An Innovative Sensor in the Agro-food Supply Chain: a RFID Technology Model

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Abstract. This paper explores an opportunity for technology transfer monitoring and control, based on the use of miniaturized, smart and innovative sensors able to follow the product and guarantee the quality during all stages of the agro-food sector. The information concerning to the state of the product is transferred in real time in a wireless way, according to the RFID technology. The aim is to improve the quality and the logistics of the chain and offer therefore, environmentally friendly and cost-effective solutions to optimize production flows, by networking the existing Italian hubs. This opportunity also offers the chance to develop business ideas through which encourage settlement in the territory of new public and/or private subjects, able to offer goods and services with high technological content. Moreover, the paper aims to enhance the results of public research, through the diffusion and transfer of technologies to the productive system and the creation of high-tech enterprise.

Keywords: System of innovation, Agricultural technology, Agro-food quality and traceability, RFID Tag

1 Introduction

Policies to promote and encourage transfer of technology and innovation in the agricultural sector may take different shapes depending on both the specific target and strategies. Some may foster the creation of a community-supported network focus on how to improve the quality and the logistic of the chain and other stress efficiency of production functions of local food system. One of the main issues of the Italian system of knowledge and innovation in agriculture lies in the weak coordination among its components, particularly among development services and research. In this context, it is useful to promote policies aimed at: i) creating networks stressing multi-level stakeholders behaviors; ii) being able to facilitate the transfer of knowledge from research and agricultural innovation. Part of the needs that emerged from the development programs for Southern Italy (Mezzogiorno d'Italia) in Puglia and from the Rural Development Programs (RDP), highlight, indeed, their goals of competitiveness and sustainability of the agricultural, agro-industrial and rural sector. In this framework it might be productive to find a solution

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to optimize the agro-food supply chain through an innovative way to control the traceability of the product. The article makes use of a project useful as an example of innovative process that put the most modern information and communication technologies (for other IT innovation in agrofood sector, see also Contó et al., 2015) at the service of knowledge produced and its use. The project, which involves the use of RFID technology (Radio Frequency Identification), builds a public-private partnership composed by local institutions and various actors involved in the generation, dissemination and adoption of knowledge in the agricultural sector. Researchers, development services technicians and, through these, agricultural enterprises, have been so included in a network that aims to meet the demand for innovation and the supply of research to address specific needs of the apulian agro-food chain. After a brief literature on the system of innovation and the innovation processes, the paper provides insights about an innovative sensor based on RFID technology for the certification and food safety. Finally, it defines the role of CESAR research project, as useful tool to promote the diffusion of innovation and knowledge to boost the apulian agricultural sector. Conclusions are drawn. This work can be considered a working in progress, an attempt to propose a concrete way to foster innovation and technology transfer in the agro-food sector.

2 The System of Innovation and Innovation Process: the General Framework

Innovation is one of the key strategies proposed in the literature and economic government policies as a crucial driver of the agro-food sector. Innovation, especially in the agricultural sector, is not manifested only as adoption of new technologies, but also requires a balance between new practices, techniques and alternative ways to organize and manage: markets, labor, land tenure, distribution of benefits, etc. An innovation system is a network of organizations, companies and individuals with the aim of bringing to market new products, new processes and new forms of organization, together with the government institutions and policies that influence the methods of action of the different agents the supply chain (World Bank, 2006). Beyond researchers, extension agents and farmers, an agricultural innovation system consists of all types of public, private and civil society actors, such as inputs and processing industry actors, agricultural traders, retailers, policymakers, consumers and NGOs. The system approach recognizes the influential role of institutions (i.e. laws, regulations, attitudes, habits, practices, incentives) in shaping how actors interact (World Bank, 2006). Innovation can't be seen as a linear approach to innovation in which public sector agricultural research delivers new technology through a dissemination approach, but calls for systems approach in which innovation is the result of a process of networking, interactive learning and negotiation among a heterogeneous set of actors (Leeuwis, 2004; Röling, 2009).

