czso.cz
[5] http://epp.eurostat.ec.europa.eu/portal/page/portal/european_business/introduction

on the obligatory published annual accounting reports of legal entities and provided by Solidet (www.solidet.cz). Creditinfo covers about 70 dairy industry companies including primary and secondary manufacturers. The statistical figures were supplemented by face to face interviews with various stakeholders in the innovation system. The selection was made to cover a broad spectrum of them: producers, research institutions and information and networking agents. Concerning the producers, the effort was made to concentrate mainly on the national ones, nevertheless we included a foreign owned one too. In all producer cases we chose dynamic companies in terms of production expansion or ownership changes incl. acquisitions. The willingness to share their opinion was shown by all institutions and companies contacted. The specification of the selection is given in Table 3.

4. Characterisation of the milk processing sector in the Czech Republic

The milk production past through a dramatic adjustment period in the 1990s, and it stabilised before the EU accession at the level of approximately 2.5 billion litres of raw milk annually (Table 4). It is still about 15-20% above the domestic consumption of milk products. From the time series we can also see that the Czech Republic does not utilize the extended quota since 2007. Joining the EU market resulted in more trade; more precisely, some of the Czech milk (currently about 15% of the production) is delivered to the two German dairies situated close to the Czech borders and at the same time imports of processed products increased sharply (tripled between 2003 and 2011). It indicates that the Czech milk processors have not been competitive in the Central European dairy market. Ratinger & Boskova (2013) based on interviews with dairy cooperatives argue that it was rather terms of contracts than price what turned milk deliveries to Germany.

Table 4 Milk production and trade in the Czech Republic

	Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011
Milk products imports [1)]	%	13,5	15,6	24,5	32	37,3	36,6	38,2	38,6	39,9
Milk products exports [2)]	%	30,5	26,9	24,9	20,9	21,5	19	17,6	20,5	22,8
Raw milk exports [3)]	%	0	1,4	8,4	11,6	15	16,5	17,5	15,5	16,8
Raw milk purchased [4)]	mil. l	2 532	2 613	2 496	2 612	2 618	2 639	2 588	2 508	2 555
Self-sufficiency in raw milk	%	121,7	123,8	114,4	119,2	116,7	119,1	115,9	114,2	119,5
Milk quota utilization[5)]	%	.	.	99,75	100,62	98,07	98,59	96,91	93,41	90,69

Notes: [1)] Share on domestic consumption, all products considered in milk equivalent; [2)] Share on domestic raw milk production, all products considered in milk equivalent; [3)] Share on raw milk produced; [4)] All raw milk produced within the CZ milk delivery and dierct sales quota; [5)] Utilization of delivery quota, for 2005 the quota year 2004/05 shown and similarly further.
Source: 1. Own calculations based on data of MoA (2011) - chapters 5.2.1 and 8.2.1, and the Czech Statistical Office – customs statistics; 2. The Czech Agricultural and Intervention Fond – the quota administration.

