Structure, Innovations and Performance of the Czech Dairy Value Chain

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Abstract

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 the innovation activities and knowledge transfer in the dairy value chain in the Czech Republic are examined in order to assess the potential for enhancing sustainable dairy production. A particular attention is given to the collaboration with R&D organisations and other important agents. Concurrently the role of the structural changes is considered. The methodological approach builds on the concept of the sectoral system of innovation. Based on statistical figures and face to face interviews the increasing dynamics in the innovation process is observed, however, farmers and processors are in their innovation activities disconnected and their collaboration with research institutions and other companies is rather low. The main innovation objectives as well as drivers and barriers of the collaboration are specified.

Key words: *innovation system, dairy farms, dairy processing*
JEL classification: O31, Q13, Q16

1. INTRODUCTION

The Czech dairy value chain has experienced rather gradual structural change. Clearly, these changes has been induced by political-economic reforms of the 1990s and by the accession to the EU the common market and the agricultural and food safety policies. The dairy sector (farms and industry) has managed to adjust production and market structures and has maintained self-sufficient at all the levels of the value chain. However, this rather smooth development is to large extent due to the considerable governmental (national, the EU) support to farming and partly also to the processors. For years, the governmental intervention provided pillow for rather soft budgeting of farms with dairy production (MoA, 2011). Dairy producers and processors got preferences in the modernization programmes. A new CAP is coming into being. The post 2014 policy will contain a range of liberal elements pushing the EU agriculture further towards the market oriented business. At the same time the policy shows a high level of responsibility for global sustainable developments and natural resources maintenance. In this context a mobilisation of research, knowledge transfer and innovation became one of the priority areas 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.

The objective of the paper is to examine the current level of innovation activities and knowledge transfer in the dairy value chain in the Czech Republic and the role of the structural changes in it in order to assess the potential for enhancing sustainable dairy production. A particular attention is given to the collaboration with R&D organisations and other important agents.

The paper is organised into 7 parts. After a brief literature review in the next section we specify the methodology and data. In section 4 we briefly introduce the Czech dairy sectors performance. Some innovation statistics is presented in section 5. The core of the paper are case study stories in section 6. We sum up our findings in section 7.

2. THEORETICAL BACKGROUND

In the recent literature, the innovation system is understood as 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, Dargan & Shucksmith, 2008). In spite of the identical underlying social learning principle, 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). The 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". 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. The vertical effect is emphasized by Hall (2002) arguing that the system of innovation process is defined as a network of agents interacting to design, encourage, assist and implement innovations on various levels of the network. Le-Gal et al. (2011) identifies main actors in the innovation system besides of farmers and research organisations also policy-makers, agro-industries and facilitating organisations and services.

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-Oliver et al. (2012) 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.

The innovations at the farm level are peculiar in several respects: (i) the businesses are relatively small,; (ii) the technology must respect natural conditions, (iii) there are high interactions with natural resources; and (iv) there are traditions in the way of farming and the innovations must respect it to some degree. Bellon et. al (2007) point out that the innovations at farm level often entail reshaping of the production system by their implementation. In this context Le-Gal et al. (2011) argues that it is risky, time-consuming, and costly for farmers to individually test such innovations on their own through a trial and error process. In order to identify methodological guidelines for researchers involved in the process of supporting farmers in innovations, Le-Gal et al. (2011) classify the categories of activities how do research stakeholders address the design of innovative agricultural production systems at the farm level. The assistance may consist of either (a) the direct design of the innovation by proposing systems tested in experimental farms (prototyping methods) or assessing the value of innovation conceived to solve (modelling methods), or (b) the design support, which cover mainly identifying the main issues, providing data to be entered into the models, defining the structure and content of the models or experiments and implementing and evaluating the innovative systems. From (ii) to (iv) above, it is evident that tacit knowledge might be absolutely critical for the

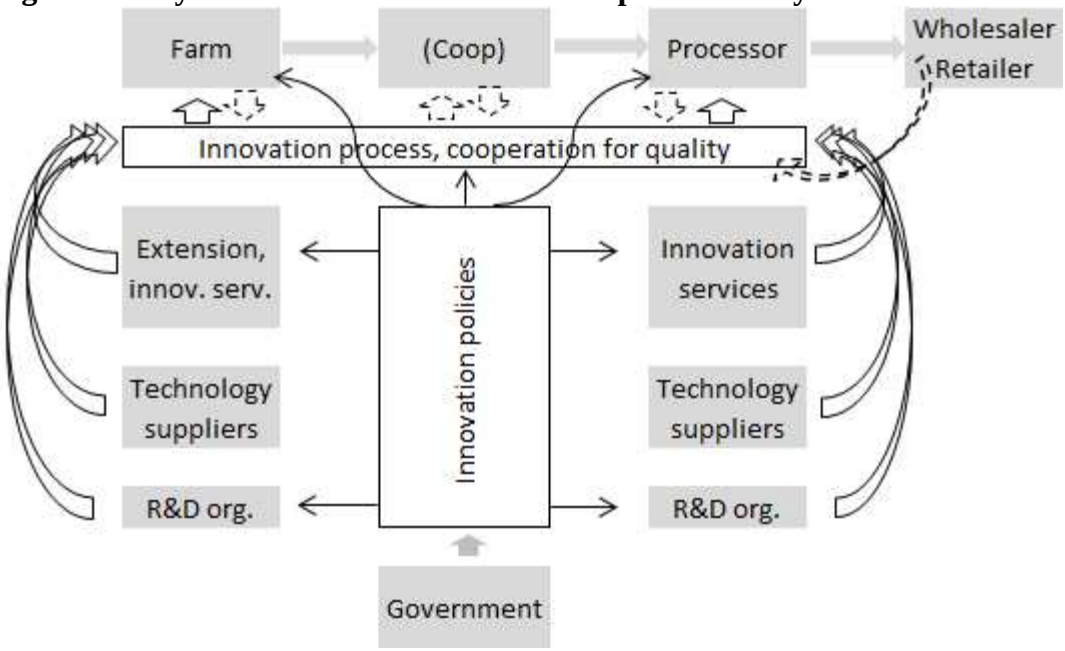
technological improvement at farm level. Thus the assistance will rather comprise both (a) and (b) in the proportion of the importance of tacit knowledge. Note that the same holds for food processing whenever the product is traditional or locally specific.