The European Commission in its Europe 2020 Strategy (European Commission, 2010), places innovation and research at the center of attention for face future challenges. The orientations for the "CAP towards 2020" (European Commission, 2010) underlines the role of innovation as being a main leader in the European Union

agriculture in the coming years. Analysis of systems of innovation (Freeman, 1995; Lundvall, 1992; Nelson, 1993; Arundel and Geuna, 2004; Edquist and Johnson, 1997; Breschi and Malerba 1997), innovation and scientific networks (Freeman, 1991; Callon, 1994; Hohn and Lutz, 1994), triple helix model (Etzkowitz and Leydesdorff, 1997, 2000; Leydesdorff and Etzkowitz, 1998) and the innovation becoming more open or distributed over time (Coombs et al., 2003), in turn associated with increasing levels of collaboration and outsourcing (Chatterjee, 1996; Howells, 1999a), has led the analysis to investigate more closely the role of the nodes and links in this process (Howells, 2006). It has been applied in other sectors, mainly in industry. The concept is considered to have great potential to add value to previous concepts of agricultural research systems and growth by drawing attention to the totality of actors needed for innovation and growth, consolidating the role of the private sector and the importance of interactions within a sector, and emphasizing the outcomes of technology and knowledge generation and adoption rather than the strengthening of research systems and their outputs (World Bank, 2006). This central role of research and innovation is developed further in one of the seven EU 2020 flagship initiative "Innovation Union" (European Commission, 2010) which introduces the concept of European Innovation Partnerships (EIP) as a new way to foster innovation.

The EIP aim to foster a competitive and sustainable agriculture and forestry that achieves more from less' and works in harmony with the environment (Contò et al., 2012); help building a competitive primary sector that secures global food availability, diversified products and production, long-term supply of various raw-materials for food and non-food uses, as well as a better allocation of added value across the food chain. Under these conditions, the EIP identifies two main objectives: as an indicator to promote the productivity and efficiency of the agricultural sector, it aims to reverse by 2020 the recent downward trend in the increase of productivity; and as an indicator of sustainability of agriculture, it aims to ensure the achievement of a satisfactory level of functionality of soils in Europe by 2020.

Regarding the transfer innovation in agricultural practices, the EIP make use of a number of existing policies: the Common Agricultural Policy (CAP) rural development policy in the field of Union research and innovation, to finance innovative actions concrete; the Rural Development Programs (RDP) are implemented generally within the strict boundaries of the regions covered by the program, especially at the local, regional or national, innovative actions at the interregional level, cross-border, and must be co-financed by the Union policy in the area of research and innovation. Synergies are sought with the opportunities offered by cohesion policy, in particular through regional strategies for innovation and transnational and interregional cooperation programmes (Materia, 2012).

Others key concepts related to the innovation as system and diffusion of knowledge, can be find on social dynamics and the so-called open innovation. In line with the communication of the European Commission, the rural sectors in Europe call for a review of the links between knowledge production and its use to foster innovation. The new agricultural knowledge and innovation system (AKIS) must adapt to the emerging economic, social and environmental challenges by making the best use of diversity in technologies and innovations that can achieve more with less while respecting the environment. Social innovation stresses the need for social and

political changes in the context of rural development and producer-consumer relationships. Social innovation includes collective and creative learning processes, in which actors form different social groups and rural and urban contexts participate (European Commission, 2013). Together they develop new skills, products and/or practices, as well as new attitudes and values that make a difference in addressing the sustainability challenge in rural societies. The necessary skills, moreover, to achieve new forms of competitive advantage for small and medium-sized enterprises (SMEs) in the agro-food sector as "dynamic capabilities" emphasizing the key role of strategic management in appropriately adapting and integrating internal and external organizational skills, resources and functional competences to match the requirements of a changing environment (Teece et al., 1997). The role assigned to the social innovation passed thus through the concept of open innovation and its relation with the competitive advantage for the SMEs. The theory of Open Innovation and the business model that derives from it, are particularly adaptable to the configuration management of SMEs. Many smaller companies manage to be innovative only in the moment in which they are able to define, support and give continuity to its competitive advantage. Nevertheless, the likelihood of such optimal conditions is reduced to the high level of risk related to innovation, the high degree of uncertainty about the possible economic returns, the lack of a coherent model of innovation management (Cooper et al., 2005). We must, however, emphasize that economic conditions are forcing even the most entrepreneurial "closed" to consider the possibility to go beyond their boundaries and explore the outside world. Faced with this situation, recent studies in the field of innovation and technology management, explained the potential benefits related to an innovative process of opening to the outside (Gassman, 2006), usually characterized by reduced bureaucracy and greater inclination to risk by administrators, possession of highly specialized knowledge, increased ability to react to rapid changes in the market (Christensen et al., 2005). In SMEs, even more than in the large corporates, being innovative means knowing how to better manage their "strength" competitive. From this point of view, the rapid changes in technology are certainly not helpful, because induce small businesses to activate processes of product development in an ever more quickly and efficiently manner. This, in some ways, could result in enormous sacrifices but, arriving before the direct competitors, would mean obtain innovative and cost effective advantages. One way to stimulate this new evolutionary process consists in emphasizing links with actors in the micro and macro business environment, thus creating that knowledge system useful to acquire the dynamic capabilities to meet the challenges that agricultural companies have to face.