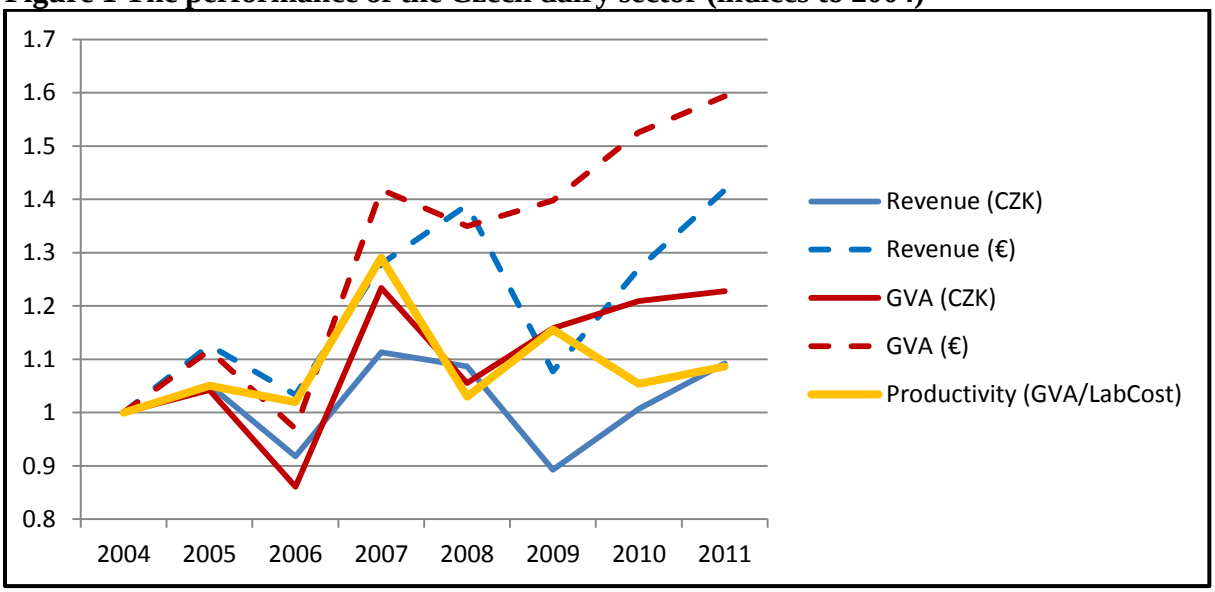
About 40% of raw milk is processed to cheeses, 10% to fermented products, 15% is dried in milk powder, 25% is consumed as liquid milk and cream and less than 10% goes to special products. Thus more than a half of the purchased raw milk is processed into high value products.

Sector performance and structure

There are 41 dairy plants registered in the quota system by the Paying Agency of the Czech Republic; i.e. only these process raw milk at a considerable scale (in 2010/2011). And there are about 70 dairy processing companies - legal entities publishing their accounting figures gathered in the CreditInfo sample . This sample includes all important primary processors of milk covering 99.6% of milk purchases in the Czech Republic. In addition, there are specialised second stage processors as ice cream processors, cheese processors etc. (about 30). Using this sample we can get notion about the dairy sector performance and the market structure.

In Figure 1 we present the performance of the dairy sector over the 8 years after the EU accession. The revenue at current prices exhibits stagnation in Czech crowns, oscillating roughly by ±10. The value added in Czech crowns slightly increases. Due to the currency appreciation, the both parameters in euros exhibit strong upward sloped trends. The worrying thing is, however, stagnating productivity (measured by GVA over labour costs).

Figure 1 The performance of the Czech dairy sector (indices to 2004)



Source: CreditInfo database, own calculations

The five largest companies accounted for 50% of the sector revenue in 2010. In this case we merged enterprises with the same owner in one company. These five largest companies include two domestically owned and three foreign companies. There were seven companies having at least 5% share on the sector revenue; they together represented 63% of the dairy product sales. It can be showed that the productivity (GVA/labour costs) of these five largest was of 13% above the dairy sector average in 2010.

