International comparison of product supply chains in the agri-food sector:
determinants of their competitiveness and performance on EU and international markets

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Innovation in agro-food supply chains – The EU policy context

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Abstract

This report provides insights into the definition of innovation and specifically how policies affect knowledge creation and innovation in agro-food supply chains (D9.1a, objective 1), considering innovation as a key determinant for competitiveness. The innovation system – rather than the linear model of innovation – will be central to our discussion. The first part of the report focuses on innovation systems. It discusses basic definitions of innovation, the relationship between innovation and competitiveness and the measurement of innovation. These three topics are discussed both in general terms and with specific reference to the agr0-food sector. Next, the report provides a conceptual framework based on the National Innovation Systems approach with reference to the agro-food sector. The second part of the report focuses on the role of policies and provides insights into the main policies set at the European level that affect research and innovation in the agro-food domain.

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1 Introduction

Owing to advances in technologies and greater flows of information, knowledge is more and more viewed as a central driver of economic growth and productivity (OECD, 2005). As a result, there is a new focus on the role of information, technology and learning in stimulating economic performance and it is recognised that knowledge and learning are key to competitiveness for firms, regions and countries (Tödtling and Trippl, 2005). The “knowledge based economy” stems from this fuller recognition of the place of knowledge and technology in modern OECD economies (OECD, 1996), and is an expression coined to describe trends in advanced economies towards greater dependence of businesses and public sectors on knowledge, information and high skill levels. The knowledge-based economy focuses on the interactive process through which knowledge is created and exchanged both within and outside firms and other organisations. Notwithstanding, it is still debated how knowledge and access to information affect innovation (OECD, 2005).

In the knowledge-based economy, innovation is driven by the interaction of producers and users in the exchange of both codified and tacit knowledge. The former is transmitted through computer and communication networks in the emerging information society, the latter includes the skills to use and adapt codified knowledge, which underlines the importance of continuous learning by individuals and firms (OECD, 1996). This interactive model has replaced the traditional linear model of innovation. The configuration of national innovation systems, which consist of the flows and relationships among industry, government and academia in the development of science and technology, is an important economic determinant.

This report provides insights into the definition of innovation and specifically how policies affect knowledge creation and innovation in agro-food supply chains (D9.1a, objective 1), considering innovation as a key determinant for competitiveness (WP9). The innovation system – rather than the linear model of innovation – will be central to our discussion. The first part of the report focuses on innovation systems. It discusses some basic definitions of innovation, the relationship between innovation and competitiveness and the measurement of innovation. These three topics are discussed both in general terms and with specific reference to the agro-food sector. Next, the report depicts the conceptual framework based on National Innovation Systems thinking with reference to the agro-food sector. The second part of the report focuses on the role of policies and provides insights into the main policies set at the European level that affect research and innovation in the agricultural domain.

Appendix A1 presents the evolution over time of the perspective on innovation in the policy domain.

Part I. Innovation systems

2 Definition of innovation

2.1 Innovation according to the OECD

According to (OECD, 2005, p. 46), innovation is the implementation [i.e. the introduction on the market and the consequent actual economic use] of a new [to the firm] or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. Innovation activities are then all scientific, technological, organisational, financial and commercial steps which actually lead to, or are intended to lead to, the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation (OECD, 2005, p. 47). This broader OECD definition will be applied throughout this report.

When it comes to defining innovation, the most common and well established definitions regard exclusively process and product innovations. A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics (OECD, 2005, p. 48). A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software (OECD, 2005, p. 49).

New information and new approaches to collecting data suggest the emergence and relevance of extending this narrow definition of innovations to include also marketing and organisational innovations (OECD, 2005).

First, a marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing (OECD, 2005, p. 49):

- Product design: e.g. changes in product form and appearance, taste and flavour of food and beverage products;
- Product placement: e.g. new sales channels such as franchising or exclusive retailing;
- Product promotion: e.g. different media, techniques, personalized information systems;
- Pricing: e.g. pricing strategies following the products' demand.

Marketing innovations can improve the success of new products as well as market research, and contacts with customers can play a crucial role in product and process development through demand-led innovation.

Second, an organisational innovation includes the implementation of a new organisational method in a firm's business practices, workplace organisation or external relations (OECD, 2005, p.51). Organisational innovations not only support product and process innovations, they can also have a crucial direct impact on a firm's performance: they can improve the quality and efficiency of work, enhance the exchange of information, improve the firm's ability to learn and utilize new knowledge and technologies.

The inclusion of marketing and organisational innovations creates a more complete framework to analyse innovation, one that is better able to capture the changes affecting firms' performance and contribute to the accumulation of knowledge (OECD, 2005). The addition of marketing and organisational innovations along with the use of a broad definition of innovation that includes activities to both develop and adopt innovations, means that a larger share of firms is likely to meet the basic requirement for being "innovative". Methods and studies are therefore needed for identifying different types of innovative firms, based on the type of innovation they have implemented and on the firms' innovative capabilities and activities. Box 1 provides an overview of how innovation has featured in the main disciplinary approaches over the last centuries.

Other relevant distinctions concerning the concept of innovation are put forward by (Grunert et al., 1997) and (Slocum and Rubin, 2008). They stress for instance the difference between innovation and innovativeness. The latter is conceived as characterising a company as a whole, while the former relates to a specific product, process or organisational aspect within a company. Furthermore, innovations may be more or less fundamental. This is often captured in the distinction between radical (or revolutionary), versus incremental (or evolutionary) innovations. Although recognized at least since Schumpeter, researchers have tended to draw upon a wide range of terminology to describe whether an innovation is presumed radical or incremental. Radical innovation has been generally characterized as both the result from a stroke of individual genius or luck, or conversely, as a lengthy, complex, and highly uncertain process, fraught with barriers and difficulties (Slocum and Rubin, 2008). The concept relates to an innovation that could not have evolved through improvements to, and modifications of, the existing technology. Conversely, incremental innovations improve upon and extend existing technology, and are stimulated mainly by the need to lower costs or improve quality, design, performance and adaptability of a company. Adding to the distinction between radical vs. incremental innovations, some scholars distinguish between innovations that are: (1) new to the world, (2) new in the national context, or (3) new to the firm (Nielsen, 2008).

Box 1. Different disciplinary approaches to innovation

Research on innovation spans a number of disciplines, with economic approaches alone adopting several different theoretical perspectives (OECD, 2005). These theories address a number of issues, such as why a firm innovates, what forces drive innovation and which factor hinders it. The work of Schumpeter, with his theory on the dynamic process in which new technologies replace the old, i.e. creative destruction, gives insights on why firms innovate. Innovation in this theory is more a business strategy, a market experiment. Industrial organisation theory emphasises instead the significance of competitive positioning. Organisational innovation theory focuses on the role of organisational structures, learning processes and adaptation to changes in technology and the environment. Marketing theories focus on consumer behaviour, market exchanges between sellers and buyers and normative approaches. Theories of diffusion focus on diffusion as a process involving not only the mere adoption of innovation and technology, but rather as learning from and build on new knowledge and technology. Sociological views on the diffusion of new technologies highlight the relevance of firms' attributes as influencing their decisions to adopt new knowledge and technologies. Evolutionary approaches view innovation as a path dependent process whereby knowledge and technology are developed through interaction between various actors and other factors. The system innovation approach studies the influence of external institutions, broadly defined, on the innovative activity of firms and other actors, emphasising the importance of transferring and diffusing knowledge, ideas, skills, information and signals of many kinds. This latter approach is at the core of this report.

The firm has always played a central role in the innovation process[1], since it is also the place where decisions are made and inventiveness/creativity is turned into new products. However, this role has changed over time: differentiation and specialization have affected the innovation process, and more than in the past innovation has become the result both of organized interactions between formally independent firms (Dankbaar and Vissers, 2009) and of strategic options shaped and constrained by environmental factors, such as collaborative patterns, regulatory systems, customary practices etc. (Bergek et al., 2010). As a result the complexity of the innovation process has increased, requiring new organisational capabilities. Consequently, competitiveness is no longer a matter of prices (as in neoclassical economics thinking) but rather a matter of doing things differently: advancing new products and services, achieving new levels of productivity, creating new markets and uncovering latent needs.

2.2 Innovation in the agro-food sector

Innovation studies that focus on the primary sector in general and the agro-food in particular include relatively little empirical evidence (Christensen et al., 2008). With the aim of exploring to what extent innovation activities take place also in the agro-food sector and how this influences competitiveness, it becomes necessary to define innovation in this domain.

According to (Nielsen, 2008) and (Christensen et al., 2008), when defining innovation in the agro-food domain different dimensions should be dealt with. In addition to the types of innovations included in the OECD definition (product, process, market and organisational innovations), innovations in the agro-food sector also include new types of fodder, new feeding systems, new types of packaging, new types of conservation, new additives, new flavours, new consumer products introduced continuously on the market, and new types of logistics. Therefore, innovation in the agro-food sector is not necessarily easily incorporated in the traditional, manufacturing-oriented conceptual and empirical classification of innovation.

Furthermore, typical characteristics of agricultural and food products such as their nutritional benefits and perishability, have consequences for the focus in particular of product

[1] The role of firms gained relevance in Schumpeter's thinking (1939), albeit still in a view of a firm innovating in isolation.

innovation and organisational innovations. The quality of inputs from agriculture is crucial for food products, which makes vertical integration with farmers and sometimes also with breeding companies important for the innovation process (Grunert et al., 1997).

The innovation process itself differs greatly from sector to sector in terms of development, rate of technological change, linkages and access to knowledge, organisational structures and institutional factors. Also within the agro-food industry, differences among sectors reveal heterogeneity in the way innovation is adopted and used. Box 2 presents an experience realized in the framework of a current FP7 project in this direction.

Box 2. ICT as innovation stimulator in the food supply chain: an interesting experience

An interesting in-depth market analysis of the current use of ICT and eBusiness solutions in the agro-food supply chain has been recently realized within the EU eFoodChain project (eFoodChain, 2012). Covering different stakeholders in three agro-food sectors (fresh fruit and vegetables, dairy products and cereals) in 10 European countries, the project shows that there are significant differences between supply chains, companies and business practices in terms of ICT adoption and use. The cereals and the fresh fruits and vegetables industries seem to be well advanced, but the dairy industry appears less involved in the implementation of ICT solutions for business to business transactions. Moreover, a huge gap has been noted along the value chain (eFoodChain, 2012, p. 11). In general, the use of electronic data exchange seems very low at the producer level (and almost inexistent in some countries such as Portugal, Spain or Greece) while there is almost a full use at the retail level. However, even at the retail level the use of ICT is mostly limited to the exchange of financial information, whilst the exchange of logistics information is still very limited (eFoodChain, 2012, p. 11). The project shows that intervention is needed mainly in the upstream segments of the agro-food supply chain.

Lessons learned

Innovation is a complex concept; in the framework of the COMPETE project we will adopt the following statements as guiding light for the future activities:

- *Innovation is the implementation of a new product, process, marketing method, or organisational method;*
- *Innovation activities lead to the implementation of innovation;*
- *Innovation in the agri-food domain is not easily incorporated in the traditional, manufacturing-oriented conceptual and empirical classification of innovation*
- *The innovation process differs from sector to sector in terms of development, rate of technological change, linkages and access to knowledge, organisational structures and institutional factors.*

3 Drivers of innovation

3.1 Review of the general literature

Different theoretical as well as empirical studies have sought to investigate the drivers of innovation, explaining the speed and direction of the innovative processes, and to estimate the role played by internal and external factors in determining the propensity and intensity of firm innovation (Capitanio et al., 2009; Galende and de la Fuente, 2003).