Following the global challenges of sustainable food production, the innovation system should relate to the agri-food vertical, should not aim entirely at high productivity. In such an innovation system down- and up-stream agents collaborate among each to others and with the research in order to integrate use of renewable resources, biodiversity conservation and other environment-friendly proceedings into production, marketing and consumption (e.g. Bogetoft (2005), Doré et al., 2011; Keating et. al., 2010).

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).

Figure 1 Dairy value chain and the innovation process: analytical scheme



Source: own scheme

In order to handle the challenges of the Czech dairy sector we perceive the innovation system as a part of the dairy value chain where downstream agents affect the upstream performance and the other way around (Figure 1). We consider four levels of the dairy value chain: farmers, farmers' cooperatives, dairy processors and wholesalers/retailers. We included cooperatives of dairy farmers as a level, since we believe that they might have a specific role in the innovation process – special interest in marketing innovations and in innovations at farm level as they (coops) might represent a collective interest in improving quality of milk or logistic/costs of the milk deliveries. We do not aim at marketing strategies (innovations) of wholesalers and retailers, however we recognise that they

might initiate and contribute to the development of new products (including those which require guarantee of sources and production methods throughout the dairy value chain).

We consider three categories of external knowledge agents (extension and innovation services, technology suppliers, and R&D organisations). These agents are likely industry specific (farm level, processing level). In addition we recognise the role of the government as an agent in the innovation arena; the government through its policies affects the external agents (typically by financing R&D organisations, extension services, innovation services), farmers and processors (by providing resources for financing innovations), and the innovation process itself (e.g. support to technological platforms, innovation networks, incubators, etc.).

Table 1 Research scope and sources of information

Industry (food, dairy)		Actors	Knowledge and technology	Institutions		CIS (only processors)	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 organisations								x	
	Technology suppliers									x
	Extension, innov. serv.									
	Interest groups								x	
	Market structure							x		
	Policies								x	x

Source: own scheme

Analysis is fed from five sources of information: Community Innovation Statistics, R&D statistics, business surveys, interviews with actors and literature. The use of 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[1]. 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)[2]. 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 the milk produced in the country in 2010 and 2008 respectively. In turn it means that the CIS samples have captured the most dominant dairy processors.

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

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.

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%[3] of economic subjects in the country; there are about 50 food processing enterprises of which 10 are dairies.

The information on market structure and productivity have been obtained from two business surveys: the Structural Business Statistics of the Eurostat[4] and Abertina[5], the statistics based on the obligatory published annual accounting reports of legal entities. Albertina includes about 70 dairy processors covering almost all processing of the Czech raw milk.

The statistical figures were supplemented by face to face interviews with various stakeholders in the innovation system. We interviewed 5 rather large dairy producers (200-600 cows), 5 dairy plants across sizes, of 4 national and 1 foreign owners. In all producer cases we chose dynamic companies in terms of production expansion and ownership changes incl. acquisitions. Further, we talked to 2 livestock research institutes (The Institute of Animal Physiology and Genetics, The Research Institute of Animal Production), to 2 research organisations of milk processing (The department of milk, fat and cosmetics of the Institute of Chemical Technology /university/, ICT, and the Dairy Research Institute) and to a supplier of dairy farm technology. We also discussed innovation issues with 4 dairy marketing cooperatives and two rather interest organisations of dairy processors, which nevertheless include as members several technology suppliers.

4. THE CZECH DAIRY CHAIN

Dimension of the sector

The milk production past through a dramatic adjustment period in the 1990s, however, it stabilised before the EU accession at the level of approximately 2.5 billion litres of raw milk annually. It is still about 15-20% above the domestic consumption of milk products. Nevertheless, the quota has not been fulfilled since 2007. Joining the EU market resulted in more trade; more precisely, some of 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 rather low competitiveness of the Czech milk processing industry. Ratinger & Boskova (2013) based on interviews with dairy cooperatives argue that it was terms of contracts rather than price what turned milk deliveries to Germany.