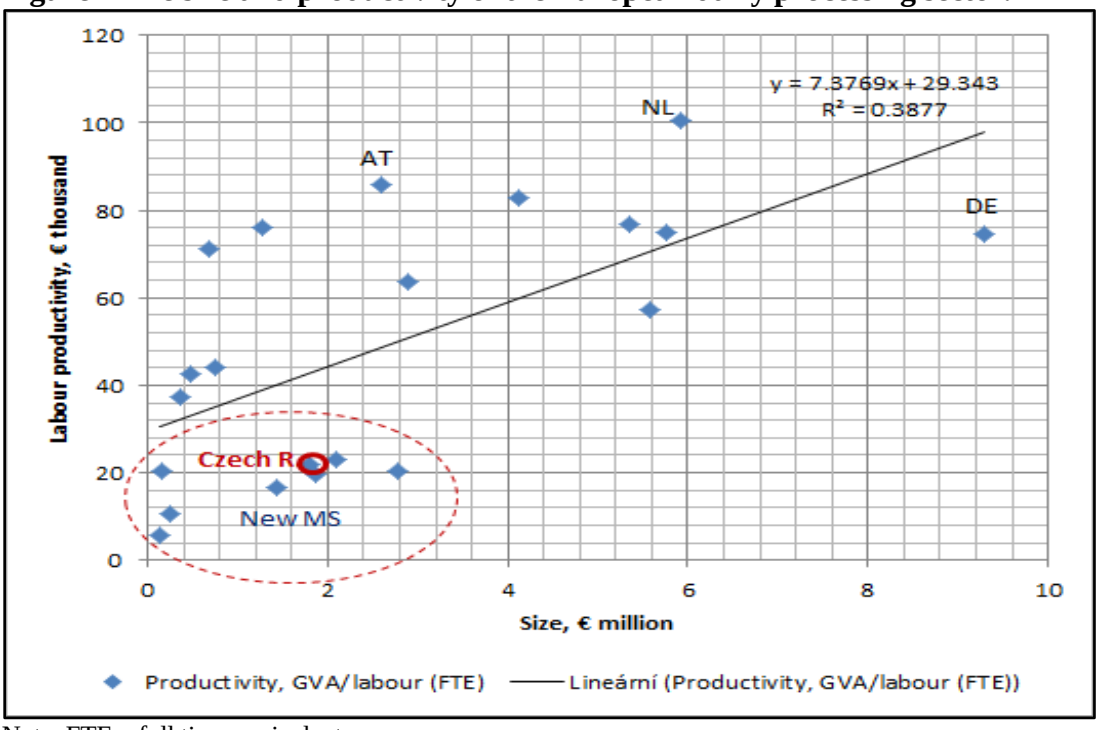
These figures might indicate fairly high concentration of dairy production in the Czech Republic. However, comparing to the other EU countries the Czech dairy processors are rather small. In Figure 2 we present the relationship between firm size and labour productivity in the dairy processing and cheese making sector across the EU Member States (MS). The size is expressed in terms of GVA per company and the labour productivity is measured by GVA per labour full time equivalent (FTE). The Czech Republic (red) as the other new MS (in the red circle) exhibit small size and low labour productivity. In contrast, German and Dutch dairy companies are big and highly productive. Using a simple regression we can estimate that productivity increases with the firm size; or in other words, that there are economies of scale (in terms of productivity gains). These economies of scales can also be attributed to research and innovation activities which improve and extent with the scale (e.g. Hervas-Olivier et al., 2012)).

There are four categories of policies supporting innovations in the food sector: R&D programmes, support to the development of research capacities in regions (Regional operational programmes of ERDF), the direct support to innovations (ERDF, EAFRD) and building up business capabilities through training (ESF)[6]. The National Agency for Agricultural Research (NAZV) supervised by the Ministry of Agriculture provides principal support to applied research in the area of main food commodities (sub-sector) including the dairy one. The Czech Technology Agency (Ministry of Education and Sport) would finance

[6] ERDF - European Regional Development Fund, EAFRD – European Agricultural Fund for Rural Development, ESF – European Social Fund

applied research also in the food sector if it fits to one of its priority areas - in this case the development of bio-technologies. There is also available the EU framework programme; Czech participation in the dairy research is rather weak. Building up-research capacities of the ERDF is restricted to the lagging behind regions, i.e. to all Czech regions except Prague. This fund contributed to the development of research capacities in the area of cheese making technologies in Zlin (east Moravia); in contrast the leading milk processing research institutions (Dairy research institute and the Faculty of Food and Bio-chemical technology, ICT University) are located in Prague, thus without access to the ERDF means. The objective of Measure 124 of the Rural Development Programme[7] is to support directly innovation process in food industry. The programme requires collaboration between food processing firm and research institutions (min. CZK 1 million, i.e. €40 thousands). The milk processing gets preferential treatment. The use of the Operational Programme "Business and Innovations" cannot be used by dairy industry, since milk as the other main food commodities are excluded from the support. The programme, however, can be used by producers of technologies for dairy industry. Recently, large dairy processors utilize the support of the ESF for enhancing skills of employees including those relevant to innovations.

