The problems of measuring innovation in primary activities: a dilemma seeking a solution in the countries of Latin America

Anlló, Guillermo[1]; Bisang, Roberto[1]; Berardi, Valeria[2]; Erbes, Analía[3] & Stubrin, Lilia[4]

Introduction

The present study arises from the importance of innovation in biology-based activities. For the purposes of this study, this is understood as primary agriculture and livestock production[5]. It also considers the transformations that have occurred in recent years in the productive context of these activities, which has led to major changes in production processes, in organization and marketing forms, and in the emergence of food products in a quantity and quality never seen previously.

In this context, two main objectives are proposed. Firstly, to present an initial approach to the existing limitations of current instruments for measuring innovation in agricultural activities. Secondly, to identify from surveys undertaken by various institutions some relevant elements which should, in the authors' judgement, be considered to show the specificities of the innovation dynamic in this type of production.

With this in mind, the following section will present the main transformations that have occurred in recent years, both in the production and in the marketing of products derived from agricultural activities. Particular consideration will be given to changes occurring in the technological sphere of these activities and in the logic of integrating these into value chains, highlighting the incidence of all these processes in countries in the Latin American region. This will be followed by a brief historical overview of the evolution of the concept and measuring of innovation in general –with particular mention to the milestones of the Frascati family of manuals– and in particular for the agricultural sector, seeking to contribute some elements for a reflection on how to capture the phenomenon. We will then present the main blocks of indicators traditionally used to show the dynamics of innovative processes in the manufacturing industry, and discuss the suitability of these for analysing innovation processes in agriculture and livestock from the compilation of progress made to date in terms of measuring innovation processes in agricultural activities. This will begin from the analysis of what is set forth by different innovation manuals, evidence observed in the analysis of the innovation process of the agricultural sector and various survey forms used at national and provincial level in Argentina, with the objective of inquiring into the characteristics, dynamics and requirements of the new agricultural sector.

---

[1] CEPAL office in Buenos Aires.
[2] Universidad Austral Rosario
[3] Universidad Nacional de General Sarmiento-CONICET
[4] UNU-MERIT
[5] With this clarification in mind, the rest of this text will refer indistinctly to agriculture and livestock/primary activities and to the agriculture and livestock/primary sector.

1. A new technological model for agricultural production

1.1. Transformations in global markets of biology-based inputs and final goods

In recent decades, in the context of a growing process of globalization and regional integration, the world has witnessed major transformations in the design, production, exchange and consumption of goods and services, changing the way countries participate in the global economy. These processes have been accompanied by changes in the organization of production, in the characteristics of economic agents that streamline productive activities and, more slowly, in forms of regulation and institutions, configuring what appears to be a new stage of economic development.

Many authors place these changes in the context of the emergence of a new technological paradigm characterised by the use of information and communication technologies and biotechnological techniques (Freeman & Pérez, 1984; CEPAL, 2009; Pérez, 2009). The current period appears to be a transition moment between an old and new paradigm, in a kind of recreation of the Schumpeterian concept of "creative destruction": while one old, consolidated part of the productive apparatus is brought into question, the other, more recent part, with new economic agents, enjoys clear dynamism (Schumpeter, 1942).

Any phenomenon of this type brings with it changes and new challenges. In particular, the diffusion of the new paradigm redefines the value of the various assets, sectorial limits and balances, while opening up the possibility of a new form of insertion into the global economy. In the case of developing countries with the advantage of abundant natural resources –as in most of the region– the budding paradigm poses opportunities from the generation, adoption, adaptation and diffusion of new technologies in activities associated with "biology-based inputs"[6]. Under this new paradigm, the reference to "primary elements" refers to a group of biology-based inputs which may be intended for diverse uses in various industries, including foods, biofuels and biofactories.

These developments also imply major changes in the conception of activities related with land use, which traditionally were considered non-dynamic productions and with a scarce or insufficient multiplying effect on the rest of the economy. Both from a technological and productive point of view, their evolution was associated primarily with climate fluctuations and the additional incorporation of resources. In this context, agricultural production and food production were practically synonymous (since agricultural products were intended exclusively for food production) and shared the term "primary".

At present, the breakthrough of the new techno-productive paradigm has come simultaneously with a greater dynamism in demand for agricultural products, which in turn are not only used as food inputs, but are also used as inputs for other productions. This process of growing demand for production of biological origin in recent decades is mainly due to:

[6] In this study, those products traditionally known as "primary" (mainly grains, oilseeds and livestock products, and related almost exclusively to food production are called "biology-based inputs", given their multiple possible uses for industrial transformation.

a) the **development of economies** of considerable size, with growing incomes and growth rates –China, India, some African and Eastern European countries, based on this, have driven variations on their **food consumption** levels and make-up, As their incomes grow, they tend to change from a relatively elemental food system, based on green proteins (soy, vegetables, etc.) to one centred on red and/or white proteins (meat and dairy products) with greater processing (within and/or outside the home), quality and differentiation (branded meats, fine wines, fresh fruit);

b) **new mass demand** from attempts to establish **energy matrices** that contain a growing component of fuels from **renewable sources** (Rothkopf, 2008). This means that a broad range of grains and oilseeds are reoriented particularly towards energy production, in the context of legislation that forces growing percentages of blends with fossil fuels (Argentine Chamber of Renewable Fuels, 2009)[7];

c) the growing use of **biomass** –organic compounds from plants activated with bacteria and/or specific technological processes– intended for the production of industrial inputs (bioindustry) previously produced from cracking oil. Although commercial cases are still incipient, the trend indicates that over the coming decades the chemical industry (pharmachemical and fine chemical) will be sustained by biofactories (animals and/or plants pre-designed to operate as industrial transformers and/or producers of diverse industrial raw materials);

As expected, the new technological paradigm implies changes –some of them radical– in multiple aspects of production, including product and process technologies, the way production is organized, characteristics of actors involved in the productive process, and the functioning and regulation of the process. In turn, these changes affect global exchange in at least two respects. Firstly, intangible factors such as knowledge, the mastery of techniques, the capacity for innovating and the handling of quality, gain relevance over the condition of having an abundant supply of natural resources. Secondly, trade of these products is generally a trade of more complex products with a greater degree of processing and/or value which allows the formation of segmented demand through the development of specialized supply.

1.2. An alternative way of organizing exchange: global value chains and agro-food productions

Traditional models tended to account for the trade of final goods from the endowments of static technologies and factors. At present, these dimensions are not enough to account for commercial flows of intermediate products, due to the international fragmentation of activities in markedly dynamic contexts, which lead to a growing specialization in productive stages and processes to supply demands which become universal. In this context, each country seeks to develop activities that permit it to specialize in segments with greater accumulation capacity, within productive chains

[7] Both the USA –ethanol/maize– and the European Union –biodiesel/oilseeds– have legislation that stipulates growing percentages of blends with fuels of vegetable origin. Around forty countries have similar types of legislation.

which include everything from production to final consumption of goods, configuring a dynamic process which necessarily admits multiple and new patterns of specialization, since there are very few countries that can integrate complete chains within their territory (Farina & Zylbersztajn, 2003; Gereffi, Humphrey & Sturgeon, 2005; Giuliani, Pietrobelli & Rabellotti, 2005; Bisang & Sztulwark, 2009).

These new models of production and exchange question the analytical relevance of traditional "sectorial" studies whose analytical unit implies a group of independent, homogenous, undifferentiated agents connected exclusively through the price system. Thus, a new approach emerges of global value chains (GVCs), identifying a group of inter-related activities through an increasingly global governance structure in which a broad range of new and updated economic agents participate (Gereffi, 1996; Kaplinsky, 2000; Kaplinsky & Morris, 2000).