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 slightly more than a half of the purchased raw milk is processed into high value products.

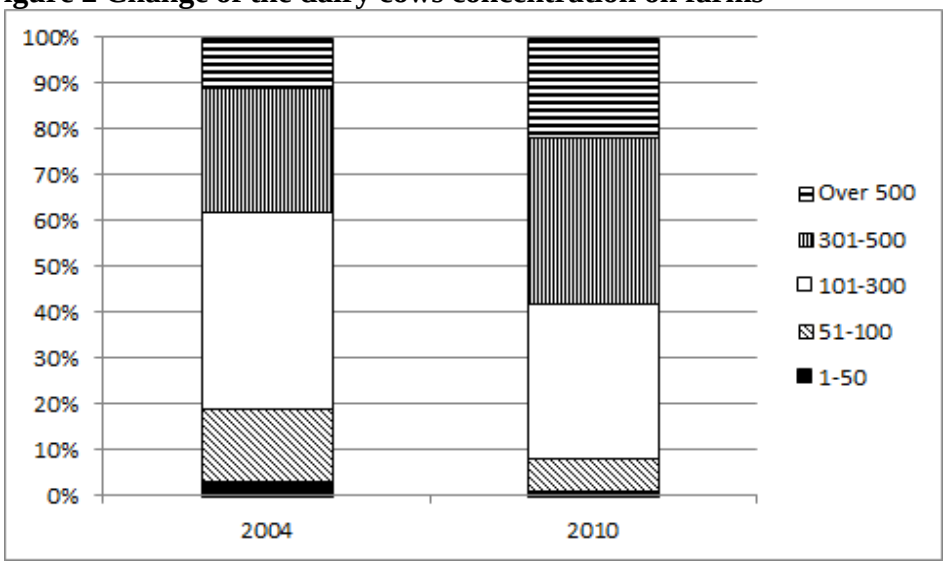
Sector performance and structure

The dairy herd has undergone a remarkable process of concentration. According to the milk yield records (Kvapilík, 2011), which cover around 95 % of dairy cows in the country, the number of

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

dairy farms under the milk yield control decreased from 4 224 in 2000 to 1 593 in 2011, which in turn means a reduction by 62 %.

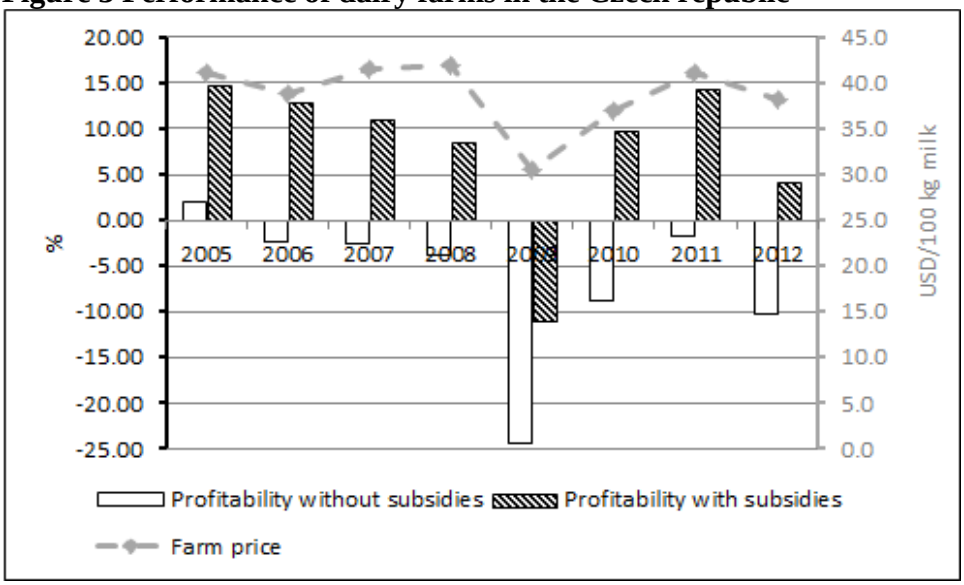
Figure 2 Change of the dairy cows concentration on farms



Source: Kvapilík (2011)

At the same time the concentration of dairy cows increased remarkably; there was 60 percent of dairy cows on farms with less than 300 heads in 2004 and it turned around within 7 years with 60 percent dairy cows in herds of more than 300 heads (Figure 2). Farms with less than 50 heads almost disappeared. This trend refers to the dramatic adjustment process of the primary production to the market, in which only the most competitive farms could survive. The problem of competitiveness is illustrated in Figure 3.