Figure 2 The size and productivity of the European dairy processing sector.



Note: FTE – full time equivalent
Source: Eurostat, own calculations

5. Results

Innovation performance and activities in the dairy processing sector

Most of food firms included in the CIS sample innovate products (Table 5). However, we can see substantial difference between the food industry as whole and the dairy sector. Around a half of food firms innovate products in each survey. In contrast, the dairy sector exhibits significant dynamics; from about a half of firms innovating their products in 2003 to three quarters in 2010. The dairy industry shows significantly higher activity in process (production methods) innovations too. Actually in all types of innovation there is a higher participation of dairy processors than among all food industry firms. The financial crisis is well reflected in

[7] http://eagri.cz/public/web/file/61102/prv_zmeny_cerven2010_web.pdf

lower figures for 2010, a year when it culminated in the Czech Republic. SMEs show lower innovation activity in all respects than the whole dairy sector, however, the figures are usually higher than for the whole food industry, e.g. 50% and 60% in product innovations and 50% and 30% in process innovations in 2008 and 2010 respectively (not reported in Table 5).

Table 5 Type of innovation (the share of respondents in the subsamples)

	2003		2005		2008		2009	
Firms …	**F**	**D**	**F**	**D**	**F**	**D**	**F**	**D**
Developing process innovation	30%	32%	54%	45%				
Developing product innovation	41%	56%	45%	64%				
Introducing new products					38%	71%	34%	76%
Introducing new services					13%	18%	11%	18%
Introducing new logistic and distribution methods					19%	53%	13%	29%
Introducing new production methods					33%	76%	24%	53%
Introducing new support activities					28%	35%	20%	35%

Note; F – all food industry firms, D – dairy processors
Source: CIS, own calculation

In spite of the large emphasis on innovation of products, their novelty is mostly restricted to the country; according to the CIS 2010 only 8 of 215 food producers indicated developments of products new in the EU, no such novelty was indicated among dairy processors.

Food safety is not considered by interviewed firms as an innovation field in the dairy sector, regardless the firm has or is required to have the private standard certification (IFS, BRC etc.). More often it is the pressure of supermarket chains on extending shelf-life of fresh products without conservation additives which inevitably leads to increasing hygienic standards, aseptic packaging etc. Another perhaps most pervasive directions in product innovation are improvements of taste characteristics of established products (internally i.e. to continue production and also by customers i.e. keeping products the customers are used to buy). Only foreign own companies are introducing really new products in the Czech market. Concerning processes innovations they aim at friendly treatment of milk which protect physical structure of milk particularly important for cheese making and at improving efficiency (lowering costs, energy and water consumption).

The CIS surveyed seven innovation activities ranging from research to investment in technological equipment (Table 6). We can see noticeable increase of the uptake of these activities in food industry between 2003 and 2010. Table 6 shows that dairy firms are more active than the rest of the industry; vast majority of dairy processors (76% in 2010) provide marketing innovations. Two thirds of dairy processors invested in machinery and equipment in 2010. Actually, investment in technology equipment represented the major innovation costs in food industry in all years8. The average innovation investment cost per firm jumped from € 68000 and € 225000 in 2003 to € 480000 and € 841000 in 2010 (in nominal terms) for the whole food industry sample and the dairy sub-sample respectively. Dairy firms are substantially more active in designing their products than the food sector in general. This is doubtlessly associated with the intensive innovation of products and their targeting to specific consumer groups. This was confirmed in all interview with dairy processors.