Next section, then, will focus on the way in which we can apply such innovation system models, analyzing how to develop innovative ideas using the most recent information and communication technologies.

3 An Innovative Sensor in the Agro-food Supply chain: a RFID Technology Model

3.1 Quality and Traceability of food product

As mentioned before, it is useful to promote policies aimed at creating networks stressing multi-level stakeholders behaviors, able to facilitate the transfer of knowledge from research and agricultural innovation. With this aim has been achieved the CESAR project (Certification and Food Safety by RFID), still in early stages, in the Apulia region, an attempt to bring together the efforts to create a network that involutes public and private institutions to promote transfer of technology. For farms participating in the project represents an opportunity offered totally free, to test a system of transfer of technology for monitoring and control, based on the use of miniaturized sensors and intelligent able to follow the product and guarantee its quality, during all stages of the food chain. The quality and food safety are parameters that accompany the whole life of the product, since the primary production, in all stages of processing, storage and packaging. In these stages (post-harvest or post-production) is more critical to perform controls due to the risk of a deterioration which affects the work done upstream and degrades a product which initially was of high quality. Keep under control and continuously monitor certain parameters essential for the quality of the product is an activity which, however, still today, is not carried out in a totally efficient manner. The current procedures provide, in fact, to set the best conditions for the processing and to perform a test on individual lots, but this system does not provide the certainty that uncontrolled lots are in accordance. The potential economic saving should not be underestimated because sometimes the individual lots are so broad as to cover a working day or a whole order of the customer. To reach this goal is necessary to move completely the way to manage the traceability of the product: not affects only the origin of it but involves detailed information on what happened at each stage of the life cycle, consistently and without interruption. Currently, the management systems of traceability and quality are concerned with collecting data at various stages of production, but these data are acquired in necessarily discontinuous procedures and grouped in batches. In other words the data available are restricted to individual production lots which represent quantities far greater than those refer to the individual production units. The quality is seen as the average value of more detections, in the best of cases, or as the single value of the significant sample on which are performed the analysis. There is no way to know what happens at the level of single production unit. The information is then distributed and not centralized and "follows" the product along the way acquiring and transmitting the parameters that identify the preservation of quality. System developed in turn provides a system of checks distributed and will be responsible for read the information collected and continuously detect the value of the individual parameters, allowing, appropriate steps to verify if they comply with the directions of the production rules. This allows

to assess whether conditions that occurred, have altered the quality of the product, including expense of food security.

3.2 RFID model

Briefly, in this session we describe the functioning of the technology. The information relating to the state of the product is transferred in real time in a wireless manner, according to the RFID technology. RFID technologies, thanks to the possibility of monitoring and tracking deals, are suitable for applications increasingly widespread within the various food chains, especially to uniquely identify the products and reconstruct the history along the chains. The RFID systems, compared to those more established as the barcode, offer additional benefits such as greater number of storable information, the presence of unique identifiers and irreproducible, a greater reliability of reading and the possibility of storing information in either a centralized, in a database, and decentralized way directly to each product. The sensors are in the network and communicate the data in a wireless manner using RFID technique that allows the transmission in two different ways.

First mode involves querying the sensor to pass through special gates, with readers and places corresponding to certain stages of production (at the entrance of the storage area, at the entrance of cold storage, at the beginning of line processing, packaging, shipping, etc.). The second mode provides for the spontaneous transmission by the sensor when one of the detected parameters, which proves to be particularly critical, exceed certain threshold values. In this phase, the sensor sends a signal to indicate that the product is at an early stage of degradation and action must be taken promptly.

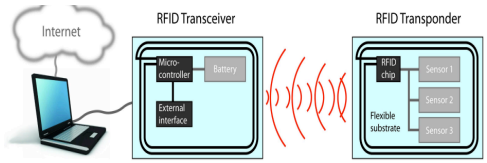

Fig. 1. RFID technology. Source: our processing.