Among the internal factors, attention has focused on firm size and firm experience (age), as well as some other organizational features linked to the management-property relationship and the structure of decision-making processes (Capitanio et al., 2009). For example, firm size is often indicated as a key-factor to explain the role of organizational complexity (i.e. bureaucracy), effort in R&D and market power (Acs, 2005; Arundel and Kabla, 1998; Bhattacharya, 2004; Bougheas, 2004; Bougrain and Haudeville, 2002; Galende and de la Fuente, 2003; Lee and Sung, 2005). Also firm age is highlighted as a key factor because it proxies companies' experience, know-how, accumulative processes and dynamicity (Kuemmerle, 1998; Molero and Buesa, 1996). A firm's innovation processes may depend also on external factors (Bougheas, 2004). These include market size and demand growth, which may represent an incentive to innovate (Dosi, 1991; Love and Roper, 1999). In process innovation, the total output of the firm can affect the average cost of research and of the investments in innovation; while new buyers can be captured by product innovation, thereby allowing the firm to increase its market share and its profits. Firm innovativeness is also related to the institutional conditions in which food firms operate (chain and network size). These external factors include the linkages in the market chains and concern the ability to enter formal networks (consortia, production-based associations, manufacturing joint-ventures, etc.) (Omta, 2005).

3.2 Drivers of innovation in the agro-food sector

As highlighted by (Capitanio et al., 2010), in the context of the agro-food sector the innovation pattern, at the firm level, is the result of factors that can be analysed according to two different perspectives. First, innovation can be studied as a process of development and change (Grunert et al., 1997; Teece, 1996). In this sense, the innovative process is directly influenced by the level of expenditure in R&D and by the way this activity is carried out (for example, by means of internal or external structures), and by the "technological" characteristics of the innovations, such as the degree of uncertainty related to their effectiveness and to market success, the level of tacitness of knowledge, the degree of appropriability of innovation, and the capacity to accumulate know-how within the organization (Christensen, 2008; Christensen and Lundvall, 2004).

Secondly, innovation can be analysed as the firm's ability to satisfy the needs and preferences of its potential customers, using its own resources, skills and capacities (Grunert et al., 1997; Traill and Meulenberg, 2002). In this sense, innovation is correlated to the market orientation of the firm and its marketing activities. In the food sector this approach to innovation is particularly important as it deals with the adoption of new technologies that allow firms to respond to higher quality standards, with new ways to present more traditional products, with product diversification, with new and different functions to be embodied in food products (Capitanio et al., 2010).

4 How to measure innovation

4.1 Review of the general literature

Although innovation has been studied extensively, there is no generally accepted way of measuring it. Innovation success is in fact a rather diffuse concept, operationalized in many different ways: innovation performance measurement typically differs according to the measures used (financial versus non-financial), the level of analysis (project or program performance) and, for research investigations, even the source of data (self, expert or peer assessment) and the data collection method (personal versus mail questionnaires) (Grunert et al., 1997).

OECD pioneered international efforts to develop innovation indicators: the publication of the *Frascati Manual* in 1963 set down a common methodology for collecting and analysing indicators on science, technology and innovation in OECD countries (OECD, 2005; Spielman and Birner, 2008). Throughout the years, OECD revised and updated these indicators and, with the *Science, Technology and Industry Scoreboard* (1981), provides country-level measures in the areas of R&D (e.g. trends in R&D expenditures, business R&D by size classes of firms and by industries, government R&D budgets); human resources in science and technology (e.g. flows of university graduates, international mobility of doctoral students, R&D personnel); intellectual property rights performance (e.g. patent intensity, patent applications to the EPO); information and communication technology infrastructure (e.g. investments in ICT equipment and software, ICT occupations and skills); knowledge flows embedded in trade and investments (e.g. international trade, intra-firm trade, foreign direct investment flows), and on regular basis also introducing new indicators to capture emerging trends at regional level. The *Oslo Manual* collects efforts to promote data collection more in line with the innovation system approach (OECD, 2005).

According to (OECD, 2005) there are two basic families of indicators for Science and Technology (S&T) relevant to measure innovation: resources devoted to R&D and patent statistics. In addition, several other indicators can be used, such as: bibliometrics or the number of scientific publications; publications in trade and technical journals; skilled human resources; technology balance of payments; globalisation indicators, etc.

Resources devoted to R&D are generally the most used since they represent regularly and recognised data collected on the main source of technology (Clark and Guy, 1998). However, this indicator has some limitations: on the one hand, it represents an input, meaning that even if related to technical change, these expenditures are not supposed to measure innovation output; second, R&D does not encompass all the efforts of a firm in this area, as there are many other sources of technical change, such as learning by doing; finally, as a measure it lacks detail (technical fields and specific firms) and small firms, design and product engineering are strongly underestimated.

Patent statistics are the second common indicator of output of research activities. Advantages are that these statistics reflect the technological dynamism of a firm; they represent a rich and documented source, can be collected on regular basis and often are long term data. The main disadvantage is that not all innovations are patented, some are covered by multiple patents, some have a high technological value, others not.

Other initiatives in measuring innovative activities include data collected in the *European Innovation Scoreboard* (EIS) that provides technical innovation and economy-wide indicators to benchmark the innovative capabilities of the EU countries with reference to four main thematic groups (Clark and Guy, 1998; Spielman and Birner, 2008): human resources (e.g. population with a tertiary education, participation in lifelong learning); creation of new knowledge (e.g. public R&D expenditures on R&D on GDP, SMEs involved in innovation cooperation); transmission and application of knowledge (e.g. SMEs innovating in-house, or in cooperation, innovation expenditures); innovation finance, output and markets (e.g. share of hi-tech venture capital investment, sales of “new to market” products, sales of “new to the firm but not to the market” products).

Furthermore, the World Bank has developed the Knowledge for Development (K4D) database designed to support the efforts of developing countries to transition into knowledge-based economies. K4D describes the knowledge economy in terms of four main pillars: the overall performance of the economy (e.g. average annual GDP growth, GDP per capita); the economic regime (e.g. intellectual property protection, soundness of banks, etc.); governance (e.g. regulatory quality, government effectiveness, etc.); the innovation systems (e.g. FDI outflows and inflows as % of GDP, researchers in R&D, university-company research collaboration, etc.); education (e.g. adult literacy ratio, average years of schooling, tertiary enrolment, etc.).

Finally, the World Economic Forum’s Global competitiveness Index (GCI) combines a range of indicators to measure a country ‘s potential for productivity growth and, ultimately, international competitiveness. Indicators are categorized under the pillars of institutions, infrastructures, macro economy, health and primary education, higher education and training, market efficiency, technological readiness, business sophistication and innovation.

4.2 Measurement of Innovation in the agro-food sector

When it comes to measuring innovation in the agro-food sector, authors like (Nielsen, 2008) claim that the concept of innovation, including technological development, is particularly ambiguous and thus difficult to measure. From the mid-1980s, the OECD has developed a classification of economic sectors according to R&D intensity, measuring the latter as an indicator of innovativeness. Following this approach, the OECD classifies the agro-food sector as generally a low technology sector (Grunert et al., 1997; OECD, 2005), since R&D expenditures count for less than 1% of turnover, compared to 4% in high-tech sectors.

However, as (Smith, 2002) and (Grunert et al., 1997) point out, direct R&D is but one indicator of knowledge content, and technology intensity is not mapped solely by R&D. Moreover, focusing on food-processing, (von Tunzelmann and Acha, 2006) cited in (Nielsen, 2008) argue that it is generally inappropriate to characterise the food sector as either low-tech or stagnant, since part of the food sector is characterised by advanced knowledge bases and technology, and the sector develops in several dimensions such as new applications of biotechnology, smart materials, and changes in the vertical structure of the industry (p. 4).

The reason why R&D effort is considered as a poor indicator to capture innovation intensity within the agro-food sector is due to specific features of its innovation pattern (Avermaete, 2004; Capitanio et al., 2010; Galizzi and Venturini, 2008):

- Food firms are mainly process-innovation oriented (Archibugi et al., 1991) and use new technologies developed by upstream industries (Martinez and Burns, 1999);
- Most product innovations in the food industry are incremental rather than radical. This may be related to so-called consumer inertia, that result from conservative consumer behaviour and aversion to new food products (Galizzi and Venturini, 2008; Grunert et al., 1997)

As reported in (Avermaete et al., 2004), several authors have illustrated that product and process innovation in the food industry, and in particular in small food firms, is often primarily the result of marketing capabilities. This helps to explain why market orientation is probably stronger than research and development activities as a key driver in determining innovation in this sector. As a result, indicators such as “new or improved products launched in the market” or their market success (i.e. turn-over or market shares related to these products) may be more appropriate as indicators for measuring innovativeness in the agro-food sector (Enzing et al., 2011). In contrast, other authors such as (Huiban and Bouhsina, 1998) state that innovation in the food industry is still a technologically driven phenomenon, whereas the role of other capabilities is limited.

While (Avermaete et al., 2004) claim that R&D and market orientation are key elements to understand and measure the innovation process, especially for large firms, others point to the crucial role of entrepreneurship for innovation in SMEs (Grunert et al., 1997). In SMEs the role of the entrepreneur is often the key determinant of the firm’s competitive strategies, including innovativeness. The age of the entrepreneur has therefore been analysed as a proxy for measuring the firm’s innovativeness: younger entrepreneurs are likely to be more motivated to innovate, having a long time horizon within the firm. Furthermore, studies claim that the entrepreneur’s experience, competences and educational background are crucial drivers for innovation, nevertheless empirical studies do not show a positive relationship between the educational level of the entrepreneur and the innovativeness in small firms.

Apart from in-house capabilities, small firms also need external sources of information to successfully innovate since their own resources and capabilities are limited (Avermaete et al., 2004). (Stewart-Knox and Mitchell, 2003) find that food manufacturers draw heavily on market information from customers for developing innovations; (Diederen et al., 2004) state that informal contacts with similar firms tend to be particularly important for innovation. Finally, other studies demonstrate that in sectors where product and process innovations are incremental and often present some of the characteristics of imitation, the capacity of firms to learn from the successes and failures of their colleagues lets them improve their own strategy, organisation and operations. Co-operation with research institutes is also regarded as crucial for innovation in small low-tech firms which often lack the means and the know-how to carry out their own research activities.

Lessons learned

There is no generally accepted way of measuring innovation:

- *Innovation performance measurement differs according to the measures used, the level of analysis, the source of data and their collection method;*
- *Different initiatives have been launched by OECD, the World Economic Forum and the World Bank to measure innovation;*
- *In the framework of this project, great relevance is given to the OECD's Oslo Manual, which promotes data collection in line with the innovation system approach;*
- *According to the Oslo Manual, two basic families of indicators to measure innovation exist: resources devoted to R&D and patent statistics, but both have shortcomings;*
- *In the agro-food sector, market orientation and the role and experience of the entrepreneur are proven to be stronger indicators than R&D activities in determining innovation.*

5 Innovation and competitiveness

5.1 Review of the general literature

Competitiveness can be depicted as a complex, multi-dimensional and relative concept. At the micro level (company), competitiveness is generally understood as the ability of a firm to grow in size, profitability or market share (Clark and Guy, 1998), thus generating high factor income and factor employment levels (Hatzichronoglou, 1996). Recently, however, it has been consistently underlined how other non-price factors determine competitiveness: human resource endowments (skills and worker motivation, for example); technical factors (R&D capabilities, ability to use and adapt technology); managerial and organisational factors (relationships that are both internal and external to the firm) (Clark and Guy, 1998). At the macro level (country), competitiveness has long been viewed in relation to trade and trade policy, industrial policy and technological policy. Since the 1990s also a more social perspective is added by (European Commission, 2008; Latruffe, 2010).