Dairy firms also do increasingly internal research. Nevertheless, the relative expenses to internal research has stayed low (around 8% of the investment costs).

[8] We do not present shares, since there were collected different cost items in each survey.

Firms usually combine innovation activities, also in this respect there is a significant development in the last decade. The share of firms adopting more than four innovation activities increased considerably over the period 2003-2010; in 2010 it was already 65% of the surveyed dairy processors comparing to only 24% in 2003. It holds more or less for dairy processing SMEs too (40% in 2010). The whole food industry figures stayed low at 24%.

Table 6 Innovation activities

Item - Firms …	2003		2005		2010	
	F	D	F	D	F	D
Investment in machinery and equipment	19%	32%	31%	41%	38%	65%
Introduction of innovations in the market	19%	44%	25%	59%	29%	76%
Provision of other external knowledge	7%	12%	8%	14%	8%	12%
Design of products	13%	40%	16%	36%	26%	65%
External research	8%	12%	10%	27%	13%	35%
Internal research	19%	28%	22%	45%	32%	76%
Training and education	15%	20%	16%	36%	22%	59%

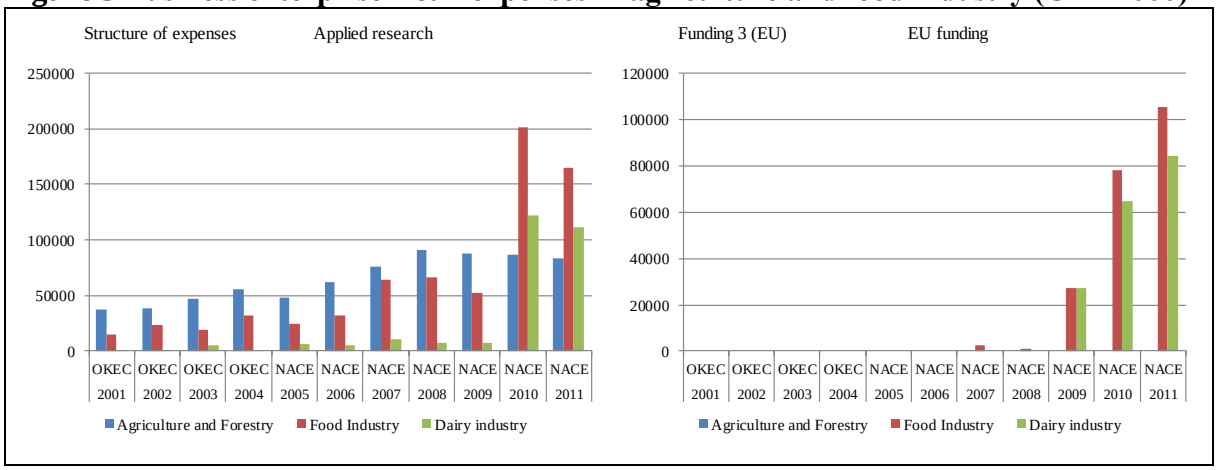
Note; F – all food industry firms, D – dairy processors
Source: CIS, own calculations

About a quarter of the food firms in the CIS use public support programmes to finance their innovation activities, mostly the national ones (often national implementations of the EU funds as EAFRD[9], but also from the national and the EU (framework) research programmes). Among the dairy processors the situation was worse (only 11% took part) in 2003, but it improved significantly over the investigated period; about 57% of dairy processors in the CIS benefited from the innovation support programmes in 2010.

R&D expenditure

Expenses of food industry in applied research increased markedly in 2010 (Figure 3, the statistics on R&D expenses). Some improvement is visible since the EU accession, but in 2010 the innovation support measure (M124) of the Rural Development Programme (RDP) came into effect, which claimed involvement of research institutions in the innovation-investment projects.