The last frontier in the field of RFID technology is the introduction of active tags equipped with sensors that can detect environmental parameters (temperature, pressure, humidity, gas) where the products subject to control, they are immersed. The values measured by the sensors are stored in a special internal memory, and remain there until an operator equipped with card reader, do not run the exhaust on a Handheld PC. This is of strategic importance for the monitoring of organoleptic parameters of food and perishables in general, where it is necessary to ensure operational regimes controlled. The tags, because of the small size, can be placed in "uncomfortable" points, where it would be difficult to bring a card and a cable access needed to fuel a measuring device, and offer much content costs, a reliable solution and easy to implementation. Thanks to the use of such solutions can monitor the state of conservation of a substance, or report an alarm when the temperature parameter is not in the desired range, without opening the packages that protect the substance stored in temperature and managing the data in a data processing, from a central site,

where to take the appropriate decisions: delete the product or accelerate the treatment of a process. The software platform, by interfacing with the appropriate RFID detectors, will deal with the acquisition of the data collected by the sensors and processing them in order to ensure the constant monitoring of the products during each phase of the production cycle. In each phase, the system will be able to determine the condition of the product and to promptly identify the conditions that may lead to a degradation with consequent reduction of the quality and healthiness. In this stage is important to disclose the technology which in fact consists of a platform integrated and configurable able to adapt to the specificity of each individual production, both within the same chain, either of different sectors. The technology therefore consists in a system of distributed monitoring of perishable food products through the use of intelligent micro sensors placed on the individual units of product. The system consists, briefly, of two basic elements: a network of distributed sensors and a software platform for the collection and analysis of data and may also be implemented in an integrated form (RFID tags) for the monitoring of the individual products and as Mini-Card (black box) for the monitoring of batches. In the first case the chip (RFID tag) is integrated in the package and intended to be thrown away with the packaging when having assumed his job during the life of the product on the shelf or shelf distributor; in the second case the black box will follow the life of the batch of product and will be destined to be reconfigured and reused over time.

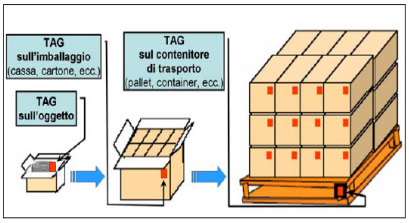

Fig. 2. Tag's positions. Source: our processing

4 The CESAR project and the public-private Partnership

The aim of the RFID model is to improve the quality and supply chain logistics and propose therefore, environmentally friendly and cost-effective solutions to optimize production flows, networking italians hubs already exist and so favoring the process of internationalization of local companies. This opportunity also offers the chance to develop business ideas through which encourage settlement in the territory of new public and/or private individuals, able to offer goods and services with high technological content. The implementation of the concepts expressed above and the adaptation of the methodology to the specific case, is the result of the "Associazione temporanea di scopo -ATS" (Syndacate association on a temporary basis), who presented the CESAR project. The CESAR project (Certification and Food Safety by RFID) identifies the research project presented in the spring of 2012 to the italian Ministry of Economic Development. It consists on a public-private partnership

composed by the Polytechnic of Bari, Unione provinciale agricoltori (Provincial Union Farmers) Foggia, Confindustria Foggia, Agro-food Regional District (DARe) and the University of Bologna, in response to the program from the system for Technology Transfer Research to SMEs and the creation of new high-tech companies. The CESAR research project, still in an early stage, has a duration of 24 months. The main activities concern (i) the structured analysis of the connections between the supply of technologies and demand for innovation; (ii) the development of an innovation strategy geared to productive specialization and (iii) the needs of the SME market and the strengthening of a common culture of innovation in relation to the subsequent processes of technological spillover and start-up company.

Specifically, monitoring technology of perishable product and processing of data will be managed at the Polytechnic of Bari and at T3LAB (University of Bologna), experts in engineering and RFID technology; the presence of the other partner, DARe, Confindustria and Provincial Farmers Union Foggia, will overcome any difficulties in technology transfer in areas of the territory not informed of developments occurred in the field of quality control in the food chain using RFID techniques and more generally will address the dissemination of knowledge and intermediation between universities and farmers. For support, supervise and coordinate the activities that govern the transformation of research results into economic value, such as the protection and enhancement of the results found and the generation of innovative entrepreneurship, the partnership provided for the definition of specific actions.