The concept implies the analysis of a group of coordinated activities, developed by different economic units and in diverse physical spaces, but with one or various coordination nodes (whether by induction and/or control of diverse forms of capital – physical, financial, technological). This translates into enterprises that deverticalize stages and/or complete activities from their production role, while simultaneously expanding or focusing on activities that remain under their control. The trend for dispersing production physically necessarily affects the territorial distribution of economic activity, which translates into a growing redefinition of global specialization of these activities (Dicken, 2003).

In this operational structure of the global economy, which has a correlation in internal productive specialization, the accumulation of a society, activity and/or enterprise is strongly associated with the "place" which it occupies in the world network, and the structure and dynamics of its operation. Some authors have identified specific command "nodes" of these new organizational forms from the strong economic, financial, technological and IT (among others) asymmetries which are habitually seen in economic agents. The most studied include the relevance of availability (globalized chains commanded by suppliers) and/or commercial networks (dominated by the buyer) in GVCs, which defines that a large part of the profit is directed towards these nodes via diverse operational mechanisms, including the control of commercial channels, carrot-and-stick mechanisms and the creation of entry barriers (Gereffi, 1996; Gereffi, Humphrey & Sturgeon, 2005; Bisang & Sztukwark, 2009).

The specificities of biological elements add distinctive characteristics to this particular way of organizing production. As GVCs imply a geographic segmentation of activities and, as a consequence of this, the differentiated incorporation of new economic agents/stages in the flow of global trade, the location in the GVC redefines the national possibilities of accumulation. In the new context, then, it is not only the availability of national resources and their subsequent exploitation that is important, but also the type of specialization adopted and insertion into the GVC as a result of this. That is, agents' behaviour and innovative strategy becomes a determining factor.

Graph 1 presents generically the new structure of GVCs in agro-foods, whose greater complexity and specificity lead to rethinking producers' global insertion strategy. Their operation can be described as follows.

The agro-industry, in its broadest sense, uses inputs whose production is subject to biological time, not totally controlled by man, which defines the length of time in a cycle of primary activities and, in turn, their fixed/circulating physical capital relationships. This means that, in depending crucially on natural products, agro-industries have a high production risk due to such factors as climate variations, soil behaviour and various diseases. Consequently, the quality of the final product depends on the quality of the raw material affected by innumerable variables generally beyond the producer's control. Natural inputs, final products and technical processes vary greatly in their technical parameters (no two living things are identical), hence the standard product definition and quality, safety and health norms are vital in determining a product "travelling" within a chain.

Graph 1. Generic structure of global value chains for agro foods

Source: Anlló, Bisang, & Campi (2009)

In addition, and specifically with foods, the final consumers "form" their demand according to tastes that reflect cultural and social aspects, with specific customs of each social and territorial segment, which do not necessarily respond to objective technical parameters, defining as an initial precondition the "adjustment" of the final product on the chain to naturally segmented demands. From the supply side, it has been observed that an increase in primary production of agricultural products does not automatically translate into a greater availability of foods and/or industrial raw material, as between these and the consumer there is a long series of steps involving industrial transformation, conditioning, concentration, transport, logistics and marketing. In turn, uncertainty necessarily leads to the presence of a multiplicity of contracts as a way to cover and share risks, while high subjectivity and biological variability also mean the presence of multiple instances of product and process certification.

In the context described at least two reconfigurations occur that are related to the stages of industrial production included in these chains. On the one hand, there is an increasingly relevant existence of an industrial supply of inputs for primary production, dominated by large enterprises (mostly with multinational capital) dedicated to the procurement of improved genetics, herbicides and insecticides, in the context of new technological packages. On the other hand, the subsequent industrial stage is also transformed, generating less vertically integrated firms, with high levels of subcontracting –especially for provisioning producers (the agricultural part of the contract) and/or marketing– and a growing use of new technologies, both in foods and in biofuels and biomaterials[8].

Therefore, a new form of organization of production and exchange is configured which has a growing presence of multinational enterprises which, stimulated by new

[8] Among other things, the new paradigm has generated changes in the way in which research is done, in the types of technology that are created and the way they are shared. These new developments demand a high level of complex scientific knowledges, as well as considerable investments in research and development. As would be expected, these factors have generated transformations in enterprises which have become dominant in the new paradigm, which come from chemicals and the pharmaceutical sector, and work together with seedbeds, biotechnological enterprises, laboratories and universities, through a process of agreements, mergers, takeovers and other business strategies which position a limited, concentrated group of enterprises as leaders.

international financial instruments, undertake merger and takeover processes to gain a leading position in the main GVCs. Although these enterprises have their core in the industrial phase, they tend to deverticalize their activities in this sphere by generating networks of providers, controlling brands, distribution channels and technology centres, broadening their activity ranges over other stages (production, marketing, etc). In this context, access to large investments, intellectual property rights legislation, brand control and the existence of entrance barriers for new producers are all vital for capturing part of the profits generated over the length of the process.

In turn, the industry/consumer interface is altered by the mass emergence of great commercial distribution, which not only redefines its operation as an intermediary without acquiring products, but also leads to productions with own brands and production of third parties. This so-called great distribution, made up of globalized supermarket and hypermarket chains, currently controls between 40% and 60% of world food trade, depending on the region. New economic agents also enter this stage, such as HORECA (hotels, restaurants and catering) chains, which aim at the creation of foods with various degrees of serialization –which become nodes of some relevance in some segments of particular markets– and logistics enterprises, which complete this new panorama from initial production to consumption.

Despite the importance that the new organization of production has taken on and the exchange in the agricultural sector, it is important to highlight that at present this model coexists with the previous model, characterised by greater segmentation based on specialization between agriculture, industry and trade, and integrated by spot markets.

An international crisis such as in recent years is fertile ground for a new positioning of economic agents, the relocation of activities and the modification of controls of critical nodes within the networks, as well as the revision and/or consolidation of GVCs. From this perspective, it is worth inquiring into the techno-productive profile of local activity and its compatibilities and/or incompatibilities to adapt to these forms of global organizations. In other words, is local agriculture and its subsequent industrial derivation in a fit condition to adapt to international networks? Can it scale up to more complex stages? The answer to these questions is invariably tied to the innovative capacity of the sector. Therefore, given the economic weight of the sector for Latin American countries, it is peremptory to explore further this innovative capacity.

1.3. The productive integration model in the network context[9]

The preceding sections have highlighted the importance of various structural changes which in the last two decades have led to the emergence and dominance of a production model with renewable resources of biological origin characterised by **network organization**, which is expanding in the region, at least predominantly in Southern Cone countries. To survey innovative activity in the sector it is fundamental that one understands the nature of the major agents in this, in order to know whom should be surveyed.

[9] Although the analysis undertaken in this section in predominantly based on observations of the agricultural production of cereals and oilseed –the most widespread crops in Southern Cone countries– the characteristics described are similar to those found in other types of agricultural production.

In a stylised and reductionist description, this production organization model presents the following general features: i) the person undertaking agricultural activities may no longer necessarily be the landowner, ii) there are enterprises that coordinate financial capital, decide which activities to undertake and hire land and services to carry this out (**Agricultural Production Enterprises**); therefore, iii) previous Agricultural Exploitation activities are deverticalized and providers of services and inputs of an industrial origin take on greater presence; iv) productive, commercial and technological exchanges are sustained by temporary lease contracts for undertaking activities; v) technology is increasingly relevant for sustaining competitiveness, now with a notable external element in its supply; and, finally; vi) demand for products (grains, milk, meat, etc.) translates into more quantity, quality and differentiation. Operating along these lines necessarily means a new map of economic agents and new models in terms of productive specialization, constant innovations, relationship systems, risk sharing and a dynamic operating group.