The relationship between innovation and competitiveness is generally interpreted in terms of growth, productivity and trade performance: firms' competitiveness stems from country-specific long-term trends in the strength and efficiency of the economy's productive structure, its technological infrastructure, and other externalities on which firms build (Clark and Guy, 1998). In much of the literature, one or more indicators of competitiveness is then tested against an innovation indicator for empirical links.

Empirical analyses investigate, for example, links between R&D expenditures or ICT investments and productivity growth, or between patents and world trade flows. Generally speaking, these types of analyses strongly suggest that technological change is a critical source of economic growth, with high returns to R&D, but in the literature it is possible to observe divergent findings and opinions. At a business level, some authors demonstrate that the creation of knowledge (i.e. R&D investments) positively influences the development of the firm in terms of sales growth, profitability or employment creation (Del Monte and Papagni, 2003; García-Manjón and Romero-Merino, 2012; Geroski, 2005), while other authors find no significant relationship (Bottazzi and Secchi, 2003; Grunert et al., 1997; Sundaram et al., 1996). As far as the propensity to export is concerned, the existence of a positive relation is found between an index of innovative activity and the propensity to export as well as between research intensity (i.e. R&D/sales ratio) and the propensity to export, measured by the exports/sales ratio (Del Monte and Papagni, 2003). Whenever an index of innovation based on patents is utilised, few authors find a positive effect on the rate of growth of firms and on their market value (Ernst, 2001). An extended review of the literature about these econometric analyses can be found in (Del Monte and Papagni, 2003; García-Manjón and Romero-Merino, 2012; Grunert et al., 1997). Differences often depend on the industry, the country, or the period of time under study (Brynjolfsson and Yang, 1996; Clark and Guy, 1998).

In addition to empirical analyses, the literature regarding the relationship between innovation and competitiveness encompasses also economic models that treat technology-related behaviour as the engine for economic growth and that show a reasonable fit with empirical data.

5.2 Innovation and competitiveness in the agro-food sector

Innovation is regarded as a major source of competitive advantage. Following the view that innovation is closely linked with technological change, the food industry is often defined as low-tech having one of the lowest R&D to sales ratios of any industrial sector (Grunert et al., 1997). However, according to the marketing literature that offers a view of innovation as the market-orientation process of a company, R&D in itself does not guarantee innovative success: it is rather of crucial importance that intellectual inputs interact with the needs in the market. A balanced R&D-marketing coordination is then seen as crucial to achieve innovation success and this is particularly relevant for the food sector.

Most studies that measure innovation are of a general nature, looking at relationships across industries (Grunert et al., 1997). Even when applied to the food sector, empirical analyses are only focussed on large firms (Avermaete et al., 2004)[2]. There is only qualitative case-study evidence on the relationship between R&D and performance (and then competitiveness) in the food industry (Avermaete et al., 2004). Nevertheless this has resulted in a number of interesting insights.

The ability to patent food products is often questioned. As reported in (Grunert et al., 1997), biotechnology research is faced with patenting problems, since the patenting of life (e.g. living organisms used in the production of yoghurts) is not allowed. Moreover, it has been estimated that, in the food sector, technological advance relative to competitors is usually more crucial to generate profits than patent protection. Few technological ruptures exist in

[2] The authors, in particular, claim that it is crucial to recognize the role of small food firms since they play a potentially important role in achieving sustainable economic growth in local economies, they are still typically located in rural areas constituting an important source of employment and they tend to rely heavily on local industries and local services, producing specialised regional products.

the food industry, but the ones which have occurred have had considerable impact on competitive positions (Grunert et al., 1997)[3].

In examining the determinants of product and process innovation in small food and drink manufacturing firms, (Avermaete et al., 2004) highlight the key role of the workforce's skills, the firm's investment in know-how and the use of external sources of information, sometimes even more than the R&D activity itself. However, they cannot find evidence of a significant relationship between the characteristics of the entrepreneur and the firm's innovation performance.

There is therefore no clear-cut evidence on the relationship between R&D and business performance, neither in general nor in the food industry. The riskiness of the innovation process implies that innovation management, and specifically the way in which technological and production skills are related to market opportunities, becomes especially important.

Lessons learned

Both theoretical and empirical analyses provide insights in terms of the relationship between innovation and competitiveness:

- *Apart from price, human resource endowments, technical factors, and managerial and organisational factors determine competitiveness;*
- *Technological change is proven to be a critical source of economic growth, but the literature identifies divergent findings and opinions;*
- *Differences often depend on the industry, the country, or the period of time under study.*

6 Innovation systems

Over the time, there have been a number of attempts to conceptualize the innovation process. Some of these attempts have conceptualized innovation as a smooth, linear process. However, this representation ignores the complexity, the causal relationships and the dynamics in the innovation process (Dankbaar and Vissers, 2009; Kline and Rosenberg, 1986). The following sections present a conceptual framework for innovation based on the National Innovation Systems thinking. This framework is then applied to the agro-food sector.

6.1 What are innovation systems?

Major contributions to the understanding of the nature of innovation have been made by the Systems of Innovation concept, developed in the framework of the evolutionary economics approach (Edquist, 1997; Lundvall, 1992). Evolutionary economics argues that innovation should be seen as a non-linear and interactive process requiring intensive communication and collaboration between different actors favouring the diffusion and economic exploitation of knowledge. These different actors include networks among firms and other organisations

[3] As the authors report, for example, this was the case with biological processes instead of chemical processes in producing aspartame, or with the introduction of frozen food instead of canned food.

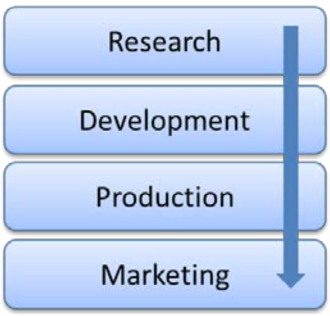
such as universities, innovation centres, educational institutions, financing institutions, industry associations and government agencies, but also suppliers and consumers (Acs et al., 2002; EU SCAR, 2012; Evangelista et al., 2002; Tödtling and Trippl, 2005). Box 3 presents further details about how the concept has been depicted in the literature.

Box 3. Some definitions in the literature

As stated in (OECD, 1997), a National System of Innovation has been defined in the literature as follows: "*the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies*" (Freeman, 1987); "*the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge [...] and are either located within or rooted inside the borders of a nation state*" (Lundvall, 1992); "*a set of institutions whose interactions determine the innovative performance [...] of national firms*" (Nelson, 1993); "*the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country*" (Patel and Pavitt, 1994); "*that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies*" (Metcalfe, 1995).

The National Innovation Systems approach reflects the rise of systemic approaches to the study of technology development as opposed to the linear model of innovation. In the linear model (Kline and Rosenberg, 1986), as depicted in figure 1, the initiator of innovation is science (research) and an increase in scientific inputs is expected to directly increase the number of new innovations and technologies flowing out of the downstream end.

Figure 1. The linear model of innovation



Source: Kline and Rosenberg, 1986

The linear model has been criticized as it distorts the reality of innovation: ideas for innovation can come from many sources and at any stage of research, development, marketing and diffusion; innovation is the result of a complex interaction between various actors and stakeholders; technical change does not occur in a perfectly linear sequence, but through feedback loops within this system and on-going development processes (Kline and Rosenberg, 1986; OECD, 1997; Röling, 2009).

There are many channels through which knowledge can flow between the actors of the innovation system. Examples include technical collaboration among firms, universities and public research institutions; diffusion of knowledge and technology to enterprises via adoption rates for new technology or personnel mobility within and between the public and the private sector (Acs et al., 2002; OECD, 1997). The systems approach has emphasized the role of both "hard" or formal institutions (i.e. organisations and laws) and "soft" institutions (i.e. practices, norms, routines) shaping the behaviour of actors and their interactions. Institutions act as the rules of the game, reducing uncertainty in human interactions. (Röling, 2009) argues that institutions are embedded in diverse contexts and that they express specific historical frameworks that cannot be designed, tested and replicated as technologies do. The presence of appropriate and effective innovation policies plays a crucial role in this respect. This means that policies have to be operationalized taking into account actors, institutions and linkages at a national scale[4].

6.2 Linkages in innovation systems

The innovative activities of an enterprise depend in part on the variety and structure of its links to sources of information, knowledge, technologies, practices and human and financial resources. Linkages act as sources of knowledge and technology for a firm's innovation activity, ranging from passive sources of information to suppliers of embodied and disembodied knowledge and technology, to co-operative partnerships (OECD, 2005) p.77)

Each linkage connects the innovating enterprise to other actors in the innovation system: government laboratories, universities, policy departments, regulators, competitors, suppliers and customers. Linkages vary by source, cost and level of interaction. For instance, less interactive linkages that require no interpersonal contact and are based on one-way information flows, such as reading publications or searching patent databases, can only provide codified information. on the other hand, highly interactive linkages involving close working relationships, such as with a supplier, can provide both codified information and tacit knowledge and real-time problem-solving assistance. However, firms may avoid some types of highly complex links if they have concerns about the loss of intellectual property (OECD, 2005).

The benefits of linkages will depend on how well knowledge is operationalized within the firm and channelled into the development of new products, processes and other innovations. Knowledge management (Kline and Rosenberg, 1986) involves practices for gaining external knowledge and interacting with other organisations, and for sharing and utilising knowledge within the firm.

Diffusion is the spread of innovations, through market or non-market channels, from the first implementation anywhere in the world to other countries and regions and to other markets and firms. The diffusion process often involves more than the mere adoption of knowledge and technology, as adopting firms learn from and build on the new knowledge and technology. Through the diffusion process, innovations may change and supply feedback to the original innovator.

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[4] In recent years, increased attention is given to the geographical dimension of innovation, leading to the emergence of the Regional Innovation Systems (Tödtling and Trippl, 2005).

Identifying how transfers of knowledge and technology take place, what the main sources of knowledge and technology flows are for firms, and which of these are of greatest importance, are central to understanding linkages in the innovation process (OECD, 2005). This is of direct relevance for innovation policy.

Three types of (external) linkages or flows of knowledge and technology between firms can be distinguished (OECD, 2005):

- open information sources that do not involve the purchase of knowledge and technology or interaction with the source: e.g. fairs and exhibitions can give access to tacit knowledge through personal interaction with other participants; codified knowledge can take different forms (publications, etc.); feedback from clients and suppliers may be easy to use; knowledge networks such as Communities of Practices (informal) or formal networks (Chambers of commerce, etc.) can arise in the normal course of business;
- purchase or acquisition of knowledge and technology without active co-operation and interaction with the source: this external knowledge can be embodied in machinery, equipment, software, employees, use of research contracts;
- innovation co-operation with other firms or non-commercial institutions: all the parties take an active role since they can get information they would be unable to utilise on their own (synergies, cooperation); it can take place along supply chains involving customers and suppliers in the joint development of new products, processes or other innovations.

6.3 Open innovation and the organisation of innovation

Innovation management calls for an “open innovation” in contrast to the “closed innovation” of the 1970s and 1980s. (Chesbrough, 2003) states that companies need to make use of internal as well as external ideas in a conscious and organized manner: external R&D can create significant value for a company, provided that it has the capability to claim some portion of that value. In other words, it is possible to profit from ideas that have been generated elsewhere, because it is not necessary to be first on the market as long as you have the better business model (Dankbaar and Vissers, 2009).

Open innovation means therefore that a company is increasingly using external knowledge to speed up its own, internal innovation process (Dries et al., 2013). As (Chesbrough, 2006) argues, an open innovation is generated in cooperation or collaboration with universities, research organisations, customers and/or suppliers, cluster associations or business assistance centres, venture capitalists and industry as well as other agro-food companies. Contrary to the closed innovation paradigm where innovations were entirely generated within the company, the open innovation paradigm argues that external knowledge has the same potential as internally generated knowledge (Chesbrough, 2006).