Moreover, the activities can be summarized as follows: the study activity has declined in three logical functions. The function of knowledge mapping through which organize and manage data about the technologies. The function of innovation intelligence through which detect and correlate the need for innovation, the technological potential, the enablers and the value propositions of companies. The function of community building through which support the relations of exchange and mutual learning. These functions will be based on three other tasks:

1) structuring the portfolio of technologies and technology scouting activities. This activity aims on the one hand to develop a strategic review process technology offers, in order to compose a technology portfolio structured according to the innovative profile of protectable and market opportunities. On the other hand, consider the placement of technology both with respect to the characteristics of specific regional clusters of agribusinesses, and opposed to the larger technological scenarios for the sector, in order to create the appropriate conditions for subsequent technology transfer actions;

2) analysis of the innovation needs. This activity is designed to detect the needs of innovation coming from companies in the region through the analysis of key business needs, technological competence in terms of assets and know-how, resources and organizational capabilities. A clear and shared approach paves the way for the adoption of a dynamic orientation to the formulation of strategies aimed at overcoming the gaps of innovation;

3) establishing patterns of technology transfer. This activity aims to identify, analyze and select the most suitable models for technological transfer to the enhancement of the proposed technologies, depending on the characteristics of the technical-scientific (transdisciplinarity), the regime of appropriability of knowledge (replicability), the

nature and type of additional resources needed (absorption), the coordination and integration of the flow of knowledge and information (organization).

5 Discussion and Conclusions

The present paper intended to define a model of organization based on theories of system innovation and technology transfer, able to enhance the results of public research through the dissemination and transfer of technologies to the productive system and the creation of high-tech enterprise.

Especially in Puglia, the majority of small and medium enterprises in the agro-food sector feel as fundamental the satisfaction of the need for technological innovations that allow to improve food security and the health quality of their products, thus adapting to the constraints posed by food law, and eliminating or reducing the risk of poisoning, infection and disruption to consumers related to the presence of biological contaminants in food, chemical or physical. The ability to create a model that deals with traceability and certification of agro-food product based on RFID technology, would mean improve the quality and the logistics of the chain and offer therefore, environmentally friendly and cost-effective solutions to optimize production flows, by networking the existing Italian hubs.

The analysis carried out with the implementation of the CESAR project has strengthened the idea of the innovation system and technology development, involving public and private stakeholder of the territory. The project allows to: (i) analyze a structured connections between the supply of technology and demand for innovation; (ii) develop an innovation strategy oriented to productive specialization and to the needs of the SME market; (iii) strengthen a common culture of innovation according to the subsequent processes of technology spillover and start up business; (iv) disseminate information, prospects and opportunities resulting from research and experimental development; (v) ensure the active participation of the largest number of SMEs and the most relevant regional stakeholders operating in the agro-food sector; (vi) determine and assess the skills, processes and technology needs of a sample of SMEs, identifying strengths and weaknesses and (vii) explain the potential of technologies to be transferred demonstrating their actual applicability on a pilot scale. The paper used as a tool for technology transfer and innovation in agricultural sector, the Partnership presented within the CESAR research project allowing a strong link to territory and making possible the enhancement and the creation of high-tech enterprise in Puglia.

We conclude that the partnership represents an organization of public and private actors which is able to foster the implementation of the RFID model creating a system of technology transfer in the agricultural sector. We believe that the guiding principle of the actions promoted by the ATS lies in the awareness that a stronger relationship between the universities and the socio-economic context provides a solid basis for the exploitation of results and the strengthening of institutional relations and economic benefits in favor of the Apulian agro-food sector. We are aware that promote an effective dialogue between universities and industry, focusing on innovation and technology transfer, therefore means supporting businesses in the

difficult task of facing the challenge of competition relying on access to adequate levels of quality research and development.

For the future, the strategy to be adopted will therefore help to bridge the gap that still exists between research and the market in the innovation process. The exchange system is designed both to provide answers to specific questions, and to help qualify the same demand for innovation. The need for exploiting the results of research does not sit just downstream of their implementation, but encompasses the whole operating process, from decision making to scientific processes and institutional relations.