In this model, the "agricultural producer" includes various economic agents coordinated from a growing separation between **Landowners**, who lease this means of production, **Agricultural Production Enterprises (APE)**, which carry out production by coordinating activities based on the possession of knowledge, and a group of specialized suppliers of goods and services. The APEs, in undertaking their activities with a marked deverticalization, articulate ("drag") a large number of other service providers (contractors) and input suppliers. All of this is dedicated to an activity which has gained in technical complexity and, as such, requires a **knowledge support system** far more complex than earlier "tacit knowledge" in the integrated model[10]. Knowledge is no longer exclusive to the producer, but is shared by different economic agents in the network.

What distinguishes the APE is not land ownership and access to capital, but the coordinating function it carries out in the new model and its possession of the strategic asset of "knowledge". This is an economic agent that coordinates the use of land (whether own land or the land of others) and knowledges with the performance of different productive work to develop a set of products of biological origin. To do so, it is financed by concentrating monetary capital (from investment funds to private agreements) while, like any company, seeking ways to minimize risk through insurance (future price cover, adverse weather insurance) and/or diversify the portfolio of products/productions by producing at different locations, producing a mix of diverse crops and/or combining with livestock and/or dairy.

In terms of organization, the APE is generally characterised as a small structure but highly specialized in financial, legal, productive and technological matters, albeit with different nuances, sizes and forms of operation (Barsky & Dávila, 2008; de

[10] The productive organization model, known as **vertical integration** or **integrated** production, was predominant in past decades and is present in part of current production. It is based on the control, via ownership or lease, of the key factor of land and its direct exploitation by the agricultural producer. This models a consistent strategy in developing internally and at the producers' own risk the greatest possible number of processes with equipment which they own themselves. The aim of this form of production organization is mainly to increase produced quantity by homogenizing procedures and products (similar to the Ford production model at industrial level) and gaining in economies of scale. To this end, productive and technological efforts quickly aimed to mechanize agriculture, homogenize and increase seed productivity and standardize productive processes (ploughing, sowing, etc.) with necessary adaptations to each particular area (Anlló, Bisang, Campi, 2010).

Martinelli, 2008; Cloquell et al., 2007; Lattuada, 1996; Posada & Martínez de Ibarreta, 1998). From the legal perspective, the "formats" used by these enterprises include de facto business associations (relevant for small-scale developments or incipient financing for small sowing pools), commercial corporations; transitory unions of companies; common investment funds and agricultural trusts, among others. These economic agents are not necessarily present purely in production, fundamentally as a consequence of the increased variability of the model in terms of changes in the economic and regulatory environment.

The technology that sustains APE activities has an initial component incorporated in the inputs (machinery, seeds, etc.) and a complementary component in the form of non-codified knowledges (such as the layout of the package of optimal inputs for each production lot) which are generated internally and which often require the incorporation of professionals. As productive complexity grows, the growing weight of scientific knowledge begins to grow, and its core lies in biotechnology.

In turn, in the context of network organization, another group of relevant actors is aligned around these enterprises which vary according to the activity in question (agriculture, livestock, dairy and others)[11]. All these make up the new productive model, influence the generation and transmission of knowledge and therefore must be taken into account when measuring innovative processes within the primary sector.

Concurrent with the consolidation of network production, an innovation model was configured which, in the context of major differences between primary activities, shares a number of common features, including: i) a series of tacit technical knowledges generated progressively by enterprises that undertake production and which materializes both in the operating procedures of human resources and in the availability of genetics; ii) a number of codified knowledges –in agricultural machinery, manuals, instructions of use– provided by the public sector (via S&T agencies, universities, etc.) and the private sector (consultants, technical consultancy firms, etc.) which despite being external to production, operate on it; iii) suppliers of industrial inputs (fertilizers, seeds, agricultural machinery, etc.) which –as interested parties in the business– transfer knowledges to productive spheres (Ekboir & Parellada, 2002; Bisang, 2008; Campi, 2008).

At technology **generation** level there is a distinction in the relevant weight of inputs and equipment suppliers. This phenomenon is perhaps most notable in agricultural production, where on the one hand there is an outstanding availability of complementary inputs, from biofertilizers to herbicides, for the development of the planting of seeds "manufactured" in processes closer to the industrial sphere than to traditional natural reproduction. On the other hand there is also a considerable renewed availability of agricultural machinery, which introduces both new equipment (direct

[11] For example, in agricultural production, equipment matters lead us to reconsider the typical integration levels of the previous production model. "Equipment" –the basic set of agricultural machinery necessary to produce within the new paradigm– has a cost which implies a minimum entry barrier, which discourages small landowners from entering into such activities. The way to lower the entry barrier to the market is through the acquisition (and/or leasing) of equipment, which leads to the enterprise to be indebted to the formal financial system and to equipment suppliers, and in all cases implies the presence of real guarantees. Faced with this, the alternative is to turn to the labour contractor market, service enterprises that have specialized in a set of activities and which share territorial migrations. Another alternative for the small producer is to go into the rental market.

seed drills, bagging machines, self-propelled fertilizers) and improvements in their provision due to prior engineering concepts, especially via the incorporation of electronics in metallurgy. In turn, formal education systems, with varying nuances and speeds, are readapting their curricular training to these new advances. As a complement to this, public science and technology institutions operate as “generators” of pre-competitive technologies which drip down into the system via various channels.

In addition to the process of technology generation, importance is given to the process of **sharing** innovations, the notable speed of which is guided predominantly by the profitability of the new model. The role played in this respect by the traditional network of public institutions is complemented, currently, by the actions of: a) the Service Centres of input suppliers which, in addition to marketing their products, provide technical and financial advice; b) the service providers themselves and the APEs which, regardless of their specificities, sizes and economic and technological capacities, are quick to identify innovations as a business tool; c) the actions of private non-profit institutions dedicated to promoting and/or developing innovations; d) new and/or regenerated trade union entities organized by production chains which count technological issues among their main objectives; e) the existence, at the opposite end of the spectrum, of growing pressure on internal and external demand which impose production and quality norms and which, mediated by the contractual conditions of commercial intermediaries, leads the technological conduct of the group and, lastly, f) renewed local and international public interventions regarding the normalization of products, processes, environmental norms and other complementary norms which also tend to indirectly model the innovative development of the activity.

This group of “inducers” of technological behaviour in the activity rests on the group of actors which undertake production: landowners, APEs and service providers. These agents not only need to recreate a series of operational knowledges about the new technological model, but also others of a specific nature for each region/area which take in the particular behaviours of their respective climates and soils. Thus, part of current and future productivity is “constructed” with the generation of these tacit knowledges, often dependent on scientific knowledges and operational practices.

Thus a network is gradually configured that permits the development of innovations, made up of institutions, enterprises, individual operators and even trade union organizations, which enables the flow of codified knowledges via inputs or decodified knowledges through consultancy and/or direct contact. The greater complexity of the agricultural package transfers part of the decision-making power from the producer to input and machinery suppliers, contractors, science and technology organizations, trade unions and even downstream buyers. There is a connecting thread which (with varying nuances and densities) articulates the action of each of the components of the network, meaning that individual success depends on the success of the group.

In synthesis, agricultural production has increased the number of sectors involved and the number of enterprises that directly or indirectly contribute to the business. In diverse activities which make up agriculture in the network there are variable degrees of concentration, economic and technological asymmetries and development strategies (vital for interpreting productive, technological and financial behaviours) which make up the different nodes of the network.