Figure 3 Business enterprise R&D expenses in agriculture and food industry (CZK '000)



Source: Czech Statistical Office, R&D expenses microdata, own calculations.

[9] European Agricultural Fund for Rural Development

This particularly evident from the right chart in Figure 3 – use of the EU funds for financing private business research jumped in 2010 from almost zero in 2008 to CZK 78 millions (€ 3.1 millions) in 2010 and further to CZK 105 millions (€ 4.3 millions) in 2011.

Dairy industry which constitutes about 7% of food industry (measured by GVA), acquired most of the RDP support (80%, see the right chart in Figure 3). This is partly due to the programme conditions which favoured the dairy sector[10] and partly due to relatively good fitness of the milk processing industry. The latter does not include exceptionally the sector's financial situation which improved substantially after the EU accession, but also own research capacity. From almost no scientific staff in the dairy plants in 2001 the figure increased to on average 3 persons in 2011. The process has been common in food industry, the recent figures of food industry average are slightly above 2 researchers per an enterprise.

Acquirement of external knowledge and absorption capacity

In spite of some on site research capacities, the use of research in innovation process is limited. Among the food industry firms research was conducted in only 17 cases in 2010; among the dairy processing firms the situation is better, about a half of the survey firms did research; in 2/5 cases by own capacities and in 3/5 cases it was outsourced. CIS 2010 surveyed 8 innovation skill reported in Table 7. The presented shares in the table relate to the total number of respondents in each category and therefore, one has to keep in mind that there are some firms (in many cases it might be a majority of respondents) which do not use the respective techniques.

Table 7 Capacity for innovation techniques and outsourcing in 2010

	Skills		Design	Engineering/ applied sciences	Graphics	Multimedia	Market research	Mathematics/ statistics	Software development	Development of web pages
D	in the firm	All	19%	18%	22%	12%	30%	19%	11%	18%
	outsourced	All	19%	10%	30%	25%	15%	10%	34%	44%
F	in the firm	All	0%	18%	6%	0%	24%	35%	12%	24%
	outsourced	All	76%	29%	82%	71%	53%	18%	59%	65%
D	in the firm	SME	17%	12%	20%	11%	28%	15%	8%	15%
	outsourced	SME	17%	7%	28%	22%	13%	8%	31%	44%
F	in the firm	SME	0%	0%	10%	0%	40%	20%	10%	40%
	outsourced	SME	70%	20%	80%	60%	30%	20%	60%	50%

Note: the shares are in respect to all firms in the category which in turn means that the difference between the reported percentages and 100 should be accounted to no use or no reporting of these skills; F – all food industry firms, D – dairy processors
Source: CIS 2010, own calculation

It is obvious from Table 77 that dairy processors use innovation techniques more intensively than food industry firms in general. The dairy firms which use them outsource them in vast majority in most skill categories; particularly high outsourcing is in product design, graphics, software development and market research. In turn, it can be interpreted as essential dependence of dairy processors on "external skills". Their observed uptake relates to demand i.e. innovation needs and internal capacities of dairy processors as well as to the supply. The

[10] In general cattle production received great attention of RDP.

low uptake of "external engineering/ applied sciences" might well indicate insufficient supply of the service. Actually, the interviews with research institutions as well as with dairy processors indicate that research services are not offered at demanded scale and scope. The leading research institution in the field of milk processing and cheese making (ICT University) is short of staff, lacks up-to-date equipment and medium term funding is limited, dependent on scientific publications. The same holds basically for the other few research institutions in the milk processing field. The similarly dissatisfactory situation was indicated concerning laboratories and experimental centres providing a technical support to testing the intended invention. Large dairy processors look for these services abroad, the smaller ones direct their needs to the ICT University in Prague which considers it inappropriate (out of scope).