As depicted in (Dries et al., 2013), the food sector seems particularly suitable to a more open system of innovation since food companies normally rely even more on external resources than other industries: the high dependency on natural resources, the need for specific know-how in production processes and the intense interactions with both upstream and downstream partners favour an innovation model in which openness plays a key role.

In the policy domain, open innovation takes the form of increasing pressure on both universities and government laboratories to collaborate with the private sector.

The literature on open innovation falls within the broader topic of the organisation of innovation activities. As stated in (Pascucci et al., 2012), the literature on organisation and management of innovation processes considers decisions to innovate "in-house", to "collaborate" or to "outsource" as important aspects of a company's strategies. Researchers stress the complementarity between in-house R&D and external know-how (Veugelers and Cassiman, 1999): a company innovates in-house if it is able to develop internal competences, for example through R&D investments, but at the same time might well develop and maintain external ties for example with research organizations, while organizing and investing in collaborative networks (Pascucci et al., 2012). This opens the way to mixed decisions, such as investing in collaborative networks based on R&D and learning activities or in other words, a hybrid form of innovation organisation.

Box 4. Open Innovation: some examples

In their study on open innovation, (Dries et al., 2013) present several examples of open innovation in the agro-food sector: Heinz has recently established its open innovation platform, including all relevant stages of food production; Unilever has introduced a renewed innovation platform focused on an open innovation approach; the Barilla group (one of the largest pasta-makers in Europe) has funded a branch-company Academia Barilla, as an open (web-based) platform to collect traditional recipes from the Italian cuisine, and to use them to produce high quality food products.

6.4 Innovation systems in the agro-food sector: conceptual framework

Agricultural (and agro-food) innovation is mostly seen as a co-evolutionary process that combines technological, social, economic and institutional change (Klerkx L. et al., 2012). In this sense it can be represented by the Agricultural Innovation Systems (AIS) approach (Hall et al., 2001). AIS are defined as networks of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, together with the institutions and policies that affect the way in which different agents interact, share, access, exchange and use knowledge (World Bank, 2006).

A wide range of approaches to agricultural innovation has emerged over the past 40 years (for a complete reference, see Klerkx et al. (2012) and box 5). The AIS approach studies the set of interrelated actors who interact in the generation, exchange and use of agriculture-related knowledge in processes of social or economic relevance, and the institutional context that conditions their actions and interactions (Spielman and Birner, 2008). In doing so, the approach goes beyond earlier studies that were based on the National Agricultural Research Systems (NARS) and Agricultural Knowledge and Information (later, Innovation) Systems (AKIS) frameworks. Whereas the studies based on these frameworks focused primarily on the role of education, research and extension in supplying new knowledge and technology to farmers, the AIS approach includes the farmer as part of a complex network of heterogeneous actors engaged in innovation processes, along with the formal and informal institutions and policy environments influencing these processes (Spielman and Birner, 2008).

Box 5. Evolution of approaches toward AIS

The NARS framework, developed during the 1970s, was informed by neoclassical economics and the inherent failures in the market for agricultural research in developing countries. Although numerous studies had empirically demonstrated that agricultural research generates a high social rate of return in developing countries (Alston et al., 2000), the private benefits of such research were often limited by poor market infrastructure in rural areas and weak purchasing power among farmers, thus requiring public investment to address a chronic undersupply (see Spielman and Birner, 2008). The NARS framework focused on ways of optimizing the investment in public research organizations, and later, public universities and extension services, as a means of developing technologies to foster agricultural transformation and development (Spielman and Birner, 2008). According to this framework, the systems concept is entirely social (Klerkx L. et al., 2012): innovations are said to spread via communication through social systems which are networks of close friends, relatives or neighbours. The institutional and policy context is seen as an external factor that influences adoption by individual farmers.

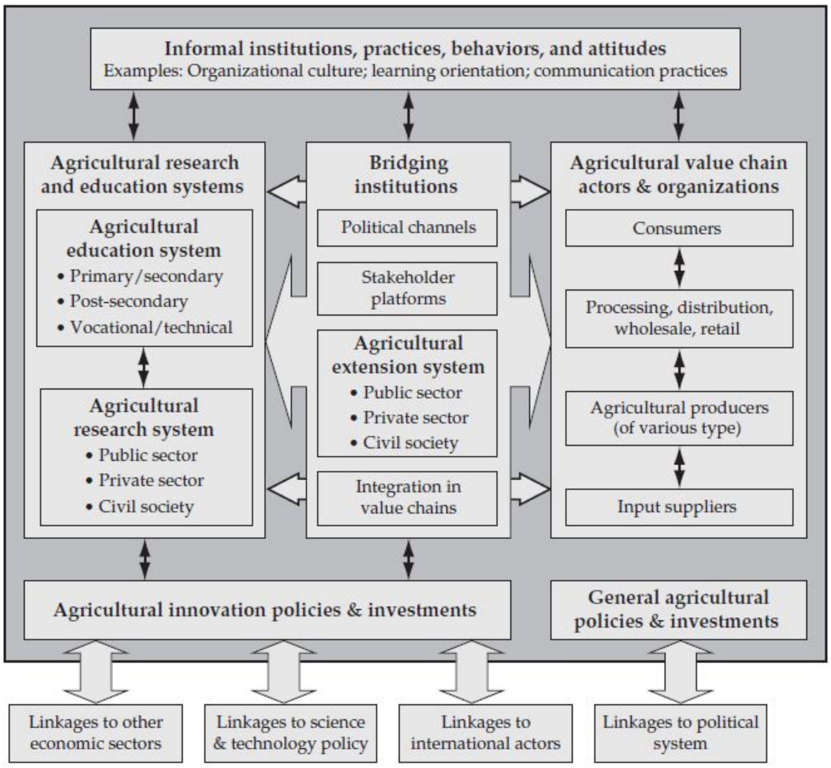
A broader approach to the study of technological change as well as to the systems concept has been introduced with the AKIS framework in the 1980s. Originally, AKIS was defined as "*a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in such processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision-making, problem solving and innovation in a given country's agriculture or domain thereof*" (Röling, 1990). In spite of this wide definition, the AKIS framework was mainly applied in a narrower sense, recasting agricultural research as one point of a knowledge triangle that also includes agricultural extension and education and which placed the farmer in the middle of this triangle. The AKIS framework succeeded in refocusing the study of technological change on the dissemination and diffusion of knowledge and information, emphasizing specifically the importance of knowledge and information flows between researchers, extension agents, educators, and farmers (Spielman and Birner, 2008).

At the end of the 1990s, researchers began to promote the AIS framework, influenced by the ideas on the national systems of innovation. The innovation systems concept embraces not only the science suppliers but the totality and interaction of actors involved in innovation. It extends beyond the creation of knowledge to encompass the factors affecting demand for and use of knowledge in novel and useful ways (World Bank, 2006).

As explained in (Klerkx et al., 2012) citing (Rivera et al., 2006), AKIS and AIS have some similarities since "*AIS did not evolve as a further development of the AKIS framework, but rather as a parallel development which did not build upon the insights of the AKIS literature and the practical experience in applying this framework. One reason for this parallel rather than consecutive development may be due to the fact that, considering the background of the leading authors, AKIS evolved from the extension perspective, while AIS was developed* *from a research perspective*". However, according to (World Bank, 2006), the main difference between AIS and AKIS lies in the greater and more explicit focus of AIS on the influence of institutions and infrastructures on learning and innovation, and its explicit focus to include all relevant organizations beyond agricultural research and extension systems (Klerkx et al., 2012).

In order to define indicators to measure innovation inputs, processes and outcomes, (Spielman and Birner, 2008) develop a conceptual framework that captures the essential elements of a national AIS, the linkages between its components, its institutions and policies representing the enabling environment for innovation (see figure 2).

Figure 2. Conceptual diagram of a National Agricultural Innovation System



Source: Spielman and Birner, 2008

According to the authors, there are three essential elements of an innovation system. First of all, a knowledge and education domain, that is composed of the agricultural research and education systems. Then, a business and enterprise domain, comprising the set of value chain actors and organizations that both use outputs from the knowledge and education domain. Finally, bridging institutions, namely extension services, political channels and stakeholder platforms, that link the two domains and facilitate the transfer of knowledge and information between the domains.

Public policies on innovation and agriculture represent the frame conditions that foster or impede innovation, together with informal institutions that establish the rules, norms, and cultural attributes of a society, and the behaviours, practices, and attitudes that condition the ways in which individuals and organizations within each domain act and interact (Spielman and Birner, 2008). Implicit throughout the system are farmers that act both as consumers and producers of knowledge and information, as producers and consumers of agricultural goods and services, as bridging institutions between various components, and as value chain actors. The system in this vision comprises even influencing factors such as linkages to other sectors of the economy (manufacturing and services); general science and technology policy; international actors, sources of knowledge, and markets; and the political system.

Lessons learned

- *The National Innovation Systems approach reflects the rise of systemic approaches to the study of technology development as opposed to the linear model of innovation*
- *There are many channels through which knowledge can flow between the actors of the innovation system (e.g. open sources, acquisition, co-operation)*
- *Both "hard" institutions (i.e. organisations and laws) and "soft" institutions (i.e. practices, norms, routines) shape the behaviour of actors and their interactions*
- *The Agricultural Innovation Systems approach studies actor interaction in the generation, exchange and use of agriculture-related knowledge, and the institutional context in which these actions and interactions take place*
- *There are three essential elements of an AIS: a knowledge and education domain, a business and enterprise domain, bridging institutions*

Part II. The EU policy context

7 Agricultural Knowledge and Innovation Systems

7.1 Origin, definitions, actors

The concept of Agricultural Knowledge and Information Systems has been introduced in policy discourses for the first time during the 1970s, sponsored by official organizations such as OECD and FAO (Knickel et al., 2009). The formal definition of AKIS has been proposed by (Röling and Engel, 1990): "*a set of agricultural organisations and/or persons, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in agriculture*".

This concept was based upon the Agricultural Knowledge Systems (AKS), a concept originated in the 1960, and driven by an interventionist policy in agriculture that promoted coordination in the transfer of knowledge as the key to accelerate the process of modernization of the sector (Leeuwis and Van Den Van, 2004). The AKS concept was implemented in many countries and was reflected in a strong integration, generally at national level, of public research, education and extension bodies, in many cases under the control of the Ministry of Agriculture (EU SCAR, 2012; Knickel et al., 2009).

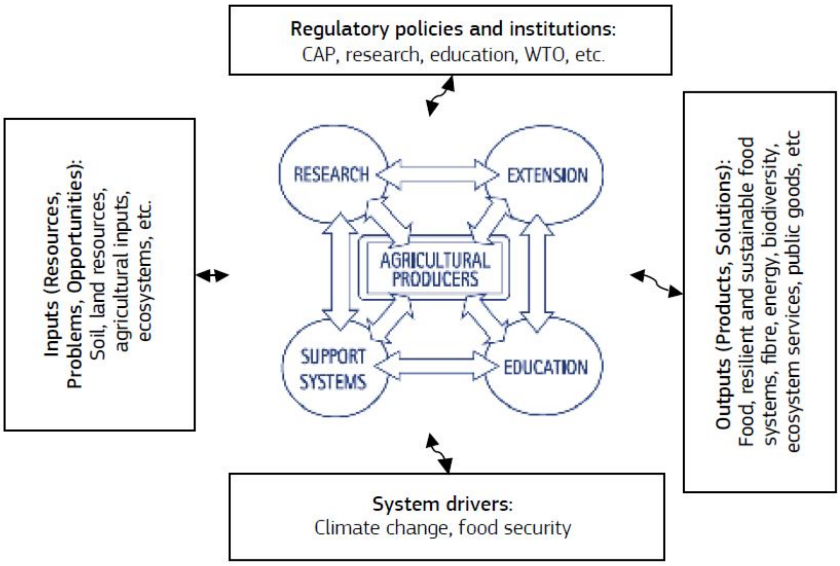
AKIS develops the notion of AKS in recognizing both the role of other actors outside the research, education and advice services (Dockès et al., 2011) and the increased attention towards information, probably in connection with the large scale introduction of computers (EU SCAR, 2012).