In their joint action, this production and innovation organization model bears a marked difference to the integrated model, characteristic of the prior stage. While in the latter the producer had scarce relationships with the environment, faced a cost structure restricted to the local economy and demanded little financing for operational capital, in the network model the inputs are highly sensitive to variations in global markets and there are greater chains to the rest of production with the strong mark of industrial logics. This necessarily leads to a greater multiplying effect on the rest of the economy than the sector traditionally had. In consequence, revenue is now shared among a more varied range of agents and enterprises, while at the same time it is more sensitive to international conditions.

The above analysis shows that the study of innovation processes in these activities is characterised by a great complexity which is mainly derived, on the one hand, from the diversity of innovation sources that impact on the production and exchange of agricultural products and, on the other hand, the co-existence of different agents about whom information has to be gathered. In particular, with regard to the latter aspect, it is necessary to consider: i) those who undertake productive activity (the producers), whether these are the landowners or APEs which coordinate different factors; ii) the providers of agricultural services, as they are the main agents producing minor innovations in these activities; iii) providers of technological knowledges, centred specifically around traditional trade union entities, the entities that control genetic registers of seeds and cattle, INIAs (National Institutes of Agriculture and Food Research and Technology) and other public bodies, and specific consultants in this activity, and iv) suppliers of biological inputs.

The innovative dynamic of the agricultural sector which is derived from interaction among these groups of agents can only be partially captured by innovation surveys aimed at the manufacturing industry, by surveying enterprises that undertake activities related to agricultural production. This context requires instruments for capturing specific data which show the way in which these procedures are developed in these activities.

With this objective, the following sections of this study will discuss the potentialities and limitations of the instruments and indicators used to show innovation in the manufacturing industry, when used to measure the same processes in agricultural activity. Of the agents considered, as sustained thus far, the APEs (producers) will be used as unit of analysis, although there will also be a discussion of the importance and characteristics of the relationships which these must establish with the rest of the actors involved to develop successful innovation processes.

2. Innovation in agriculture: definitions and descriptors

Changes in the agriculture sector have occurred since humans ceased to be nomads and became sedentary. Closer in time, agriculture was also a relevant protagonist in the Industrial Revolution, inaugurating the modern capitalist era from the possibilities, due to new agricultural techniques, of surplus food production. However, it was generally seen as a passive sector, receiving knowledge developments generated externally, and was therefore never seen as an area that demanded greater effort of understanding about what went on inside. In any case, the relevant matter was to improve mechanisms for sharing knowledge. Today, the reality shows that something else is occurring in the sector. The following section will seek to establish fitting questions for measuring these changes, but first it is relevant to review the evolution of the understanding and international analysis of the innovative phenomenon in the agricultural sector in recent years.

2.1. The agricultural sector as a mere receiver of knowledge: the green revolution, the dissemination of technology and the Frascati Manual

The "green revolution"[12] motivated the first studies and analysis of the innovation process in agriculture. The focus of these was on the dissemination of technologies in the agriculture sector and in the factors that influenced and determined the adoption of these by agricultural producers. Fundamentally, for less-developed countries in which the agricultural sector carried greater weight, it became vital to understand the phenomenon of the adoption of technology in agriculture in order to increase production and income derived from this activity.

According to this approach, the study of innovation in the primary sector is restricted exclusively to the dissemination and adoption of new knowledges, under the assumption that the sector is a mere importer of knowledge. In agricultural activity this leaves aside the analysis of the generation of these knowledges and questions relating to efforts made by producers to adapt technologies to the specific conditions of each context. That is, it is assumed that the technologies come from outside of the sector and that the producer does not directly or indirectly influence their production or creation.

This study analysed the technology dissemination process from two perspectives. The first adopted a **microeconomic**-type approach, focusing the analysis on the understanding of factors that influence the decision of the agricultural producer to adopt certain technologies. These theoretical models were developed in order to study the decision-making process through which was adopted an optimal combination of technologies which make up a technological package (including new varieties, fertilizers, herbicides, modes of production) at a certain time. Some of the determining factors studied on that occasion were the availability of loans and information, risk, and the size of the agricultural establishment. The underlying theoretical concepts in this approach arise from the ideas of "technological complementarity" and "adoption under uncertain conditions". The theoretical contributions made by these models were validated empirically by different econometric studies which tested the factors that

[12] The green revolution is the name given to the expansion process of less-developed countries in the 1960s of a group of new productive technologies, based on high-performance inputs developed in more advanced capitalist countries and Mexico after 1943. This had a strong impact on world food as it enabled production levels to increase in a sustained manner.

influence decisions to adopt technologies (e.g. Jamison and Lau 1982, Rahm and Huffman 1984, Norries and Batie 1987, Lin 1991).

The second perspective studied the patterns and rhythms that follow the processes of dissemination of technologies between adopters and non-adopters, over time and in a given population. One model used extensively by this perspective was the logistical model known as the “epidemic model”, in which the dissemination process of a technology is compared to the dissemination of a disease or epidemic. The analogy is based on the idea that contact with other agents who have already adapted the new technology (contracted the disease) and the greater availability of information about the innovation lead to an increase in the adoption rate of the innovation (contagion of the disease)[13] (Arrow, 1968). That is, the process of dissemination is driven by the “imitation” of practices developed by adopters, by those that have not adopted the technology. Griliches’ founding work (1957) on the adoption of hybrid maize in the USA found this logistic distribution pattern in the dissemination process of the crop. Other studies have developed models that extend the logistic dissemination pattern and make it more complex, adopting other function types considered more representative of the dissemination process (e.g. Gregg et al. 1964, Maddala 1977, Sharif and Ramanathan 1986).

As mentioned above, the approaches presented start from a very limited conception of the innovation process within the agricultural sector, exclusively restricted to the dissemination of innovations, ignoring the wealth of these processes from the dynamics of gestation, adoption and final adaptation.

In parallel, the first precedents of measuring the inputs of innovative processes, under the lineal model logic, can be found in the Frascati Manual, the first edition of which was published in 1963 (OECD, 2003). Although this instrument focuses on measuring human and financial resources allocated to R&D, and is intended to contribute to discussions on scientific and technology policies that would be necessary to drive development processes, this issue is similar to innovation as a space for generating knowledge[14]. Although the manual is intended to show resources allocated to R&D in five sectors– enterprises[15], government, private non-profit institutions, higher education and abroad– the guidelines developed from this manual present some important limitations to showing innovation inputs in enterprises. This is greater in a context such as Latin America’s, where the specificities of productive structures characterised by relatively scarce investment in R&D cannot always be captured correctly using these indicators.

---

[13] Assuming a homogenous population in which each agent has the same chance of coming into contact with the other (of catching the disease), it was found that the dissemination of innovations follows a logistic-type distribution (distribution which takes the form of an S). This is due to the fact that the adoption rate within a population is low at the start –as few people know about the technology– but as more individuals know about it and adopt it, there is a greater chance that others will too. Once half the population has adopted the technology, the dissemination rate starts to slow down until all the population has the technology.

[14] Although assuming this as the only source would lead to analysing the innovative phenomenon from the perspective of the lineal model.

[15] When presenting the sub-sectors included in the enterprise sector, the Frascati Manual respects the classifications of internationally standardized activities, thus highlighting agriculture and other primary activities as a space for the application of guidelines established for the collection of data referring to investment made in R&D.

Successive revisions of the manual, with the latest published in 2002, focused on perfecting the manual conceptually and methodologically[16], while broadening the scope of the analysis of inputs in the innovation process, incorporating new disciplines involved in the production of R&D and new characteristics of the context in which these activities take place.

Evidently, from this perspective and under the assumption that agricultural activity is a mere receiver of knowledge/innovations from spheres outside the sector, it is hard to find initiatives that seek to study and/or measure innovative processes within the agricultural sector, as in general agricultural activities lacks formal instances of R&D, which are precisely the spaces evaluated by the Frascati Manual.