Figure 3 Performance of dairy farms in the Czech republic



Source: Cost survey, UZEI (2013)

The cost survey of dairy farms[6] shows that without subsidies dairy production will be unprofitable. Subsidies turn it in highly positive figures, nevertheless, it is clear that price shocks can

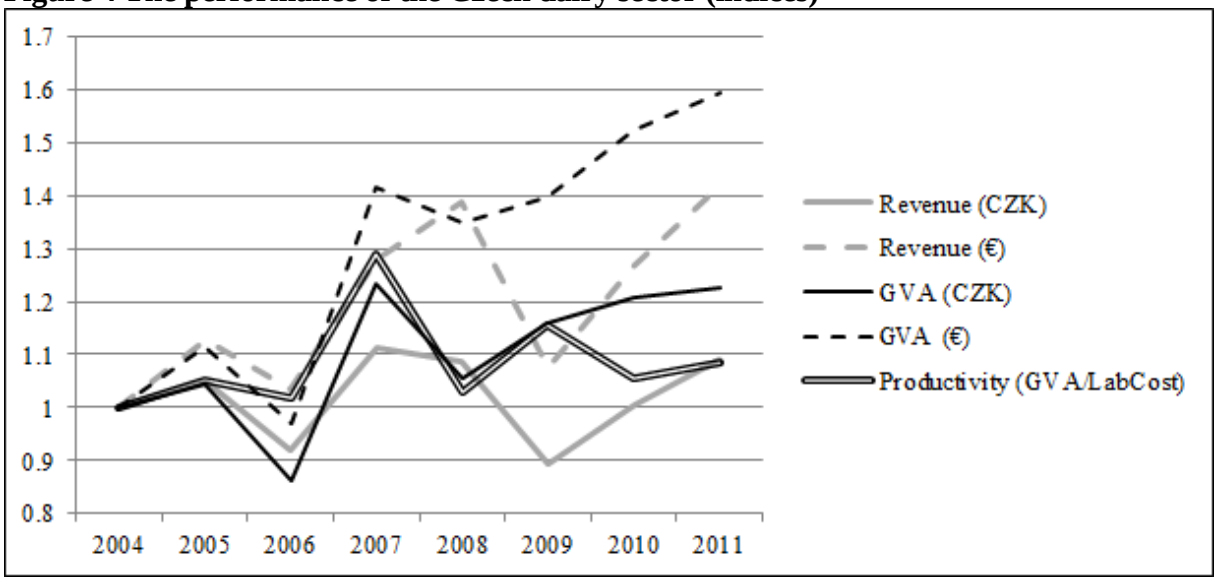
[6] The annual cost survey is done the Institute of Agricultural Economics and Information (UZEI) on the sample of about 200 farms with significant dairy production.

even stress the profit including subsidies to zero or even in red figures. It is also evident that costs (high input prices) can significantly reduce profit.

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

In Figure 4 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 4 The performance of the Czech dairy sector (indices)



Source: Albertina database, own calculations

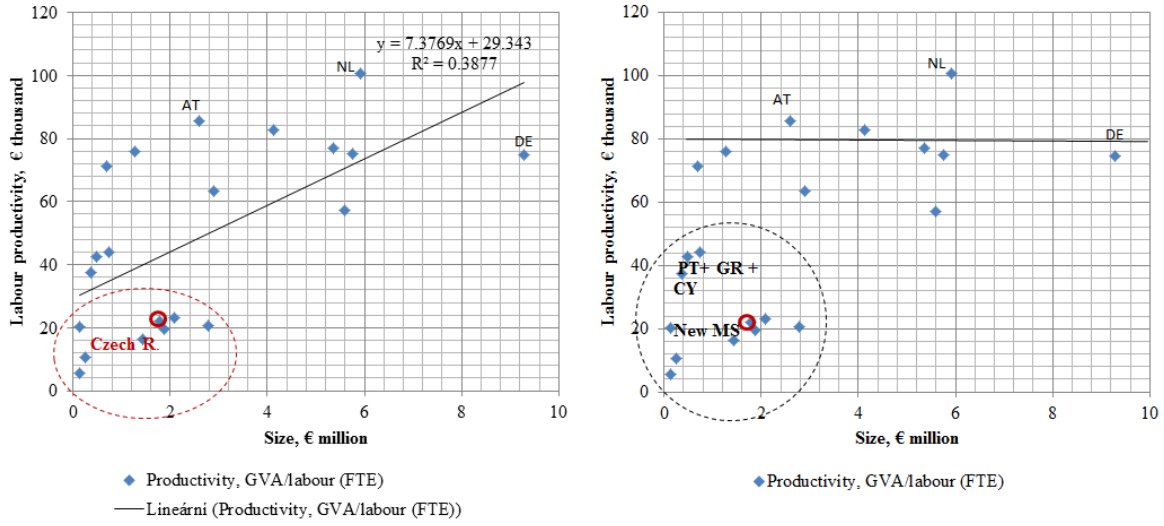
The five largest companies accounted for 50% of the sector revenue in 2010. These five largest companies include two domestically owned and three foreign companies. There were seven companies having at least 5% share on the sector revenue; they represented 63% of the dairy product sales. It can be showed that the productivity (GVA/labour costs) 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 5, the left chart, 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-Oliver et al., 2012).

We can however see the chart from the other angle too. We can distinguish a group of countries in the low left corner (the right chart in Figure 5) which consists of New Member States, Greece and Portugal, thus countries with some structural and institutional difficulties. If we separate this group, the rest of countries will not exhibit productivity gains due to scale. We still can assert that high productivity is due to intensive research and innovation activities, but we can hypothesize that these depend more on the institutional framework and the overall business environment including the access to financial means than on the size.