More recently, this concept has further evolved, acquiring the meaning of innovation (therefore, Agricultural Knowledge and Innovation System), opening up AKIS to more public tasks and to support of innovation (Dockès et al., 2011; Klerkx and Leeuwis, 2009). As showed in (EU SCAR, 2012), there were four principal reasons for this change in definition. First of all, trends toward liberalisation (e.g. privatisation of service delivery, multiplication of extension organisations, farmers contributing towards the cost of these services, competitive bidding for research and extension contracts, and tighter evaluation procedures) resulted in a deep restructuring of research, extension and education. Second, the policy agenda began to deal with new emerging issues, like increasing concern over the environmental impact of industrial agriculture, the quality of life of rural populations, rural employment, and the need to support the positive externalities linked to agricultural production. Third, the linear model of innovation depicted in the previous sections of this report was progressively replaced by an interactive and more participatory network approach, in which innovation is "co-produced" through interactions between all stakeholders in the food chain. Finally, the growing disconnection between farmer knowledge and research and extension systems necessitated the revision of the concept.

A further extension of the AKIS framework was the recognition that the target should not only be agricultural development, but more broadly rural development (RD). As a result, references to AKIS were replaced by AKIS/RD even in the FAO and the World Bank official documents.

(Rivera et al., 2005) assert that AKIS integrates farmers, agricultural educators, researchers and extension service providers to harness knowledge and information from various sources for better farming and improved livelihoods, as well as regional and national stability and growth. A graphical representation of an Agricultural Knowledge and Innovation System, as proposed by (Dockès et al., 2011) and based on (Rivera et al., 2005) is presented in figure 3.

Figure 3. A model for AKIS



Source: adapted by Dockès et al., 2011 from Rivera et al., 2005

The model suggests that agricultural information systems for rural development link institutions with people (agricultural producers, the end users of knowledge and information) to promote learning (Knickel et al., 2009). The four main domains illustrated by the model, namely research, education, extension and the support system (i.e. all organizations related to credit, inputs, producers' associations, etc.) act upon farmers' and rural actors' knowledge. In doing so, they generate innovation with an approach that is not necessarily top-down, as the two-way arrows linking the agricultural producers and the other spheres show. However, when we look at support systems, most relevant knowledge farmers have is carried through marketing networks of seeds, fertilizers, machinery, and pesticides (Knickel et al., 2009).

7.2 Experiences from Member States: lessons learnt

The Standing Committee for Agricultural Research (SCAR, European Commission) concluded that research, innovation and agricultural knowledge systems must be fundamentally reorganized (Freibauer et al., 2011) in order to speed up transitions in food, farming and rural development in a sufficiently powerful way (Brunori et al., 2008). The challenge agriculture faces is to "*conserve local traditional knowledge, utilize new knowledge, and amalgamate the different types of knowledge in a systemic way that makes food production systems resilient and sustainable*" (Freibauer et al., 2011). But the evidence in the last decades has been of an AKS policy that is unable to support transitions because of overregulation, fragmentation and excessive competition between actors, impeding collaboration between researchers and innovators (Brunori et al., 2008; Rivera et al., 2005).

This has stimulated a revision of the European national AKS/AKIS in recent years. One of the most crucial shortcoming of the EU has been in fact the lack of a system to monitor the evolution of AKS infrastructures, preventing as a consequence the collection of crucial data necessary for designing and evaluating AKS policy formation and implementation (Brunori et al., 2008; Knickel et al., 2009). Several important initiatives (reports, case studies, working groups, see Box. 6) have therefore been launched to check the current "health" of the AKIS especially in terms of dynamics, incentives, monitoring and evaluation experiences. The main findings from these activities reveal that AKIS exist and reflect differences in contexts, institutional frameworks, competitive positions and strategies adopted by agriculture and the agro-food sector. Most European countries have AKIS (AKS) that operate at the national or regional level to support and advise agriculture and farmers, and they are quite different even among the sectors (EU SCAR, 2012; Rivera et al., 2005).

Box 6. Initiatives to monitor the AKIS

In order to provide a starting point to establish a European monitoring device of the AKIS structures and their evolution, the EU SCAR has set up a tool for designing and evaluating AKIS policy formation and implementation, namely the Collaborative Working Group (CWG) on AKIS. The group focuses on the links between knowledge and agricultural innovation in Europe and is conceived as a network of civil servants (and some counter parts from research organisations, education and extension workers) from the member states and the European Commission (EU SCAR, 2012). During its first mandate the CWG has made an inventory of national issues and structures. The results were publically presented in a workshop on the future of AKIS in Europe that took place the 5th of March 2012 in Brussels, organised in partnership with the SOLINSA project partners (http://www.solinsa.org/project-results/dissemination-seminar/first-international-dissemination-seminar/). The CWG has then been given a second mandate, on the collection and analysis of experiences in EU member states and at EU level of models and method of interaction useful for fostering agricultural innovation; special attention was asked in particular for the best practices in promoting innovation through operational groups. The results from these analyses were presented in a second joint workshop held in December 2013 in Brussels with the SOLINSA project partners.

Differences exist in terms of the links and coordination between the AKIS components (research, extension, education, support systems), and also in terms of the actors involved, their position in the system, and sometimes how they are named. It is therefore not possible to identify a one size fits all formula for what an ideal AKIS is (Box 7).

With reference to the link between (applied) research and farmers via extension, for example, it is possible to find a patchwork of management settings (Dockès et al., 2011; Laurent et al., 2006): privatised systems for extension (e.g. the Netherlands, the UK, some states in Germany) where direct payments from farmers provide funding, but are coupled with funding for research provided by the state; co-management between farmer organisations and the state (e.g. France, Finland and some states in Germany), in which public funding coexists with partial payments by farmers and farmer organisations; semi-state management (e.g. Teagasc in Ireland with a board with representatives from the state, industry and farmer organizations); management by the state through regional organisations (e.g. Switzerland, Italy and Finland); and uncoordinated individual innovation initiatives (EU SCAR, 2012).

Box 7. Actors involved in the AKIS

Research generally involves universities (dedicated agricultural universities and faculties or departments involved in agricultural research), government research institutes, funding agencies, research centres, knowledge centres, regional development agencies, technical institutes, associations and experimental stations. In many countries also independent private research providers operate, and of course companies in agrochemical, seed, machinery, computer, software etc.

Extension organisation is rather complex in most EU countries: in some countires there is an important degree of interaction between extension services and the support systems (e.g. in Italy); farmers' interest in extension services also hugely differs between countries (e.g. Denmark, France and Germany present examples of services co-funded and co-managed by the sector, while Latvia and Hungary show a lack of interest and trust). Next to extension services, other private actors also provide support to farmers. Describing the support system in a coherent way is rather complex since many different actors operate along with farmers' organisations and producers' associations: cooperatives, chambers of agriculture, product boards, information systems, financial organisations are only some of them. Finally, secondary education is provided by specific technical and vocational schools, while higher education is provided by universities and colleges (EU SCAR, 2012).

In some countries (e.g. France, Switzerland, the Netherlands), there are clear links and coordination between the actors of the system, mainly supported and stimulated through special projects or platform to bridge for instance research and practice; in other country (e.g. Italy), this coordination is still far from being achieved due to structural reasons (Knickel et al., 2009)

AKIS are dynamic: some countries have restructured their AKIS considerably, even with the aim of addressing the recent indications coming from the EU policy (see Box 8 for some examples), but although some of them have evolved toward more networked forms of organisation (from a more top-down and transfer-of-technology orientation towards more collaborative systems of multiple actors, multiple relations and exchanges, multiple focus), dis-investment and privatisation have also increased the uncertainty about who controls for the knowledge creation, the distribution and exchange of information, and the education and training of farmers and resource users.

Box 8. Experiences of restructuring the AKIS

The analysis made by the SCAR CWG provides successful examples of privatisation of the extension services (EU SCAR, 2012). The Netherlands has privatised its state extension service and has merged its applied research and agricultural university into Wageningen University and Research Centre. France presents an interesting example of clustering in the so called *Pôle de competitivité*, a regional clustering with special projects to support consortia within the AKIS framework. Denmark provides a similar example, where applied research was merged into universities in different regions. The obligation of the Common Agricultural Policy of the Farm Advisory System (to make extension available on cross compliance) has in Hungary led to the introduction of a FAS in addition to Farm Information Service (organised by the Chambers of agriculture) and the Network of Village Agronomists (and agri-business). Austria has promoted an intensive collaboration between the different players in agricultural research. In the UK, the Agricultural and Horticultural Development Board (AHDB), funded by levies paid by the main production sectors, plays now a pivotal role in the delivery of knowledge transfer/exchange to farmers and growers to improve their competitiveness sustainably.

This problem is witnessed by the system of incentives driving the AKIS components: it emerges from the analyses of the different EU AKIS that they are governed by different incentives, which hinders collaboration and communication among them. Research is often evaluated in terms of publications, citations and excellence; education is often funded based on student numbers. When considering the extension system, the incentive mechanisms show a wide variety of possibilities: for example, payments by farmers, vouchers, subsidised programmes or input finance (EU SCAR, 2012). Interaction is stimulated through individual initiatives and isolated actions, or through activities of coordination of innovation driven research by independent task forces, joint technological networks, European Technology Platforms, innovation networks to link innovative ideas, entrepreneurs and knowledge institutes in specific innovation projects (e.g. in the Netherlands the focus is on the management of the triangle Industry-Government-Knowledge Institutes in order to maintain synergy between them, and applied research projects can dedicate part of their budget on communication and dissemination; in France, Joint Technological Networks has been developed between research, extension and education in order to promote innovation).

The monitoring of AKIS is fragmented, either in terms of input, system, or output: notwithstanding the high level of attention towards innovation in the policy domain at European, national and regional level, there is a lack of data and research for evidence-based policy that suggests the need to develop a system to monitor and evaluate the capacity to generate innovation and to evolve towards new paradigms (e.g. the new bio-based economy). Only few countries present experiences of ex-post policy analysis of certain innovation programmes, whereas statistics and other data gathered mainly focus on R&D in the food industry, on patents and the number of publications of the research system and their citations (EU SCAR, 2012).

Finally, although governed by public policy, the EU AKIS lack a consistent overarching policy: rather, the analyses of the regional and national systems reveal that the subsystems operate within separate, individual (and occasionally) combined policies for education, research, industrial policy, rural development policy and/or SME policy. The interaction with innovation in the private sector (such as the food and supply industry) is often weak, and not very clearly taken into account in designing policies. As reported in (EU SCAR, 2012), then, the question can however be asked if an integrated AKIS policy is really needed to reach the objectives or is it sufficient just to coherently combine the available information, for which appropriate incentives will then be needed.

Lessons learned

- *AKIS is a set of organisations and/or persons, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of knowledge and information, with "soft" institutions shaping the behaviour of actors and their interactions*
- *Its evolution opened up AKIS to more public tasks and to support of innovation*
- *AKIS exist, but there is no one size fits all formula*
- *EU AKIS lack a consistent overarching policy*

8 EU Research and Innovation Policy

8.1 Actors involved

Several EU institutions and bodies are involved in research and innovation at EU level. At the European Parliament level, the Committee on industry, research and energy is responsible for both the Union's industrial policy and the research policy, including the dissemination and exploitation of research findings; for the space policy; for community measures relating to energy policy in general; for nuclear safety; for the information society and information technology[5].