1.4. Advances in measuring innovation as a process apart from R&D and understanding of the phenomenon in primary activities: from dissemination to the system

The recognition of innovation as a broad and complex process, involving not only work but also the results and the context in which these are produced, in addition to a number of activities more extensive than R&D, led to a search for new instruments that gave an integral perspective of the innovative dynamic exceeding what could be obtained with the Frascati Manual. In this regard, during the 1980s there were various works which were vital to understanding that the Frascati was insufficient (Kline & Rosenberg, 1986; OECD, 1992).

At the same time, in the 1980s there arose the concept of the National Agricultural Research System (NARS). This overcame the problem of technology dissemination as the only relevant aspect in relation to agricultural innovations, and centred on how innovations are generated and produced after being adopted in the sector. However, the focus maintained the conception that innovation in agriculture was gestated outside of the sector, and that agricultural producers adopted these passively. The core idea was that innovation was produced from exogenous supply, which to therefore be promoted required a strengthening of research, training and extension carried out by scientific and technological organizations, a reasoning that continues to respond to the prerogatives of the lineal innovation model.

In the 1990s, in the context of the Agricultural Research Innovation System, the concept of "innovation" began to be explained more clearly. Although this approach maintains a lineal perspective of the innovation process, it also considers that the process' core does not only lie in research, but that the existing ties between research, education and extension are also relevant (FAO and World Bank, 2002).

In parallel, "engineering" to better capture innovation processes in the world led to the creation of the Oslo Manual, first published in 1992. This was constructed from different surveys conducted in the 1980s in developed countries to capture the

[16] Conceptual and methodological changes aimed to better capture information that made it possible to interpret innovation processes and generate data compatible with data collected by the national accounts systems of different countries.

particularities of innovation processes, especially in the generation of new products and new production techniques in the manufacturing sector.

The conception of the innovation process taken by the Oslo Manual is present in some of Schumpeter's best-known work (1912, 1942), although contributions from other disciplines are also incorporated, especially to show the relevance of innovations related to processes of organizational change and marketing. In this respect, innovation is defined as:

> *"the introduction of a new, or significantly improved, product (good or service), process, a new marketing method or a new organizational method, in the internal practices of the company, the organization of the workplace or external relations"* (OECD, 2006: 56).

The Oslo Manual presents an approach that aims to overcome the dichotomy between supply (Kline & Rosenberg, 1986) and demand as drivers of the innovation process from the approach of the lineal innovation model, by thinking of the development of new products and processes as the result of the dynamics of a system. In this perspective, clearly derived from evolutionist thinking, not only are enterprises' explicit efforts relevant, but importance is also given to institutions and the general environment in which these agents perform their activities. This is because innovation is defined in a broad sense, taking in the production, adoption, absorption, adaptation and dissemination of knowledges (Anlló et al, 2009) from learning and interactions among agents.

From the beginning, the Manual focussed on the subject before the object, an important point in which the Oslo Manual differs from the Frascati Manual. While in the object focus the emphasis is on innovation itself, in the subject focus the emphasis is on the agent carrying out the innovation process. In adopting the subject focus, the Oslo Manual emphasizes the importance of enterprises in the development of innovation processes and, in this sense, defines the firm as the analytical unit for data analysis and capture. From these guidelines, a central point in the study of the dynamics of innovation processes is the strategies deployed by enterprises. In the case of primary production, therefore, it is highly important to identify the subject to be surveyed, in order to understand what strategy is deployed within the sector.

The original version of the Oslo Manual had two subsequent revisions, in 1997 and 2005, in order to perfect data capture of the innovation process, expand data collection possibilities by extending it to the services sector, and incorporate two new types of innovation, organizational innovation and marketing innovation[17].

1.5. Problems with measuring innovation in primary activities

From the beginning, one of the objectives of the Oslo Manual was to generate information on the innovation process which would be internationally comparable without ignoring, at least in theory, the analytical and political difficulties implied in such comparisons. Despite this, the different applications through surveys in less-

[17] The new types of innovations recognised by the Oslo Manual in 2005 complemented previously recognised technological innovations and showed specific innovation processes.

developed countries showed the difficulties of this instrument in capturing specificities of innovation. In this context, for the particular case of Latin America, in the year 2001 a new manual was developed, the Bogotá Manual, respecting the guidelines of the second revision of the Oslo Manual, and at the same time seeking to respect comparability, pick up on the particularities of the Latin American context, through the proposal of a new set of dimensions necessary to show the dynamics of innovation processes in the region[18].

Successive revisions of the Oslo Manual and contributions from the Bogotá Manual contributed to overcoming the limited view of the innovation process in the manufacturing industry, which only considered the importance of inputs related to R&D and results associated with new products and processes that could be patented or protected by intellectual property mechanisms. At present these two manuals allow instruments to be built that are used in the region for collecting information on the generation of new products or the implementation of new productive products, as well as on those activities that promote the development and introduction of innovations.

However, although in their theoretical and methodological conception the Oslo Manual is intended to contribute elements for measuring innovation processes in the business sector, where this is understood as the **manufacturing industry, primary activities and services** (Oslo Manual, 2006: 23), most applications of this instrument at national level have been concentrated in enterprises involved only in manufacturing. The complexity and heterogeneity, both of services and primary activities, has perhaps been one of the main obstacles that have limited the extension of measuring processes in these areas. As with the first application of the Oslo Manual to the realities of Latin American countries, and the subsequent need to write a manual that translated Oslo to the local reality (the Bogotá Manual), at present problems can still be seen in applying the recommendations of Oslo to measuring innovative activities in primary activity.

Despite existing methodological limitations in showing innovation processes in agricultural activities, some literature has sought to understand the dynamics and characteristics of the innovation process in this sector.

The changes in agriculture that occurred from the 1990s led to a re-think of the current innovation process in the sphere of primary activities. The growing need to respond in a flexible and dynamic way to changing conditions and market opportunities, the emergence of new highly dynamic niche sectors and of new players (e.g. suppliers of specialized inputs) and the repercussions of the application of new technologies (ICTs and biotechnology) to primary activity, among others, showed the need for a flexible innovation model in which extensive networks of diverse actors and institutions participate and interact by exchanging, using and adapting knowledge. In this context, scientific activities *per se* and research, development and extension activities remain relevant, although they are not the only determining factors in innovation activity in agriculture.

[18] Some of these questions were then picked up in the third revision of the Oslo Manual.

At present, there is an agreement on a number of ideas about the characterization of innovation in agriculture (Hall, 2007):

1. Different knowledge sources interact with each other, sharing and combining ideas.
2. These interactions and processes are generally specific to a given context.
3. Innovation requires knowledges from diverse sources, including the users of these knowledges.
4. Each context has its own routines, reflecting specific historical origins determined by cultural, political and social factors.

Changes in the agricultural model, added to the acceptance of previous ideas, led to the adoption and acceptance of the concept of *innovation system* to understand innovation activity in current agricultural production. This approach is an accepted theoretical conception widely used to understand innovation processes in the industrial sphere[19] [20].

The innovation system concept[21] recognises innovation in agriculture as a broader and more complex process than previous approaches, in the sense that it brings out a greater diversity of actors, disciplines and sectors involved. Therefore, according to this theoretical framework, generating the environment that sustains the use of knowledge is as important as making knowledge available through dissemination and other transfer mechanisms (World Bank, 2006).

This approach provides greater understanding of the situation of current primary activity in which there exists not only an agricultural producer who adopts innovations and a scientific-technological supply of new knowledge, but also a number of other actors who mediate, contribute and participate in different forms of agricultural production, in addition to a more active role for the producer.