Figure 5 The size and productivity of the European dairy processing sector.



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

Innovation policies

There are four categories of policies supporting innovations in the agri-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)[7]. The National Agency for Agricultural Research (NAZV) supervised by the Ministry of Agriculture provides principal support to applied research in the area of main agricultural commodities (sub-sector) including the dairy one. The Czech Technology Agency (Ministry of Education and Sport) would finance applied research also in the food sector if it fits to one of its priority areas, particularly "the development of bio-technologies". Research organisations as well as firms can apply for projects EU framework programme; the Czech participation in the dairy (dairy related) research is, however, 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 and short of

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

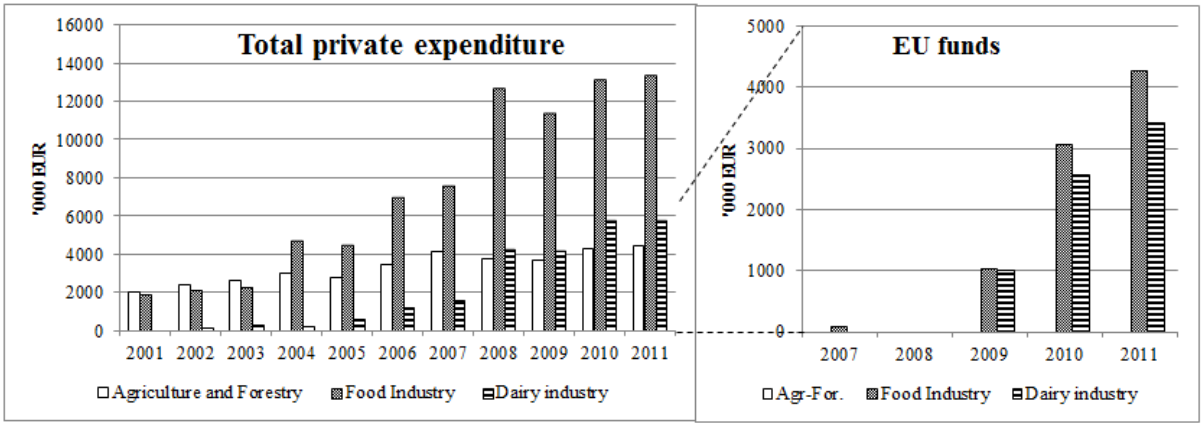
funds. The objective of Measure 124 of the Rural Development Programme[8] (RDP) is to support directly innovation process in agriculture and food industry. The programme requires collaboration between farms or food processing firms and research organisations (min. research outlays of CZK 1 million, i.e. € 40 thousands). Undoubtedly, measure 121 of RDP providing investment support to "Modernisation of agricultural holdings" contributes to the implementation of new technologies on dairy farms. Actually, "modernisation of dairy farms" as well as "innovations of milk processing" gets preferential treatment in RDP. 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.

5. SOME INNOVATION STATISTICS

Research spending

According to the R&D survey (Frascati Manual), the funding of agricultural sciences increased by 30% in real terms[9] between 2001 and 2011. It is about 3% annually. This increase is mainly due to growing expenditures of universities, while governmental outlays and private investment in agricultural R&D stayed more or less the same. It is rather moderate increase if we compare it with natural sciences which funds doubled in the same period. There is not a special category of food sciences, food research is included partly in agricultural sciences, natural sciences, medical and health sciences, and also in engineering and technology. Also the funds of the latter two doubled over 2001-2011.

Figure 6 Private sector R&D expenditure



Source: R&D statistics, CzSO (2013)

Private research activity is shown in Figure 6. There are some increases in expenditure of agricultural and forestry firms, but these can rather be accounted to the exchange rate development (i.e. stagnating in Czech crowns). Expenses of food industry on research increased gradually since the EU accession in 2004. Some of the improvements can be accounted to the innovation support measure (M124) of the Rural Development Programme (RDP), which claimed involvement of research organisations in the innovation-investment projects. The financing of private research from the EU

[8] http://eagri.cz/public/web/file/61102/prv_zmeny_cerven2010_web.pdf
[9] Using the GDP deflator

funds (the right chart in Figure 6) increased rapidly from almost zero in 2008 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 (on average 83%). This was reflected also in the adjustment of the capacity in the milk processing firms. 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.

However, we can deduce rather problematic additionality of the innovation support measure (M124 of RDP) from Figure 6. In 2009, the share of EU funding on total dairy industry R&D expenses was 24% in 2010 it was 44% and in 2011 it was already almost 60%. The figures are alarming if we take into account that the total R&D expense stagnated in this period.

Innovation statistics

Agriculture is not included in the Czech innovation survey (CIS, Oslo manual). Therefore, we concentrate on dairy processing industry in the comparison to food industry. Innovation activities are more intensive (in terms of a higher participation rate) in the dairy processing than in the food industry on average in all surveyed areas (Table 2). The most frequent innovation activities in the dairy sector are introduction of innovations in the market new design of products, investment in the machinery and equipment and internal research. Investment in machinery and equipment constitutes also about of a half of the innovation costs. Also the dynamics is higher in the dairy sector. It concerns particularly, external and internal research, and training/education which participation rate tripled in the dairy processing sector, while these increased by only 30 to 70 % on average of the whole food industry. The spending on machinery and equipment tripled too. The cost of internal research increased proportionally and stayed at 8% of the investment costs. The cost of external research increased from zero in 2003 to 3% of the innovation costs (i.e. roughly1.5% of the total innovation costs).