The Council of the European Union, made up of the ministers of the Member States, presents ten different configurations depending on the subjects under discussion. Created in 2002, the Competitiveness Council[6] ensures an integrated approach to the enhancement of competitiveness and growth in Europe. It gives its views on how competitiveness issues can be properly taken into account in all policy initiatives which have an impact on enterprises, and operates according to three strands of activities: internal market, industry, research and space. Following the objectives, rules and procedures set out by the European Community Treaty, the Council operates in supporting the priorities of creating an area where persons and goods can move freely; of ensuring the conditions for the competitiveness of the Community's industry, of strengthening the scientific and technological bases of European industry and its international competitiveness.

5 http://www.europarl.europa.eu/committees/en/ITRE/home.html (accessed October 2013)

6 http://www.consilium.europa.eu/policies/council-configurations/competitiveness?lang=en (accessed October 2013)

In the framework of the Council of the European Union, it is worth noting also COST, European Cooperation in Science and Technology, an intergovernmental European framework for international co-operation between nationally funded research activities established in 1971. Rather than funding research itself, COST brings together research teams in different countries working on specific topics, supporting networking, conferences, short-term scientific exchanges and publications[7].

In the context of the EU Commission, different Directorates-General (DG) operate to enhance research and innovation objectives: DG Research and Innovation's mission is to develop and implement the European research and innovation policy in all the areas, including agriculture, fisheries and forests, the environment, sustainable development and water resources, supporting research and innovation through European Framework Programmes, coordinating national and regional research and innovation programmes, developing the conditions for researchers and knowledge to circulate freely[8]. The DG Regional and Urban Policy is responsible for strengthening economic, social and territorial cohesion by reducing disparities between the levels of development of regions and countries of the European Union. To do so, it co-finances infrastructure projects, develops the information society, accelerates the transfer of know-how, supports investments in people and stimulates cross-border cooperation. The DG Agriculture and Rural Development is responsible for the implementation of agriculture and rural development policy, the latter being managed in conjunction with the other DGs which deal with structural policies. It is made up of 13 Directorates dealing with all aspects of the Common Agricultural Policy (CAP) including farm support, market measures, rural development policy, quality policy, financial and legal matters, analysis and evaluation as well as international relations relating to agriculture. Within the rural development policy, it supports measures and actions to promote "rural innovation", with the goal of improving the sustainable development of the European agriculture and the well-being of rural areas.

Other EU institutions and bodies operate in the research and innovation field[9]. The Joint Research Centre (JRC) is a network of seven research institutes across the EU. In addition to researching nuclear energy and nuclear safety, the JRC has developed technologies including a remote sensing technology to detect emerging food crises in developing countries where EU food aid will be needed. Rural development, agriculture and fisheries are areas in which it operates. The European Research Council (ERC) supports "frontier research", encouraging the very best, truly creative scientists, scholars and engineers to go beyond established frontiers of knowledge and the boundaries of disciplines. The ERC takes an investigator-driven, bottom-up approach which allows researchers to identify new opportunities and directions in any field of research, rather than being led by priorities set by politicians. The European Institute of Innovation and Technology (EIT) aims to translate research results into commercial applications by creating "Knowledge and Innovation Communities (KIC)". This new model of partnership involves universities, research organizations, companies, foundations and other entities. Its current priorities include climate

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[7] http://www.consilium.europa.eu/policies/cost.aspx?lang=en (accessed October 2013)
[8] http://ec.europa.eu/research/index.cfm?pg=dg (accessed October 2013)
[9] http://europa.eu/pol/rd/index_en.htm (accessed October 2013)

change, renewable energy sources and the next generation of information and communication technologies.

8.2 Funds for research and innovation and governance

Several EU research and innovation funding mechanisms are currently in place[10]. The three main instruments are the Framework Programs (FP), the Competitiveness and Innovation Framework Program (CIP) and the Structural Funds (European Commission, 2011). The Structural Funds will be analyzed in a specific section aimed at depicting their transversal feature, in conjunction with policies in the agri-domain.

The Framework Programs (FP) represent since the ‘80s the pillars of the EU support to research. The evolution of this instrument is marked by a gradual shift from a strong influence of the industrial sector during the ‘80s towards more environmental and social issues, especially since the third framework program (FP3, 1991-1994). The introduction of specific measures dedicated to SMEs, especially with the fourth program (FP4, 1994-1998), put emphasis also on the socio-economic research, whose importance gradually increased with the fifth (1998-2002), the sixth (2002-2006) and the current seventh framework program (FP7, 2007-2013). The rationale for the FP has consequently shifted towards the promotion of cooperation between countries in order to increase their scientific excellence and competitiveness: the budget, especially for applied research, technological development, coordinated projects, dissemination of knowledge and use and application of results has notably increased. The running Seventh Framework Program, with a total budget of over €50 billion for the period 2007-2013, is the EU instrument specifically targeted at supporting research and development. It provides funding to co-finance research, technological development and demonstration projects based on competitive calls and independent peer review of project proposals. Support is available for collaborative and individual research projects as well as for the development of research skills and capacity. It is structured in five Specific Programs:

- *Cooperation* (€ 32 billion) aims at fostering collaboration among research entities from academia and industry and research institutes to gain leadership in key technology areas. For the agri-related domain, one of its specific themes is “Food, Agriculture and Biotechnology”, covering farm management policies, food safety and rural development. With a budget of more than €1.9 billion, this theme is built around three major activities: sustainable production and management of biological resources; fork to farm; life sciences, biotechnology and biochemistry for sustainable nonfood products and processes. The primary aim of funding this theme is to build a European Knowledge Based Bio-Economy (KBBE), where knowledge is the best way to increase productivity and competitiveness and improve quality of life, while protecting the environment and social model.
- *Ideas* (€ 7.5 billion) supports basic research at the frontiers of science (implemented by the European Research Council). Research may be carried out in any area of science or technology, including engineering, socio-economic sciences and the humanities;

[10] http://cordis.europa.eu/home_en.html (accessed October 2013)

- *People* (€ 4.75 billion) supports mobility and career development for researchers both within and outside Europe;
- *Capacities* (€ 4 billion) helps developing the capacities that Europe needs to be a thriving knowledge-based economy. The program contains six specific areas: Research Infrastructures, Research for the benefit of SMEs, Regions of Knowledge, Research Potential, Science in Society and International Cooperation activities;
- *Euratom* (€ 2.7 billion) supports European research in fusion energy and in nuclear fission and radiation protection.

Finally, Horizon 2020 represents the EU's new program for research and innovation and aims at contributing to the creation of new growth and jobs in Europe. Running from 2014 to 2020, it aims at combining all research and innovation funding currently provided through the Framework Programs and the innovation related activities of the CIP and the European Institute of Innovation and Technology (EIT). Horizon2020 has a budget of over €70 billion, of which more than € 24 billion will be dedicated to strengthen the EU's position in science; around € 17 billion to strengthen industrial leadership in innovation through investments in key technologies, greater access to capital and support for SMEs; almost €31 billion to help address major concerns such as climate change, developing sustainable transport and mobility, making renewable energy more affordable, ensuring food safety and security, or coping with the challenge of an ageing population. Horizon 2020 adopts a market-driven approach, including the creation of partnerships with the private sector and Member States to bring together the resources needed and to bridge the gap between research and the market.

The Competitiveness and Innovation Framework Program (CIP) aims to foster the competitiveness of European enterprises and has a total budget of over € 3.6 billion for the period 2007-2013[11]. Specific CIP programs promote innovation (including eco-innovation); foster business support services in the regions and better access to finance, with small and medium-sized enterprises (SMEs) as the main target; encourage a better take-up and use of information and communications technologies (ICT); help to develop the information society and promote the increased use of renewable energies and energy efficiency. The CIP is divided into three operational programs each with its specific objectives, aimed at contributing to the competitiveness of enterprises and their innovative capacity in their own areas, such as ICT or sustainable energy: Entrepreneurship and Innovation Program (EIP), Information Communication Technologies Policy Support Program (ICT-PSP), Intelligent Energy Europe Program (IEE). As for the FP7, the funding in the form of grants is normally allocated through the publication of calls for proposals examined by a panel of evaluators and awarded only according to quality criteria and within the limits of the total available budget.

Appendix A2 provides an elaborate overview of the evolution of the EU research policy context.

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[11] http://ec.europa.eu/cip/ (accessed October 2013)

8.3 Cohesion, rural development, R&D policies

The purpose of the Structural Funds (European Regional Development Fund – ERDF and European Social Fund - ESF) and the Cohesion Fund is to strengthen economic, social and territorial cohesion by reducing disparities in the level of development among regions and Member States[12]. Each region or Member State has developed, in discussion with the Commission and in partnership with all relevant private and public stakeholders, operational programs that cover the entire programming period 2007-2013. The Structural Funds supports different thematic areas, including research, innovation and enterprise for which EU funding for 2007-2013 is above €86 billion. The level of development of a given Member State or region defines the allocation of funds. However, most regions will have some funding available from the Structural Funds in support of Research, Technological Development and Innovation (RTDI). Unlike FP7 and CIP, the management of the Structural Funds is shared between the different territorial levels of governance (partnership between the European Commission, the national and the regional authorities).

The aim of the European Regional Development Fund (ERDF) is to strengthen economic and social cohesion in the EU by correcting imbalances between its regions. Support is provided for investments in companies (especially SMEs) to create sustainable jobs; infrastructures for research and innovation, telecommunications, environment, energy and transport; financial instruments to support regional and local development and to foster cooperation between towns and regions; technical assistance measures[13]. The European Social Fund (ESF) aims at improving employment and job opportunities in the EU, acting in the framework of the Convergence and Regional Competitiveness and Employment objectives. The actions supported are in areas such as access to employment for job seekers, the unemployed, women and migrants; promotion of lifelong learning schemes, social integration of disadvantaged people, strengthening human capital by reforming education systems and setting up a network of teaching establishments[14]. Finally, the Cohesion Fund is for Member States whose Gross National Income (GNI) per inhabitant is less than 90% of the Community average. The aim is to reduce their economic and social shortfall and to stabilize their economy. Therefore, it supports actions in the framework of the Convergence objective aiming at creating trans-European transport networks and at the environment (e.g. energy efficiency, use of renewable energy, developing rail transport, etc.). Although the Cohesion Fund is not directly linked to research, technological development and innovation (RTDI) (European Commission, 2007), through the Cohesion Policy almost 25% (€ 86 billion) of the total Structural Funds budget is allocated to enhancing the capacity of regional economies to change ad innovate (Hermans et al., 2012).

In complementarity to the previous instruments depicted, specific support for innovative investments in the agricultural domain is provided within the Common Agricultural Policy (CAP): the EU Rural Development Policy (second pillar of the CAP) aims at increasing the competitiveness of EU agriculture, food processing industries and forestry; at the establishment of sustainable land management and agri-environmental practices and at

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12 http://cordis.europa.eu/eu-funding-guide/supporting-id_en.html#instruments (accessed October 2013)
13 http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm (accessed October 2013)
14 http://ec.europa.eu/regional_policy/thefunds/social/index_en.cfm (accessed October 2013)

boosting the socio-economic development of rural areas[15]. In this context, support for innovative investments in agriculture, forestry and food industry is provided by the European Agricultural Fund for Rural Development (EAFRD), and in the field of fisheries by the European Fisheries Fund (EFF). In addition to funding, these instruments also offer possibilities for networking or making use of information and other services provided.