The strength of the innovation system approach is based fundamentally on the fact that it offers a holistic explanation about how knowledge is produced, shared and used, while emphasising the actors and processes that are of growing relevance in the current functioning of agricultural activity. The greatest weakness of this perspective is

---

[19] The origin of this approach is the concept of national innovation systems (Freeman, 1988; Lundvall, 1992) which emerged as a response to the limited explanatory capacity of conventional models which saw innovation as a lineal process led by the supply of research and development.

[20] Although the central analyses for understanding innovation processes from the systems perspective have been undertaken at national level, this approach has also been used at other levels of sub-national (local) and supra-national (sectorial, regional) aggregation. In this regard it is important to highlight that different levels of aggregation do not cancel each other out, but in fact complement each other.

[21] An innovation system can be defined as "a network of organizers, enterprises and individuals whose objective is for new products, processes and forms of organization to be of economic use, along with institutions and policies that affect both their behaviour and their performance" (World Bank 2006, p.16). The innovation system concept includes not only the providers of scientific knowledge, but the whole of actors involved in the innovation process and their interactions. In this regard, it goes beyond the creation of knowledge, concerning factors that affect demand and the use of new knowledges.

centred on how to measure these systems, in order to study the evolution of their innovation capacity and their results or to compare the innovation systems of different countries. The mentioned complexity in measuring these processes in the agricultural sector increases when one considers the heterogeneity of the activities involved.

Despite these advances from a conceptual perspective, from a methodological/practical perspective of measuring innovation processes in the agricultural sector there are no precedents in the region of attempts to conduct surveys in innovation in this sector, with the exception of a recent pioneering experience in Uruguay. Because of this, and because of the relevance of changes occurring in this sector, the following section will attempt an exercise to pinpoint some of the difficulties (this is in no way an exhaustive analysis, but rather to highlight the magnitude of present problems) that exist in applying innovation surveys, originally designed for the manufacturing sector, to the agricultural sector.

2. Measuring innovation activities

From the clarifications made in the first sections of this work regarding the unit of analysis and the conceptualization of innovation in agricultural activities, this section will present the main dimensions used for measuring the innovation process in the manufacturing industry[22] and discuss their possible application to the agricultural sector. This will consider not only innovation activities and results obtained, but also other questions that impact differentially on the innovation dynamic, including:

a. Established ties, information sources and financing sources to make innovation activities possible;
b. The impact of these innovations on an enterprise's performance;
c. Restrictions on innovation.
d. Innovation protection forms.

As mentioned in earlier sections, the analysis of dimensions to be considered, especially for the manufacturing industry, will be done according to the guidelines set out in the Oslo and Bogotá Manuals.

For the analysis of agricultural activities, we will use as reference different surveys taken with the objective of showing the characteristics and growth of agriculture in Argentina. Although the specific objective of these instruments is not to inquire into the innovative dynamic of productive units, in these surveys it is possible to find some of the most important questions in this regard. At the same time, these are tools that enable an initial identification of the particularities and elements, an identification necessary to incorporate in order to measure innovation in agricultural production. In particular, three information collection instruments applied to different agricultural activities will be used:

- The Survey of Argentinian agricultural producers' needs, produced by the Faculty of Business Sciences of the Universidad Austral between August and September 2009.
- The 1st National Survey of Bovine Genetics, part of the work produced by the Forum on Bovine Genetics, in the context of a project carried out by the Office of ECLAC in Buenos Aires at the request of the Institute for the

[22] It is important to highlight that recent studies in different countries of the region add some additional dimensions which complement and complicate the gathering of information and the treatment of data using the innovation Manuals under consideration. These include the analysis of the organization of work as a proxy of the processes of knowledge circulation and of the potential capacity for the development of innovations from informal teams and informal cooperation processes among different agents oriented towards the production of knowledges. Likewise, it is important to highlight the efforts made to integrate and complement indicators.

Promotion of Argentine Beef (IPCVA, Instituto de Promoción de la Carne Vacuna Argentina).

- The CREA census, taken in June 2009.

Some additional comments merit a mention. Firstly, the surveys analysed focus on viewing the current situation (photo) and the future perspective of productive units. In this regard, the lack of past information impedes measuring the introduction of changes in recent years, in the way that innovation surveys applied to the manufacturing industry do. Secondly, surveys in general refer to a specific type of activity (livestock, agriculture, fruit production). When the formula includes more than one primary activity, the surveys have a section for each activity type. This feature is important, as in general within the farm premises more than one type of production tends to occur (in principle, it is very common to sow and keep livestock), so the specificities of each activity indicate the need to be taken into account when designing a specific survey for the sector. Thirdly, given that the nature of this study is to identify sectorial specificities on the subject, there has been no attempt to contrast results but rather formulas and question forms. It is due to this last aspect that the following section will review by each relevant section what questions the traditional innovation surveys ask, to evaluate what difficulties they present when applied to the agricultural sector.

2.1. Innovations obtained

The measuring of innovation results in the manufacturing sector from the Oslo and Bogotá Manuals takes into account four innovation areas or categories:

Product-service: new good or service or one which is significantly improved in terms of its characteristics or assigned use.

Process: new production or distribution process or one which is significantly improved by changes to techniques, materials or computer programs. New service creation and provision methods are also considered.

Organization: new organizational method in practices, organization of the workplace or the enterprise’s external relationships. This method must not have been used previously.

Marketing: application of a new marketing method from significant modification in the design or packaging of a product, its positioning, promotion or pricing. This must be a marketing method that the enterprise did not use before.

While product and process innovations tend to be referenced as technological innovations, new developments in terms of organization and marketing are generally treated together under the concept of non-technological innovations.

Innovation results in each of these areas are measured according to the Manuals, taking into account two factors. Firstly, the attainment or not of actual results is considered (i.e., if the enterprise states that it has attained a positive result in any of the innovations mentioned within the period under analysis). Secondly, the degree of newness of innovations achieved is analysed, classing into three levels: for the enterprise, for the national market or for the global market.

Additionally, in the product innovations obtained from manufacturing activity, standardization at international and regional level stipulate another two sets of indicators that enable us to approach the output of the innovation process: patents and the participation of new products in the enterprise's turnover in a given period. These indicators tend to be considered irrelevant in showing results of innovation in the countries in the region in which innovation in the manufacturing industry is accounted for especially by changes introduced in organizational methods and marketing. In the case of patents[23], because for various reasons enterprises in the region do not show conduct related to patenting. In the second case, because new products introduced by enterprises generally do not respond to major efforts within the enterprise as innovative achievements, but tend to respond more to commercial policies, which ultimately distorts the sense of the indicator.

When the analysis moves on to the production of primary products, it is worth asking whether the different innovation categories used for industrial activity are suitable for the analysis of agricultural activity, and whether each category has the same relative importance in manufacturing activity as in agricultural activity. Regarding the first of these questions, some examples can be given of each of these types of innovations attained. Hence, the production of a new seed can be considered a product innovation, the introduction of the direct sewing method a process innovation, the organization into a network of the group of activities is a new way of organizing production and the opening of new commercial channels can be identified as innovations in marketing.

In relation to the relative importance of each type of innovation, when considering agricultural activities in general, and activities in the Latin American context in particular, it is possible to observe the importance of productive structures organized around productive networks or models, which boost the chances of complementing different types of innovations. Therefore, in the primary activity the ties or relations established by productive units are, at least, as relevant as the innovations involved. In this regard, although it is possible to establish a type of innovation as the most relevant, it is to be expected that this will bring with it different knowledge production spaces which complement the earlier innovation and thus maximise its positive impact.