Table 2 Innovation activities

	2003		*2005*		*2010*	
Innovation activities	*F*	*D*	*F*	*D*	*F*	*D*
Investment in machinery and equipment	20%	32%	32%	41%	36%	65%
Introduction of innovations in the market	17%	44%	21%	59%	22%	76%
Provision of other external knowledge	7%	12%	10%	14%	10%	12%
Design	13%	40%	22%	36%	24%	65%
External research	9%	12%	12%	27%	18%	35%
Internal research	25%	28%	24%	45%	31%	76%
Training and education	17%	20%	20%	36%	25%	59%

Source: CIS survey, own elaboration

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%.

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 3. 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 which do not use the respective techniques.

Table 3 Capacity for innovation techniques and outsourcing of the dairy firms in 2010

	Skills	Design	Engineering/ applied sciences	Graphics	Multimedia	Market research	Mathematics/ statistics	Software development	Development of web pages
All	in the firm	0%	18%	6%	0%	24%	35%	12%	24%
	outsourced	76%	29%	82%	71%	53%	18%	59%	65%
SME	in the firm	0%	0%	10%	0%	40%	20%	10%	40%
	outsourced	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

The dairy processing firms outsource innovation techniques 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 low uptake of "external engineering/ applied sciences" might well indicate insufficient supply of the service. There is no substantial difference between the whole dairy sample and the subsample of SMEs.

The CIS gathers opinions of firms on barriers to innovations. The set of predefined barriers and their ranking is reported in Table 4. The respondents marked the importance a barrier on the four point scale, we calculated averages over answering firms and those we ranked. It is obvious from Table 4 that there are not essential differences in ranking between the dairy sector and food industry as whole. Also SMEs 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, as we will discuss it later.

Table 4 Innovation barriers in dairy processing firms (Average rank, 1= most important)

Barriers	*2003*	*2005*	*2008*	*2010*	*Barriers*	*2003*	*2005*	*2008*	*2010*
Too high innovation costs	1	1.5	2	2.5	Difficulties to find a cooperating partner	0	9	11	9
Insufficient financial resources	2	3.5	4	1	Uncertain demand for innovated product	3	1.5	3	4
Insufficient access to external financial sources	0	5	5	5.5	The market controlled by dominant firms	0	0	1	2.5
Lack of qualified staff	5	6	6	8	No need for innovations due to earlier innovations	8	10	10	11
Lack of information on technologies	5	8	8.5	7	Innovations are not demanded	7	3.5	7	10
Insufficient information about markets	5	7	8.5	5.5					

Source: CIS, own calculations

6. STORIES (CASE STUDIES)

In this section we concentrate on three issues in the innovation process: (i) motivation, (ii) inspiration for setting up the innovation idea and (iii) support which gets the innovator from its environment.

Milk production and processing is typically conditioned by high inputs of technical and technological equipment and the question of sustaining the business is highly related to keeping the technological progress in the sector. It is to emphasize that introducing new equipment does usually affect production methods and many times does influence production system and farm/firm organization. In this context and in accordance with Bellon (2007), the area for innovation at farm and processing levels rests in addition to technical solutions and technological equipment, also in organizational and institutional (new roles) changes often involving the down- and upstream actors.

The introduction of modern technologies at farm level is associated with concentration of cows in large herd, and the reorganisation of the production process including the management of feed stocks, labour and milk deliveries. We conducted five interviews (case studies) on farm level innovations (Table 5).

F1 Using heat from milk cooling: the farm (600 cows) wanted to shift form daily collection of milk to two day regime. It required investing in much larger milk tank and also cooling milk to lower temperature. The management learned from internet that there are systems which allow recovering the heat released during cooling for warming up water for wash-up and sanitizing operations in the milking area. It would reduce energy costs significantly. They selected one from domestic and foreign suppliers and implemented the heat recovery systems within few months. The farm did not apply for any financial support. The leader of the innovation was the livestock manager who exhibited good orientation in technologies and capacity to cooperate with technicians.

F2 Improving cheese quality: The farm was one of few which utilised the Measure 142 of RDP supporting innovation on agricultural holdings. The farm was motivated to apply for the measure as an easier way to get funds for the renovation of the cheese processing unit. They were also pushed by customers (restaurants) to improve the product mixed cow-sheep cheese in two respects: stabilizing taste and consistence characteristics throughout the year and making it suitable for grilling/cooking. In both qualitative respects, their internal knowledge was insufficient for resolving the challenges. However, they had no experience with and thus little trust to research organisations. Actually, the support measure forced that farm to involve research in the innovation-investment project. The chosen research organisation had little experience with cheese production, however, the researches knew a lot about the milk proteins. Both sides gradually and mutually learned how to collaborate for the benefit of both sides. This collaboration resulted not only in improved cheese quality, in addition they enhanced marketing (branding) which among others built on the proudness of both parties (innovator – research/extension) for the quality product. These improvements resulted in doubling the sales within a year.