The CIS 2010 investigated adoption of methods for stimulating innovations in firms. These include brainstorming at meetings, multidisciplinary teams, rotation of posts, financial and non-financial motivations and specialised training. The dairy sector seems to be more active in adoption of these methods than food industry or manufacturing in general; on average more than 50 % of dairy firms applied brainstorming, multidisciplinary teams and specialised training, comparing to about 30% firms in whole manufacturing or food industry. The interviewed large dairy processors used the opportunity of the support to training of the European Social Fund and launched intensive courses for their employees relevant to innovation needs of the business (likely, CIS 2012 will already reflect this).

Barriers to innovation

CIS gathers opinions of firms on barriers to innovations. The set of predefined barriers and their ranking is reported in Table 8. The respondents market the importance a barrier the on four point scale, we calculated of it averages and those we ranked. It is obvious from Table 8 that there are not essential differences in ranking between the dairy sector and food industry as whole. Also SME do not differ in ranking innovation barriers. High costs and lack of financial means are on the top while difficulties in finding a cooperating partner is ranked as the least important. This is in contrast to interviews, since the large (national) milk processing companies indicated that problems are rather in the opposite rank and that the limited capacity of the most common research partner (the ICT University) restricts the innovation process as we have already pointed out.

Table 8 Innovation barriers (Average rank, 1= most important)

	2003		2005		2008		2009	
Barriers	**F**	**D**	**F**	**D**	**F**	**D**	**F**	**D**
Too high innovation costs	1	1	2	1,5	2	2	2	2,5
Insufficient financial resources	2	2	1	3,5	1	4	1	1
Insufficient access to external financial sources				5	6	5	5	5,5
Lack of qualified staff	4	5	5	6	5	6	7	8
Lack of information on technologies	6	5	7	8	9	8,5	8	7
Insufficient information about markets	5	5	6	7	8	8,5	10	5,5
Difficulties to find a cooperating partner			8	9	11	11	11	9
Uncertain demand for innovated product	3	3	4	1,5	4	3	4	4
The market controlled by dominant firms					3	1	3	2,5
No need for innovations due to earlier innovations	8	8	9	10	10	10	9	11
Innovations are not demanded	7	7	3	3,5	7	7	6	10

Note; F – all food industry firms, D – dairy processors
Source: CIS, own calculations

Concerning sustainability most of the interviewed milk processing firms confirmed coincidently that this field does not rank to main objective while it showed a great potential for innovations. Actually only one processor (the one with a foreign owner) profiles its produce (mature cheese) as an eco-sustainable supply chain certified according to UNI EN ISO 22005:2008. It is necessary to stress that it is to attract increasing environmental concerns of customers in some European regions (and not in the Czech Republic) i.e. to gain foreign (EU) markets by beating the Italian competitors for their overuse of land and water). The other two interviewed firms processed organic milk, but they do not see many opportunities for further development in this direction. The national firms (particularly the smaller one) usually emphasized quality of national products which ought to be appreciated by consumers: they would like to build customer loyalty to their "national" produce. However, they are not sure about the way how to achieve it. Interesting aspect of it is that particularly cheese makers would like to build customer loyalty to a common product - young Edamer cheese, being reluctant to introduce other types of quality cheese, particularly semi-mature and mature sorts.

According to interviews, product innovations are driven by customers either retailers or the final consumers, while process innovations are often initiated by suppliers of technology. Concerning the former, retailers are particularly active if the dairy firm produce under the retailer's brand name. Concerning the latter, technologies suppliers, being usually large multinational companies with own research centres, provide the information on the current trends in milk processing and inform of new advances of own technologies. Dairy processors indicated in interviews that such way is comfortable for them as it is difficult to keep track of the recent advances in the technology. Nevertheless, they need also independent advice which might in some cases be difficult to get.

Occasionally, processors are pushed by R&D institutions, to test and to introduce some inventions as part of public research projects conducted by those institutions. This way of innovations is rather difficult for dairy processors (and food processors in general) because such research projects are driven by scientific objectives while they might miss needs of the practice. However, some successful collaboration was mentioned too.