The European Agricultural Fund for Rural Development (EAFRD), with a total budget of more than €96 billion, offers a wide range of funding possibilities for entrepreneurs and companies operating in its fields of intervention. In the design of their rural development programs (RDPs), Member States can flexibly find a balance between the sectoral dimension (e.g. agricultural restructuring) and the territorial dimension (e.g. land management and the socio-economic development of rural areas)[16] selecting from a menu of more than 40 support measures those best suited to address the specific strengths and weaknesses of individual programming areas. Programs are built around three thematic axes: economic concerns (competitiveness), the environment and the countryside (biodiversity, climate change, sustainable resource use in agriculture and forests) and social aspects (quality of life, income diversification and rural employment). Specific measures are explicitly related to research and innovation (see Box 9).

Box 9. EU Rural Development Measures related to research and innovation

The EU Rural Development Policy is structured in 4 axes reflecting its major strategic objectives and grouping all the support measures. With reference to innovation–related applications, according to the Council Regulation (CE) No 1698/2005, within Axis 1 “Improving the competitiveness of the agricultural and forestry sectors” it is possible to benefit from:

(1) measures aimed at promoting knowledge and improving human potential: among these, vocational training and information actions (Measure 1.1.1, Article 21), use of advisory services (Measure 1.1.4, Article 24) and setting up of farm management, relief and farm advisory services, (Measure 1.1.5) are related to the diffusion and transfer of knowledge and innovative practises;

(2) measures aimed at restructuring and developing physical potential and promoting innovation: modernization of agricultural holdings (Measure 1.2.1, Article 26) and adding value to agricultural and forestry products (Measure 1.2.3, Article 28) concern investments in new technologies; cooperation for development of new products, processes and technologies (Measure 1.2.4, Article 29) and improving and developing infrastructure related to the development and adaptation of agriculture and forestry (Measure 1.2.5, Article 30) support respectively the development of new products and new approaches to challenges (Hermans et al., 2012);

(3) measures aimed at improving the quality of agricultural production and products: support is provided for farmers who participate in food quality schemes (Measure 1.3.2, Article 32) for production and marketing of products with new qualities;

Within Axis 2 “Improving the environment and the countryside”, it is possible to

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15 http://cordis.europa.eu/eu-funding-guide/supporting-id_en.html#instruments (access on October 2013)

16 http://cordis.europa.eu/eu-funding-guide/supporting-id_en.html (accessed October 2013)

benefit from measures targeting the sustainable use of agricultural land through agri-environmental payments (Measure 2.1.4 , Article 39) incentivizing the use of innovative techniques to meet environmental challenges;

Within Axis 3 “The quality of life in rural areas and diversification of rural economy” support is provide for:

(1) measures to diversify the rural economy, comprising: diversification into non-agricultural activities (Measure 3.1.1, Article 53), support for the creation and development of microenterprises (Measure 3.1.2, Article 54), encouragement of tourism activities (Measure 3.1.3, Article 55), all related to new products, services and activities;

(2) measures to improve the quality of life in the rural areas, comprising basic services for the economy and rural population (Measure 3.2.1, Article 56);

(3) a training and information measure for economic actors (Measure 3.3.1, Article 58) improving knowledge

Finally, within Axis 4 “Leader” support is provided for implementing local development strategies (Measure 41, Article 63), namely for innovative forms of organization, governance and decision making (Hermans et al., 2012).

The European Fisheries Fund (EFF) aims to support the common fisheries policy. Funding is provided for all sectors of the industry, such as sea and inland fishing, aquaculture (the farming of fish, shellfish and aquatic plants), and processing and marketing of fisheries products. With a budget of €4.3 billion for 2007-2013, a limited number of projects can address research and innovation in specific areas: local development of fisheries areas; construction, extension, equipment and modernization of marketing and processing enterprises producing or marketing new products, applying new technologies, or developing innovative production methods; pilot projects to test innovative technologies; technical assistance to promote innovative approaches and practices.

Lessons learned

- *Several EU institutions and bodies are involved in the policy framework for research and innovation, different funding mechanisms, mainly Framework Programs (FP), Competitiveness and Innovation Framework Program (CIP), Structural Funds (SF) and Cohesion Funds*
- *EU support for research dates back to the late 1950s, but only during the 1980s and 1990s coordination of research activities in the Member States becomes explicit*
- *The need to set the broad policy lines for enhancing innovation, and in particular the aim of a closer correlation between “knowledge” and “competitiveness” marks the evolution of the research and innovation policy since the 2000s*
- *Policy measures are outlined aimed at encouraging the creation and growth of innovative enterprises, improving key interfaces in the innovation system, encouraging a society open to innovation: a network approach*

9 Other policies affecting innovation and competitiveness in agro-food chains

9.1 Food safety and quality policies, trade policies, marketing policies, industrial policy, ICT

The proliferation and evolution of public and private food safety standards in industrialized countries has raised concerns about their impact on global trade and competitiveness in agricultural and food products (Henson and Jaffee, 2006; OECD, 2003). As argued in (Henson and Jaffee, 2006), several studies have highlighted effects of trade reduction and/or diversion associated with food safety and quality standards (Beghin and Bureau, 2001; Maskus and Wilson, 2001). (Henson and Jaffee, 2006) propose two perspectives to examine the impact of food standards. The "standards as barrier" perspective suggests that food safety requirements in industrialized countries can represent a constraint that excludes developing countries and more vulnerable supply chain participants from trade. If key elements of an effective food safety management system are not in place, prohibitions can be applied. Smaller and more marginal agribusiness firms and producers suffer most frequently from the negative effects of stricter standards. This is exacerbated especially in the context of a supply sector that is itself under-developed. Furthermore, the growing complexity of food safety standards, the lack of harmonization between countries and the associated high costs of compliance represent potentially insurmountable barriers for developing countries that lack the administrative, technical and scientific capacities to comply. This inevitably undermines the longer-term competitive position of exporters and diminishes the profitability of high-value agricultural and food exports (Henson and Jaffee, 2006). An alternative perspective, however, focuses on seeing "standards as catalysts": strict food safety standards potentially induce reforms and stimulate upgrading required to exploit high-value market opportunities (Henson and Jaffee, 2006; World Bank, 2005). From this perspective, many food safety standards provide a common language through the supply chain and across international markets, in turn reducing transaction costs, and promote consumer confidence in food product safety without which the market for these products cannot be maintained and enhanced. Therefore, rather than hampering the competitiveness of developing countries, the enhancement of capacity needed to meet stricter food safety standards can potentially induce new forms of competitive advantage. This perspective redirects the debate to the conditions and capacities needed for developing countries to gain from evolving food safety standards and to exploit the potential opportunities in high-value agricultural and food markets.

When it comes to policies related to technology, there is a general consensus on the positive impact of technology on economic prosperity and competitiveness. The literature reports a widespread agreement on the positive association between knowledge, technological innovation and competitiveness (Argote and Ingram, 2000; Carneiro, 2000; Price et al., 2013). Information technology has a decisive role on knowledge development because competitive advantages can only be maintained by the use of information for innovation (Carneiro, 2000). High-tech information systems, in particular, can offer competitive advantages to agro-food firms when the systems support a supply chain strategy that suits the demand for the product (Salin, 1998). However, as (Oughton et al., 2002) argue, a number of unresolved issues remain. First of all, a greater understanding of the channels, mechanisms and conditions through which technological advance is translated into improved economic performance at the firm, regional and national levels is still needed. This is particularly required in order to inform the design and implementation of public policies to promote competitiveness (Oughton et al., 2002). Although the national systems approach to innovation has done much to enhance understanding about this, it has also highlighted the complexity of the relations and the need for further research, including systems analysis at the regional and sector levels (Howells, 1999; Tödtling and Trippl, 2005). Second, the systems approach itself, with its emphasis on knowledge, learning and institutions has stressed the need for institutional change and greater integration and coordination between technology policy, industrial policy, and other aspects of public policy (Lundvall, 1999; Oughton et al., 2002).

Finally, in terms of marketing policies, the agro-food sectors of many developed countries are experiencing a trend towards closer vertical coordination. Vertical coordination represents the means by which products move through the supply chain from producer to consumer. It has occurred as the use of spot markets has declined, while production and marketing contracts, franchising, strategic alliances, joint ventures, and full vertical integration have increased (Young and Hobbs, 2002). The increasing consumer demand for differentiated products and the advances in agricultural biotechnology have encouraged a movement from the production of commodities towards food products with specific diverse characteristics for niche markets. As a consequence, traditional spot market transactions impose higher search and monitoring costs on transacting parties relative to contracting, strategic alliances, and other forms of closer vertical coordination (Hobbs and Young, 2000).

9.2 Impact on the food supply chain actors

Policies that affect agro-food chains tend to emphasize in particular farmers and consumers, as the focus of many initiatives, concerns and share of governments' food chain related expenditure in many countries. However, few studies have highlighted how other stages of the chain (e.g. processors, distributors, retailers, suppliers of inputs) deserve attention when it comes to analyse policy impacts (Baker et al., 2004).

In terms of quality and trade policies, (Henson and Jaffee, 2006) argue it has become necessary to recognize and understand which are the major food safety challenges and opportunities. First, for senior agricultural and trade officials this is needed in order to "assign appropriate priorities for public programmes and expenditures". Second, when considering the owners and managers of agricultural and food processing and exporting firms, it is needed "in order to make appropriate investment decisions at the enterprise level, as well as among the industry organisations that represent them". Finally, the same need applies to farmers and their employees involved in the production and handling of agricultural raw materials. In particular, the authors stresses the importance that agribusiness firms and producers along the supply chain for export products apply risk management good practices, including the implementation of good agricultural and manufacturing practices, traceability, appropriate use of chemical input, recordkeeping etc. Since food safety management is often regarded as primarily a public sector responsibility, recognizing the necessity of risk management practices at different levels serves to emphasise the importance of the private sector in the enhancement of agro-food chain capacity.

Technology and related policies are crucial if one considers the importance of supply chain interactions (Esterhuizen et al., 2000). In particular, the integrated nature of agro-food supply chains requires business transactions between all the production processes, from the farm to the final consumers passing through suppliers, input supply companies, processors, financial and other service deliverers which deal directly with the primary producers. If only certain elements in the supply chain are efficiently performed, the full potential for value adding will not be realized, reducing through this the capacity to compete. Agribusinesses use information technology (IT) systems to varying degrees, and the uneven adoption of IT along the farm to retail chain and also across firms points to potential advantages for some firms (Salin, 1998). Information is in fact a crucial source for competitive advantages: delays in its adoption risk to be highly costly but, at the same time, its efficient use serves as a strategic resource to the chain. Since agricultural products can be either functional (i.e. staple goods with a predictable demand) or innovative (i.e. differentiated products, with high variety but also short life cycles), the way IT shapes the relationship between processor and retailers can change. Moreover, there are some concerns that are unique for the food sector at all the levels of the chain, namely the control for food quality and safety, and the potential for weather-related supply variability (Salin, 1998). This justifies for the food sector a different approach to supply chain management from the general management theory.

Finally, in terms of marketing policy, the evolution of market forms presents opportunities for commodity groups to undertake new roles, including advocating for changes in contract law and facilitating collective bargaining (Young and Hobbs, 2002). Commodity groups may act as intermediaries to bring together supply chain participants for negotiations over contract terms. Changes in the agricultural sector accompany changes in the organization of production, with increasing relevance of contracting.

Appendix A1: Evolution of the approach towards innovation in the policy domain

Innovation policy has evolved and developed as an amalgam of science and technology policy and industrial policy. It takes as a given that knowledge in all its forms plays a crucial role in economic progress, and that innovation is a complex and systemic phenomenon. Systems approaches to innovation, the focus of this report, shift the focus of policy towards an emphasis on the interplay of institutions and the interactive processes at work in the creation of knowledge and in its diffusion and application (OECD, 2005).