As regards how new the attained innovations are, this dimension complicates the analysis of the existence of results, taking into account not only if these exist, but also the weight they acquire in terms of their potential for modifying the technological frontier at international level. Although the most recent revisions of the Oslo Manual have picked up on the importance of innovations that bring something new to the enterprise but not to the market, comparisons at international level with the manufacturing industry tend to value particularly positively those that exceed the sphere of the firm. There are elements that make it possible to downplay these conclusions as regards activities related to the primary sphere. Indeed, newness at international level in the development of innovations is not always possible due to the local specificity of many products. In this context, although newness is a wholly relevant aspect in the

[23] Even in this context and despite the restrictions mentioned, the patent is a key instrument for measuring innovation results in the manufacturing sector, given its availability and easy comparability. As regards primary activities, their applicability will be discussed in the following sections in a more detailed consideration of the importance of this instrument as a mechanism of appropriation and protection of knowledge generated from innovations.

evaluation of results of innovative activities, due to the specific territorial/climatic component of this type of activity, it would be better to wait until innovations at enterprise or market level are of greater relevance, than questioning whether the innovation is new at global level.

Although heterogeneous behaviours and results is a feature of any productive activity, it seems relevant to highlight the specificities acquired by the variability of efforts and results obtained from innovations introduced in primary activities, even when, as defined in the introduction to this study, these are understood as considering only agriculture production. The diversity of agricultural activities undertaken in the same productive space hinders the identification of standardized indicators for the group of productions obtained, while the differences in the productive dynamic also influence the way they acquire innovation processes. In this context, it can be considered that the clearest heterogeneous factor is found in the existing differences between the processes of transformation and innovation characteristic of the two main activities associated with the sector: agriculture and livestock[24].

Having made this division, it is necessary to take into account a number of additional factors that influence the diversity of processes that can be identified in relation to these activities. Firstly, the existence of a high heterogeneity of results from similar efforts (i.e., it is not necessarily the case that correct actions, as defined by established practices, lead to the innovations expected, given the high number of variables which are not under control, such as weather). This can be explained by the importance of living beings in the production and innovation dynamic. Working with living beings means addressing differential production and reproduction dynamics depending on the life cycle of each of them, which is strongly dependent not only on the species in question, but also the context/environment in which it develops. Secondly, it is important to highlight the different functionalities that a good can acquire in production and innovation in agriculture and/or livestock production: the same good may be a capital good or a consumer good (a calf could be seen for its reproductive potential or as an animal to be sent for slaughter), it can be sold or reinvested (seeds obtained from a harvest), and it may be a final consumer good or an intermediate input for another productive process, which in turn may be highly diverse. Thirdly, and derived from the productive characteristics of these activities, it is interesting to highlight the incidence of diversification of the mix of production over heterogeneity. In this regard, it can be observed that the agricultural production of one farm is not generally concentrated in a single product but, on the contrary, different activities are alternated between in the same group (e.g., different cereals) or different groups (agricultural and livestock). Consequently, the innovative dynamic of a producer –which in this study is sustained as the relevant unit of analysis– cannot be defined in general terms but requires a study to establish the particularities even by generated product (our unit of analysis may be very innovative in agricultural activities, but not in livestock production, in the same productive unit, hence it is vital to define the unit of observation to be surveyed, in contrast to practices in manufacturing).

[24] This is not to ignore the heterogeneity that exists among products derived from the manufacturing industry, simply that in the case of activities related to working the land, within the same productive unit, with a relative number of similar factors the options are varied, while this is not so in the other case.

Taking into account these general definitions, from the surveys analysed it is possible to identify a set of key dimensions to be considered to show the questions mentioned above and the particularities of measuring innovation in these activities. In terms of products, it is observed that a first approach to measuring innovation can be done in terms of changes in activities undertaken in the productive establishment, which may include agriculture (annual crops), livestock, dairy, perennial crops and other activities such as rural tourism, game preserve, proving services to third parties (such as the application of fertilizers, agrochemicals, harvest, sowing, etc.), among others.

Within each type of activity, one can also analyse the changes in the mix of products produced and supplied. For example, in terms of agricultural activities, the establishment may be dedicated to the production of cereals, oilseed, industrial crops, vegetables and/or pulses; within the production of oilseed, the establishment may produce soy, sunflower or rapeseed, and within cereals, wheat, maize, barley, sorghum or rice. In the case of livestock, the productive unit may be dedicated to producing dairy cattle, beef cattle, pigs or others, and within the cattle herd, breeding, raising, fattening by feedlot, pasture fattening, or ranch fattening. More specifically, the modifications in products supplied can be analysed by taking into account whether there is production of special crops (Flint maize, popcorn, special soy), commodities or specialities (in beef production) and whether value is added to primary production before marketing.

Each of the combinations mentioned describe different production mixes, and the passage from one to another might imply innovations that are new to the productive unit, as they incorporate a new mix, a new activity or a new product within traditional production. These changes in activities can be measured in terms of surface of the establishment dedicated to each activity (which would not make sense in the manufacturing industry), of the amount produced or sales.

As regards process innovations, there is also evidence of high specificity in each activity. In this context, it is possible to detail, a priori, a group of possible areas associated with each type of activity within primary production, which implies defining the practices related to processes in primary production which need to be developed or improved. In the particular case of agricultural activity, this translates into seed analysis, new variety trials, measuring climate variables, monitoring the depth of the phreatic surface, monitoring harvest quality, analysis of soil before fertilizing, the use of herbicide with rotation of active principles and crop-livestock rotation. In turn, in livestock activity there are different activities that involve different actions. Thus, in livestock production, consideration is given to dimensions associated with processes of use of forage resources (stubble, fresh annual forage, multiannual pastures, natural grazing ground) and related technology (fertilization or direct sowing); in meat production, more specifically, attention is given to the health analysis of bulls, seasonal servicing, artificial insemination, premature weaning, strategic supplementation, waste treatment, nutritional advice and pasture rotation, and in the particular case of ranches, EPD analysis in bull sales and the possession of a DNA bank. Lastly, in dairy production, it is interesting to consider the presence of squeeze chutes, fish bones, carousels, milk controls, nutritional advice, feedlots, artificial insemination and waste treatment. All these are examples of possible processes which may be standardized and known in the sector, but tend to represent the frontier of knowledge in various activities, hence their implementation or non-implementation by different productive units may indicate the innovative aptitude of respondents.

Aside from these questions, the analysis of this type of innovation requires an evaluation of the introduction of specific process technologies, such as production with direct sowing, the use of technologies with microbiological products such as inoculants, the implementation of precision agriculture and the irrigation form used (flooding, spray, drip, micro-spray). This is because the type of innovation process introduced can show the degree of technological sophistication with that which is produced in the reference unit.

Innovations in organization and marketing also have their particularities. Of the main dimensions that can be considered new forms of organization in primary activities, those that stand out are the hiring of services provided by third parties. These services can include the application of fertilizers and agro-chemicals, as well as all sowing, harvesting and tilling, and imply an organizational change when any of these activities is carried out in the establishment and are then subcontracted, or vice-versa. New behaviours in terms of marketing translate into alternative forms of introducing products to the market, which might be new only in terms of primary activities, or even may represent new marketing forms applicable to any type of product. In this regard it is possible to mention a group of marketing techniques or channels that are distinct from those usually used in manufacturing activities, including grain brokers or consignees, agricultural cooperatives, brokers, direct sale to exporters, exchange operations, sale to nurseries or mills, sale by auction, farming fairs and direct sale to the frigorific or dairy produce industry. In the particular case of agricultural production, the marketing of products can be done using systems such as all-at-harvest, tiered sale, sale at TBA price or using forward or future markets and options. The introduction or perfecting of any of these organizational or marketing techniques, at least with a degree of newness for the productive unit, constitutes the development of an innovation related to these dimensions in primary activity.