References

1. Arundel, A., Geuna, A. (2004) Proximity and the use of public science by innovative European firms. Economics of Innovation and New Technology, 13, 559-580.
2. Breschi, S., Malerba, F. (1997) Sectoral systems of innovation: technological regimes, Schumpeterian dynamics and spatial boundaries in Edquist C. (ed), Systems of innovation, F Pinter, London.
3. Callon, M., (1994) Is science a public good? Science, Technology and Human Values 19, 395–424.
4. Chatterjee, D., (1996) Accessing external sources of technology. Research Technology Management 39 (2), 48–56.
5. Christensen, J. F., Olesen, M. H., Kjær, J. S. (2005) The industrial dynamics of open innovation: Evidence from the transformation of consumers electronics, in "Research Policy" n. 34 (10), New York-NY, 2005, pp. 1549.
6. Contò, F., Fiore, M., La Sala, P., (2012) The role of innovation in the integration processes of the supply chain and in the New Economics of Food, University of Foggia, Italy.
7. Contò, F., Faccilongo, N., La Sala, P., (2015) The effects of cloud approach in short chain administration, International Journal of Agricultural and Environmental Information Systems (IJAEIS), 6(1), 19-31.
8. Coombs, R., Harvey, M., Tether, B., (2003) Distributed processes of provision and innovation. Industrial and Corporate Change 12, 1051–1081.
9. Cooper, G., Edgett, S. J., Kleinschmind, E. J., (2005) Best practices in product innovation: What distinguishes top performers, Ancaster-ON, Product development Institute Inc., pp. 122,123.
10. Edquist, C., Johnson, B., (1997) Institutions and organizations in systems of innovation. In: Edquist, C. (Ed.), Systems of Innovation: Technologies, Institutions, Organizations. Pinter, London, pp. 41–63
11. Etzkowitz, H., Leydesdorff, L. (1997) Universities and the Global Knowledge Economy: A Triple Helix of University-Industry-Government Relations. London: Pinter.

12. Etzkowitz, H., Leydesdorff, L. (2000) The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University-Industry-Government Relations. Research Policy, 29(2), 109-123.
13. Etzkowitz, H., Leydesdorff, L. (1998) The Endless Transition: A "Triple Helix" of University-Industry-Government Relations, Introduction to a Theme Issue. Minerva, 36, 203-208.
14. European Commission (2010) Communication from the European Commission, Europe 2020: A strategy for smart, sustainable and inclusive growth, COM (2010) 2020.
15. European Commission (2010) Communication from the European Commission, The CAP towards 2020. COM (2010) 672.
16. European Commission (2010) Communication from the European Commission, Europe 2020 Flagship Initiative, Innovation Union. COM (2010) 546.
17. European Commission (2013) 1st Meeting of the High Level Steering Board of the EIP Agricultural Productivity and Sustainability, Brussels, 21 February 2013.
18. Freeman, C., (1991) Networks of innovators: a synthesis of research issues. Research Policy 20, 499–514.
19. Freeman, C. (1995) The National Innovation Systems in historical perspective, in Cambridge Journal of Economics, vol. 19, no. 1.
20. Gassman, O. (2006) Opening up the innovation process: Towards an agenda, in "R&D Management" n. 36 (3), Oxford, 2006, pp. 22-228 e U. Lichtenthaler, Open Innovation in practice: An analysis of strategic approaches to technology transaction, in "IEEE Transaction" n. 55 (1), Fayetteville-AR, 2008, pp. 148-157.
21. Hohn, H. W., Lutz, S., (1994) Contingencies of innovative networks: ¨a case study of successful interfirm R&D collaboration. Research Policy 23, 47–66.
22. Howells, J., (1999 a) Research and technology outsourcing. Technology Analysis & Strategic Management 11, 591–603.
23. Howells, J. (2006) Intermediation and the role of intermediaries in innovation. Esrc Centre for Research in Innovation and Competition (Cric), Institute of Innovation Research, University of Manchester.
24. Leeuwis, C. (2004) Communication for rural innovation: rethinking agricultural extension. Blackwell Science, Oxford
25. Lundvall, B. (1992) National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter Publishers.
26. Materia, V.C. (2012) European Innovation Partnership (EIP) and opportunities provided to the agro-food SMEs by the network approach, ISCI, Bari.
27. Nelson, R.R. (1993) National Innovation Systems: A Comparative Analysis, Oxford, Oxford University Press.
28. Röling, N., (2009) Pathways for impact: scientists' different perspectives on agricultural innovation. International Journal of Agricultural Sustainability 7, 83-94

29. Teece, D. J., Pisano, G., Shuen, A. (1997) Dynamic capabilities and strategic management, Strategic Management Journal (18) 7, pp. 509-533.
30. World Bank (2006) Enhancing Agricultural Innovation: How To Go Beyond the Strengthening of Research Systems. Washington: World Bank.
31. World Bank, (2008) Agricultural Innovation Systems: From Diagnostics toward Operational Practices, in: Department, A.R.D., Discussion Paper 38. World Bank, Washington D.C.