Systems approaches complement theories that focus on the innovative firm, the reasons for innovating and the activities undertaken by firms, as well as the enablers and disenables (objective and barriers) to innovations. The forces that drive innovation at the level of the firm and the innovations that succeed in improving firm performance are of central importance for policy making (OECD, 2005).

The development of modern innovation management dates back only to the first oil crisis of 1973: the whole idea of an economic crisis had been absent from academic and management thinking for almost thirty years (Dankbaar and Vissers, 2009).

During the ‘50s and ’60s, innovation was a more or less explicit element in several areas of government policy. It became an issue and argument in competition policy: in fact, the expression “innovation policy” was not used in that period. Somewhat more important was the considerable increase in government spending on science and technology, both at university and at government laboratories level: these “science push” policies were complemented by government demand for new technologies in military applications, space and (nuclear) energy (Dankbaar and Vissers, 2009). This perspective was characterized by a strong confidence in the effectiveness of research spending, so that this “first generation R&D spending” covered the first post-war decades: innovation was conceived as a simple process of implementing whatever findings researchers producers (linear model of innovation). Starting from the ‘60s, the discovery of innovation management was being firstly regarded as a contribution to organization theory: the idea was that innovation could thrive in organization structures characterized by loosely defined tasks and responsibilities, horizontal rather than vertical communication, and considerable latitude for workers to guide and direct their own work. Management was then in this context a matter of encouraging communication, experimentation and creativity than about standardization of tasks and hierarchical control (as in the dominant Taylor’s production paradigm of organisation).

Conditions and strategies change in the ’70s: in order to get out of the (global) oil crisis, governments began to set up programs supporting the “micro-electronic revolution” that was presenting itself as a new carrier technology and innovation in general. Great support was given to companies in order to set up collaborations in what was called “pre-competitive research”: government spending on science and applied research was maintained at high levels, but more money was flowing directly to companies as part of programs supporting not just research, but also diffusion of (micro-electronics) technology.

Apart from the military and semi-military targets, the new innovation policies had targets that were inspired by an increasing awareness of the “limits to growth” resulting from depletion of natural resources and of other negative impacts of the previous period of unprecedented economic expansion, especially environmental pollution. Targets therefore included the search for renewable energy sources, reduction of waste and pollution, creation of healthy work and living environments, etc. Firms also had to reassess their competitive positions since reduced growth implied an intensification of competition. Consumers could ask for more variety and better quality and firms had to react to maintain their market share. Competition was also increasingly global and would focus not just on price, but also on quality, speed, flexibility and increasingly on innovation.

This was the reason for starting a decentralization of R&D funds (“second generation R&D”), at the same time firms were developing a marketing function in order to better understand the customers, and innovation management inside the firm become therefore a problem of organizing and managing communication between marketing and research, also involving then organising communication between research, development and manufacturing. The “science push” practices of companies in the ‘50s were then replaced by a greater focus on market-oriented approaches.

The ‘80s were then characterized by a strong support from the governments towards strategic alliances between competing firms and universities and research laboratories. As a consequence, a new issue arose in the innovation management: the problem of absorptive capacity. In some countries and sectors, intermediary institutions have been created to facilitate communication between firms and universities. Universities have also become more pro-active in the commercialization of ideas generated by their researchers, forming the basis for new hi-tech start-ups.

During the ‘90s, it was felt that the considerable increase in the speed of technological change was the result of the combination of government policies and increased competition through innovation. Because of alliances, outsourcing, specialization and differentiation, innovation management became increasingly concerned with the organisation of processes across the boundaries of the firm: networking became the new buzz-word, ICT was enabling new ways of manufacturing and doing business. But the ICT role was not limited to the support of communication in innovation processes, since various tools and techniques were developed as innovative.

Since the management of innovation in networks brought a number of new problems to the fore as trust and protection of intellectual property rights, more people preferred face-to-face relations, so that even in a world of advanced communication technologies and global companies, (spatial) proximity remained still a factor of importance[17].

Innovation has since then become an increasingly distributed activity: over different actors (companies, universities, research institutes) and over different locations (sometimes spread out across the entire world, sometimes inside a single region).

As a result of this evolution, in a Systems of Innovation view, a well-developed knowledge and innovation system has seven functions (Bergek et al., 2010; EU SCAR, 2012):

1. Knowledge development and diffusion
2. Influence on the direction of search and the identification of opportunities
3. Entrepreneurial experimentation and management of risk and uncertainty
4. Market formation
5. Resource mobilization
6. Legitimation
7. Development of positive externalities

[17] Hence, the emergence of a wide literature on Regional and National Systems of Innovations.

Innovation systems can be analysed on these functions, and blocking mechanisms to develop or improve these functions can be identified (Bergek et al., 2010; EU SCAR, 2012). This can be a valid basis for policy interventions.

Appendix A2: Evolution of the research policy context (1960s to nowadays)

The European support for research dates back to the late 1950s, but it is only during the 1980s and early 1990s that the commitments in terms of incentives and coordination of research activities in the Member States (MS) becomes explicit. In particular, the introduction of the first multi-year Framework Programs (1984) reveals the intention to adapt methods and topics to the rapid evolution of research and European priorities. However, the European approach towards coordination of research among the MS is institutionalized only with the Single European Act (1986), recognizing to research policy a “legal status” equal to that of other Community policies.

Successively, the Treaty of Maastricht (1992) creating the European Union (EU) aims at strengthening the EU’s role in promoting research and technological development, providing the framework for a Community policy supporting cooperation in research and development (R&D). Conducting European research policies and implementing European research programs becomes then in the first instance a legal and political obligation with the Treaty of Amsterdam (1997).

At the same time, the Green Paper on Innovation (1995) followed in 1996 by the first Action Plan for Innovation in Europe highlight the important role the European Commission (EC) recognizes to technological innovation: the joint promotion of research and innovation and their integration become priorities of intervention not only in terms of research policy, but also of regional policy, supported by the Structural Funds and funds for Rural Development.

However, in the late ‘90s the research activity in Europe is yet to be carried out mainly at the national level rather than in a cohesive, integrated and dynamic way: it is still more the result of a “sum” of activities of MS (through their national and regional policies) than following a concrete communitarian approach. The evolutionary characteristics pertaining to the field of European R&D (namely, a high-level research, complex and interdisciplinary, expensive) demand for the establishment of a “supranational cooperation” and the encouraging of greater mobility of individuals and ideas.

This awareness results in the establishment of the European Research Area (ERA) (European Commission, 2000), namely a concept (or strategy) implying greater cohesion in research, greater mobility of researchers, knowledge and technology, networking and in this way a more efficient use of scientific resources to make Europe more competitive and to increase EU employment.

The need to set the broad policy lines for enhancing innovation, and in particular the aim of a closer correlation between “knowledge” and “competitiveness” marks the evolution of the research and innovation policy in more recent years. Innovation is recognized as essential for European enterprises to be competitive, and becomes therefore a major component of enterprise policy, as well as one of the main objectives of research policy: the European Council held in Lisbon in March 2000 strongly recognizes science and technology as priorities to ensure economic growth and better quality of life in Europe. The Lisbon Agenda (or Lisbon Strategy) is the EU’s joint response to facing the challenges of globalisation, demographic change and the knowledge society and in particular it aims at making Europe more dynamic and competitive to secure a prosperous, fair and environmentally sustainable future for all citizens.

To implement this strategy, the EC outlines policy measures aimed at encouraging the creation and growth of innovative enterprises, improving key interfaces in the innovation system, encouraging a society open to innovation. To do this, the EC stresses the importance of creating and maintaining a regulatory framework conducive to innovation.

The aim of a knowledge economy is then renewed and integrated: the European Council in Gothenburg (2001) highlights the role of the environmental dimension in economic growth and that an increased employment must go hand in hand with the sustainable use of natural resources. The European Council in Barcelona (2002) stresses the need to increase R&D expenditure from 1.9% to 3% of GDP by 2010.

However, since the results of the implementation of the Lisbon Agenda are not satisfied, the EC proposes in 2005 a new start for it; consequently, interventions to increase innovation in economic sectors and to enhance the human capital of companies and territories are heavily promoted under the priority objectives of all Community funds in the period 2007-2013.

A major breakthrough that led towards the coordination of European public research dates back to 2008, when the EC launches in agreement with the MS a very ambitious strategy outlined in the Communication “Towards Joint Programming in Research” (COM (2008) 468 final): it requires concrete commitments and actions by MS and a rethinking and reorganisation of the way national research programmes are defined and implemented by refocusing them towards common objectives.

In 2010 joint programming initiatives are then launched, becoming the framework for a more coordinated approach to public research and innovation. The Europe 2020 Strategy for smart, sustainable and inclusive growth (COM (2010)2020 final) aims to strengthen the social dimension and to combine in an effective and coherent strategy the development of an economy based on knowledge and innovation, the promotion of a more resource efficient, greener and more competitive economy, finally the development of a high-employment economy delivering economic, social and territorial cohesion. To ensure these targets, several flagship initiatives have been put forward, among whom “Innovation Union”(COM (2010)546 final), based not only on innovation, R&D and Information and Communication Technologies (ICT), but also on promoting excellence in education and skills development, delivering the European Research Area, enhancing access to finance for innovative companies. In particular, one of the aim is pooling forces to achieve breakthroughs providing a new collaboration tool: the European Innovation Partnerships (EIP), a new approach to EU research and innovation. Their aim is to bring together all relevant actors at EU, national and regional levels in order to: step up research and development efforts; coordinate investments in demonstration and pilots activities; anticipate and fast-track any necessary regulation and standards; and mobilise “demand” in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market (COM(2010) 546 final). Rather than taking the above steps independently, as is currently the case, the aim of the innovation partnerships will be to design and implement them in parallel to cut lead times. The Commission Communication of 29 February 2012 stated the objectives of the EIP “Agricultural Productivity and Sustainability” (EIP-AGRI), aiming to fostering a competitive and sustainable agriculture and forestry that works in harmony with the environment. The mission is to build a bridge between research and the application of innovative approaches in practice, in order to “achieve more from less”. The innovation model under the EIP-AGRI goes beyond speeding up the transfer from laboratory to practice (linear model), since it adheres to the interactive innovation model focussing on creating partnerships using a bottom up approach and linking farmers, advisors, researchers, businesses and other actors in Operational Groups (OG). OG bring together all these actors to implement innovative projects pursuing the objectives of the EIP-AGRI.

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Project information

Title:	International comparisons of product supply chains in the agri-food sectors: determinants of their competitiveness and performance on EU and international markets (COMPETE)
Funding:	Collaborative research project (small or medium-scale focused research project), FP-7-KBBE.2012.1.4-09, total EU contribution is 2,422,725 €
Duration:	01/10/2013-30/09/2015 (36 months)
Objective:	The objective of the COMPETE project is to gain a more comprehensive view on the different elements which contribute to the competitiveness of the European agri-food supply chain in order to provide better targeted and evidence based policies on the EU as well as on the domestic level. The project investigates selected determinants of competitiveness like policy interventions and the business environment, productivity in agriculture and food processing, the functioning of domestic and international markets, the choice of governance structures, and innovative activities in food processing. The research results will enable a congruent, coherent and consistent set of policy recommendations aiming at improving competitiveness of European product supply chain.
Coordinator:	IAMO, Germany, Prof. Heinrich Hockmann
Consortium:	16 Partners from 10 European countries. COMPETE brings together academics, trade bodies, NGOs, agricultural co-operative, industry representative advisory services. In addition, the project is supported by the group of societal actors, incorporating farmer, food processing and consumer associations, providing in-depth knowledge on the agri-food sector and speeding up the achievement of the project goals.
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COMPETE

International comparison of product supply chains in the agro-food sector

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