F3 Improving milk yield: The innovation concerned the modernisation of the dairy unit in an agricultural cooperative (later converted in a joint stock company). It included: renovation of two cowsheds each for 200 cows and construction of a new cow shed for 200 cows, with the air-cooling equipment for improving welfare of cows in the summer, a new milking unit, a slurry separation unit and finally a truck mixer for feed. They were introduced gradually between 2004 and 2010 with assistance of the Operational Programme for Agriculture (2004-2006) and the national Support and Guarantee Fund for Agriculture and Forestry (PGRLF).

The challenge was to improve milk yield and the economy of milk production. The management decided for innovative modernisation aimed at the above-standard economy of milk production and high standard of animal welfare and environmental management (slurry). The inspiration came from the other farm enterprise –the intensive turkey production which got knowledge and technology support of input suppliers (of chicken and feed). The farm management learned how critical is controlling feeding, health and air conditioning (ventilation, temperature) of turkeys for achieving profit. The access to scientific knowledge through the network and its mobilisation in practice was essential for the success of the turkey production. This concern of "controlling" quality of feed, feed supply and air conditioning was transmitted to the dairy cow production. The yields went up and costs dropped, The farm belongs to the farms with the highest milk yield in the country.

F4 and F5 are both typical examples of the concentration process: farms for cost an labour reasons decided to concentrate all dairy production in one spot and one cow shed.

F4 mountain dairy farm: The farm had continued the binding cow sheds in two medium size dairy unit (100 cows) for long time. The choice was to improve milk economy and continue or to quit, also in the context of outmigration of young labour from the area. The management decided finally to concentrate dairy production in one unit and expand it (up to 300 cows). The decision was supported by consultations (visits to) other farms in their network. The management was not fully happy with the proposal of the technology supplier: the proposal did not take sufficiently in to account the severity of winter in the area (a need for a firmer cow shed construction to bear a high load of snow, higher capacity of milk tank to cover the delays of milk collection etc.). Also there was a requirement for designing the shed in the way that milking automats can be installed if the labour problem arises. Therefore the farm management hired an experienced consultant which helped to correct the project.

The farm (innovator) struggled to make the project as it liked, as it suited to its needs. The services entered the process on the contract of the farm but there was no collaborative spirit among all participants in the innovation process.

F5 lowland dairy farm: The idea was to improve performance by upgrading the technology (the dairy units of 170 heads each were already modernised 15 year ago) and by concentrating the dairy production in one unit and also expanding it to 370 heads. Also here it was not easy to negotiate with the technology supplier the design of the project to the needs and experience of the farm; it resulted in moving the project preparation from the technology supplier to an independent construction office.

The innovations were initiated by farmers (members of farm management) and mostly related to improving competitiveness of the dairy production. In all cases, the innovation rested in the improvement of the process, in four cases in lowering costs, in one case the innovation resulted in higher price and thus increased sales. In most cases, the network of farms was used to see the technology options and to gather experience of users. Some ideas came from the visit abroad (in Austria: farmers could see innovation of products and technologies like a wide range of cheese varieties clearly departing from the traditional products, heating cheese in whey for getting thermic properties of the cheese, etc.). The interview with the manager of one of the dairy farm technology suppliers confirms increasing capacity farmers to manage innovation processes (initiate and control them). From the case studies it is clear that farmers utilise their information from literature, media/internet and social networks and combine them with their own experiences already gathered in current technology led farming.

The direct relationships with customers (down-stream cooperation) allowed transmission of the problem with variable properties of the product-cheese or the demand for cheese suitable for grilling. In the other cases, the customers (downstream actors) played no role.

Table 5 Innovation cycle at farm level

#	Case study, innovation project	Innovation cycle						
		Decision	Selection from the innovation options	Technical projecting	Assessing implications for farm management	Economic impacts evaluation ex ante	Implementation	Economic impacts evaluation ex post
F1	Utilization of heat from milk cooling	I,M	I,N	T	I	I	T	I
F2	Improving cheese quality.	I,D	I	R	I	I,R	I,R	I
F3	Improving milk yield	I	I,T	I,T	I	I	I	I
F4	Herd concentration, mountain region	I, N	I,N	T,C	I,C	I	I,C	I
F5	Herd concentration, lowlands	I	I,N	T,C	I	I	I	I

Internal knowledge	I		
External knowledge collaboration			
Media (internet, journals)	M	Private consultancies	C
Down- or up- stream businesses	D	R&D ordanisatons	R
Farmer's social (professional) network	N	Governmental extension servi	G
Technology suppliers	T		

Source: own elaboration

Most innovations at processing level are motivated by enhancing dairy firm competitiveness. The currently leading innovations aim at extending shelf-life of fresh products without conservation additives. It includes increasing hygienic standards in the production process, new technologies (quick heating) aseptic packaging etc. Product innovations become standard marketing strategy of dairy firms. It includes improvements of taste characteristics of established products (i.e. keeping products the customers are used to buy with new characteristics). Only foreign own companies are introducing really new products in the Czech market. Improving dairy product characteristics or stabilizing them Concerning processes innovations they aim at gently treatment of milk which protect physical structure of milk particularly important for cheese making and at improving efficiency (lowering costs, energy and water consumption). 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.)