6. Discussion and conclusions

We can argue that the above findings are in line with Terziovski (2010) and Hervas-Oliver (2012) that SME and low-tech industries (as the Czech dairy industry) see technological capabilities (advances) as an enabler rather than a driver of their performance.

It was indicated in the interviews (and perhaps partly from the statistics) that companies with in-house R&D staff have higher requirements concerning cooperation with research institutions – these firms are not satisfied with what is offered in the country and seek support abroad. It is also in line with the literature on this issue stressing that human capital relates firm's capacity to learn and thus it enables the firm to identify, acquire, assimilate and exploit external knowledge (Cohen and Levinthal 1990, Hervas-Oliver, 2012). In contrast to Hervas-Oliver (2012) we found that networking was comparably important; insufficient EU-wide networks reduced the advantage of staff with tertiary education.

It is apparent from interviews with all stakeholders as well as from the statistics that the level of cooperation for innovations is rather low among the Czech food and particularly dairy processors. The low level cooperation concerns not only research institution but also other companies in the branch and farmers. Both dairies which were in agri-food holdings reported some difficulties in cooperation with holding partners. This is in contrast to considering innovation as costly (Table 8). The lack of cooperation among producers can partly be accounted to property rights and the need to get advantage over the competition. On the other

hand, not all innovations (research) are conflicting[11], moreover the technology is rarely protected by patents or utility models[12] and thus it spreads quickly among milk processors anyhow.

The problem with property rights protection is likely one of the factors why the private sector (dairy processors) is reluctant to invest in research conducted by external research organisations. However, transfer of knowledge is essential for the sector economic success. There are three institutions (governance structures) stimulating cooperation of dairy processors with external knowledge holders:

There is a private initiative *the unions of processors*[13] which members are large dairy processors and some technology suppliers. The union provides information on the economic and technological trends by organizing regular members' meetings, educational seminars and trainings and by publishing a journal and information leaflets. The activities of both unions are financed by member fees. However, they are under-staffed, one having one fulltime person (secretary), the other having the chairman on the half time contract. The firms are finding the unions' services as useful but definitely not sufficient.

The top-down initiated *Technological platform for foods* aims to intermediate mutual communication between the R&D and production agents, especially with the objectives to coordinate research orientations and their objectives, and facilitates the communication within the agri-food vertical and its relation to administration bodies. This platform gets governmental funds for their activities. The output in respect to dairy processing is very limited. Actually, no interviewed dairy processing firm was a member of it and mostly they were not aware of its existence.

The main stimulation of processors-research cooperation comes from *the Rural Development Programme.* We have already mentioned the positive effects of the programme, but also some limits. Bringing our finding on the latter together, the constraints for the future success of the programme include i) low confidence in practical relevance of research conducted by R&D organisations; ii) some doubts in relation to price of the research service and on the other side iii) very limited capacity and iv) limited benefit for scientific output for the R&D organisations. Continuation of the support in the current way seems unsustainable.

Concerning to "innovations for sustainability" no one of the brokerage institutions/ organisations has it in its mission.

Our investigation has indicated that the "innovation" environment for the dairy sector at national level has limited capacity in terms of technology supply and R&D provision. The large dairy processor has already extended its focus to the whole EU. However, even it is the largest plant and a member of the biggest dairy holding in the country it is rather a small player in the EU dairy market. The scale does not allow it to carry its own research in desired extent. Establishing links to the European research base in the sector building-up a network which would provide information on the most recent trend and advanced technologies will be a great challenge for it as well as for the whole dairy sector.

7. Literature

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[11] E.g. environmental technologies as cleaning waste water is a problem which concerns all dairy processors.

[12] There is large scepticism among producers and researchers that it ever pays off.

[13] There are two unions of processors in the country, more or less collaborating. The traditional one was supplemented recently by a union which comes closer to government administration.

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