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.

Only one interviewed dairy processor has its own research unit; all rely on external research services. The cooperation is however underdeveloped. 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 ICT business scope).

Figure 7 Characteristics of interviewed dairy processors

		Product innovation	Process innovation	Marketing Innovation	Environemntal innovation	Innovation initiation	Own research staff	Collaboration with research organisations	Use of specialised technological services
P1	Large, domestic and export markets	x	x		?	T, I	x	x	x
P2	Large, export and domestic market, specialised in mature cheese	x	x	x	?	I			x
P3	Large, domestic market	x	x		?	T, I		x	x
P4	Medium, domestic market, fresh cheese	x	x		?	T, I		x	x
P5	Small, domestic market, young cheese	x	x		x	T, I		x	x

Product innovation	New milk product, new design, improved taste, improved shelflife/durability
Process innovation	More gentle milk processing, reducing wastes, lowering costs (improving energy efficiency)
Marketing innovation	New marketing methods: addressing environmental concerns of customers, concentration on local customers (implcations for
Environmental innovation	Separation of water and other substances, water recycling

I internal knowledge T technology suppliers x/ ? indicated/ intended

Source: own elaboration

A very specific case represents the mature cheese (high quality cheese) maker. Their innovations do not include research directly. Codified external knowledge largely available is combined with tacit knowledge (from the family business and the experienced staff) and the trial and error approach. Clearly, industrial technology of processing is up-to-date and technology services are

involved. Here, tacit knowledge plays essential role, in the other cases tacit knowledge is definitely used but in much smaller proportion to the codified knowledge. From the interviews with the processor P1 and P5, it is however clear that Czech firms increasingly gather experience transposing it in tacit knowledge reflected in their ways of milk processing, their characteristic products etc. It however, very likely creates new demands, requirements for research services (dairy processing firms know what they wish to achieve (in terms of product parameters) and what a service they need. 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.

Another peculiarity of the interviewed processor P2 is its innovative marketing. The firm profiles its production as an eco-sustainable supply chain certified according to UNI EN ISO 22005:2008. The marketing strategy aims at attracting increasing environmental concerns of customers in some European regions (and not in the Czech Republic) while beating the Italian competitors for their overuse of land and water.

An alternative marketing innovation represents the P4 processor. Its marketing strategy builds on customer loyalty to young Edamer cheese – typical chees of the communist market. The cheese has been improved in many respects, new additives (paprika, green pepper), stable taste, colour and consistency and modifications to Gouda and Ementaler cheese. The new customer loyalty is to be established on the base of regional product. In contrast to other regional products, the price is kept relatively low and the cheese will be largely available in dense local/regional network of company shops (it is a common product for local people). The reluctance to move toward higher quality cheese, particularly semi-mature and mature sorts can also be observed by the processor P3 too.

The environmentally oriented marketing approach of the processor P2 requires involvement of farmers who all should keep their practices under the above ISO norm. Here it is worth to stress that it goes beyond the milk marketing cooperative of which most of the farmers are members. It is basically because the Czech marketing cooperatives still exhibit the adherence to the bargain power objectives, although they have already grown stronger. Ratinger and Boskova (2013) observe that there is little attention paid by the milk marketing cooperatives to what is produced from delivered milk in terms “if the production programme has future or not”. According Ratinger and Boskova (2013) milk marketing cooperative made some bad experience with penetrating milk processing industry and at the moment they completely withdraw any activity in this direction (incl. facilitating the technological and strategic connection between farmers and processors).

7. CONCLUSIONS

The above analysis indicated increasing dynamics in the innovation process in the Czech dairy supply chain. 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 sector) see technological capabilities (advances) as an enabler rather than a driver of their performance.

We could observe learning on the side of farmers and dairy processors. Both, farms as well as processors invest in education of the staff, workers and often use EU funds for it. Companies with trained staff (in some cases 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 dairy farmers and processors. The low level cooperation concerns not only research institution but also other companies in the value chain. It is evident that farmers and processors are in their innovation activities disconnected and this disconnection take place also within the agro-food holdings. The innovation process is atomised, each farm or firm does its own innovations (adoption of technology). The diffusion through loose networks is slow. The lack of cooperation among processors 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, moreover the technology is rarely protected by patents or utility models and thus it spreads quickly among milk processors anyhow.

The problem with property rights protection (free riding) is likely one of the factors why the private sector (dairy farms and processors) is reluctant to invest in research conducted by external research organisations. However, transfer of knowledge is essential for the sector economic success. The interest organisations, marketing cooperatives, professional associations are not involved in the innovation system. Thus learning is concentrated in individuals while there are no functional structures to concentrate social learning which is so essential for the performance of the innovation system.

No doubts, there is a role for policies in encouraging cooperation among actors. It should however start with understanding which structures and networks are functional and what makes them functional. The effects can hardly be achieved with encouraging new formal structures which nobody trust.

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