2.2. Innovation activities

Both the Oslo and Bogotá Manuals present an extensive list of activities that show the efforts made by manufacturing enterprises to develop innovations, although with some differences between both. Below is a list of innovation activities which respond to the group of efforts considered most relevant according to the innovation dynamic in the region, as defined in the form of the Second National Survey of Innovation and Technological Conduct of Argentine Enterprises. As a general feature to highlight, it is necessary to clarify that in each of the activities mentioned, the surveys conducted in the Latin American context inquire as much into the undertaking of each activity as into the amount of experience made in it. The list is presented here to reflect on its applicability to the primary sector.

- *Research and Development (R&D):* this is creative work undertaken systematically, i.e., not occasional, with the objective of generating a new scientific or technical knowledge or applying or using a knowledge that already exists or developed by another party. Within R&D, three major categories can be distinguished: basic research (generating a new knowledge that is more abstract or theoretical within a scientific or technical area, in a broad sense, without a previously fixed objective or end, applied research (generating a new knowledge which from the beginning has the desired end or usage) or experimental development (manufacture and testing of a prototype, i.e., an original model or test situation that includes all the characteristics and developments of the new organizational or marketing product, process or technique). The creation of software is considered R&D wherever it implies scientific or technological advances. It should be clarified that R&D activities are not always undertaken in the context of an R&D laboratory or department. Furthermore, many enterprises, especially medium and small ones, do not have formal R&D structures, but this does not mean that they do not undertake this type of activities. Although it is not an easy task, it is necessary to identify the R&D activities that are undertaken without a formal structure. For example, if a group of engineers in the enterprise, who work in the same area or different areas, meet every Friday afternoon to think, consult bibliography, experiment with and/or test different ways of increasing performance or accuracy of how chemical substances are mixed, this activity should be considered as an informal R&D process. The only restriction for an activity which is intended to general new knowledges to be considered R&D is that it should be undertaken systematically, not occasionally.

This last part of the definition allows us to consider the undertaking of R&D activities within the productive units of the primary sector. There are diverse initiatives by producers and technicians where they tend to meet systematically to study in their own field the development and implementation of new techniques that lead to solutions to various problems. Equally, it is feasible to expect to find cases of experimental development rather than research.

- *External R&D*: this is creative work not undertaken within the enterprise or with enterprise staff, but outsourced to a third party, by contracting or financing a group of researchers, institution or enterprise, with the agreement that the results of their work will be the whole or partial property of the enterprise.

This was not the most common, but with new forms of agricultural production organization and the technological complexity that is being acquired by new implementations in the sector, it is increasingly common to turn to external assistance (whether by hiring technical consultants, or through new large multinationals involved in the sector through their service centres).

- *Acquisition of Capital Goods, Hardware and/or Software:* these are innovation activities only when they involved the incorporation of goods related to introducing improvements and/or innovations of organizational or marketing processes, products or techniques. The replacement of a machine with another of similar characteristics or a newer version of installed software does not imply innovative activity.

As mentioned above, in this section a capital good can be many things. In some cases, it has similar features to industry (such as agricultural machinery, or certain equipment related to the first industrial transformation made in the agricultural establishment itself). In others, the same good can be a capital good and a final product, depending on how it is used. At the same time, in the last case, although these investments of living beings have the characteristics of capital goods intended to incorporate innovations (a breeder bull of an improved breed, or a modified seed), the respondents may not see it this way. Therefore, it is important to be able to clearly define what is and what is not a capital good, and when it is associated with an innovative process.

- *Technology Transfers:* this is all acquisition of rights to patent use, non-patented inventions, licences, brands, designs, know-how or technical assistance related to introducing improvements and/or innovations of organizational or marketing processes, products or techniques.

It is worthwhile discussing the definition to evaluate how to interpret all knowledge incorporated into the sector by external agents. That is, and in line with appreciations in dissemination, agricultural production is a major receiver of knowledge from different channels. In many cases, it is not acquired directly from patent rights, licences or brands, although when certain technological packages are acquired from service providers, these are transferring technology.

- *Engineering and Industrial Design:* these include all technical preparations for production and distribution not included in R&D, as well as plans and graphs for the definition of procedures, technical specifications and operational characteristics; machinery installation; industrial engineering; and production start-up. These activities may be difficult to differentiate from R&D activities, and for this it may be useful to find out is it is a new knowledge of a technical solution. If the activity is part of the solution to a technical problem, it should be considered within Engineering and Industrial Design activities. Modification of the productive process, for example, implementation of just-in-time, should also be considered as an activity belonging to engineering and industrial design. Aesthetic or ornamental product design activities are not innovation activities unless they generate modifications that change the main characteristics or uses of the products.

The definition is fairly precise, and will make it possible to differentiate here between activities to generate new knowledges from those that seek to attain technical solutions (perhaps the latter are those that are mostly observed in the sector). Evidently, it may be necessary to adapt the idea of industrial engineering to agricultural engineering, but the essence of the concept remains the same.

- *Management:* this refers to the generation, adaptation and application of new techniques that allow a better articulation of efforts from each area of the enterprise (coordination between production, administration and sales) and/or which make it possible to reach goals fixed by management more efficiently (total quality, environment care, etc.) The activities must not be confused with the objective. In order to make an improvement in marketing techniques or procedures, it may be necessary to revise coordination between different enterprise areas.

In this case, once the interview unit has been defined, this will highlight management characteristics. Within the changes observed by case studies in the Southern Cone, this is clearly a highly relevant aspect and one which marks a change towards a more professionalized production management.

- *Training:* this is considered an innovation activity as long as it does not mean training new workers in methods, processes or techniques already existent in the enterprise. This may be internal or external staff training, both in soft technologies (management and administration) and hard technologies (productive processes).

  Having clarified the previous points (defining the unit, taking into account the specificities of the activities, etc.) the concept of training can be captured in a similar way. In all cases, the problems that can arise are regarding the type of employment generated by these agricultural enterprises, as the trend is towards outsourcing all labour and, instead of permanent employees, having staff occupied during certain seasons of the year.

- *Consultancy:* implies all hiring of third parties external to the enterprise for scientific and technical services related to engineering and industrial design activities or management. If the activities hired out to third parties is related to R&D or training, these should be considered as external R&D and training activities, respectively.

  Given that there is high subcontracting (or outsourcing) of activities related to the exploitation of the agricultural unit, this last point is key. However, to leave it only defined as consultancy does not do justice to the size and characteristics of the process. It may be necessary to redefine the chapter on subcontracting (or outsourcing) of activities, within which consultancy could be included as another of these.

In addition to the activities listed, a central element for analysing the importance attained by innovation efforts is the presence of formal teams and departments dedicated to R&D. In the case of manufacturing enterprises, there is an indicator that complements expenditure made in internal R&D and which generally is used as an element to show the capacity of absorption of firms' knowledges. These two variables –R&D expenditure, and existence of formal teams dedicated to these activities– are the most widely recognised as indicators of innovation efforts in international comparisons, given the availability of information that exists on these in different countries (Cohen & Levinthal, 1990; Dahlman & Nelson, 1993).

Although, as mentioned in the previous sector, the Oslo Manual is intended to establish guidelines for measuring innovative processes in primary activities, the innovation efforts described have fundamentally been developed with the manufacturing industry in mind and applied to this. In this context, their use in relation to the agricultural sector requires a discussion on their relevance as indicators of efforts made by agents who undertake this activity.

By way of example, it is important to discuss the role and relevance of R&D activities in the unit of analysis defined to show innovation processes in the agricultural sector –the producer– and given the characteristics of these productive activities. It is then feasible that this type of activity should be undertaken fundamentally by certain suppliers of inputs or capital goods which are then used by the agricultural producers, but not by the producers themselves. As a consequence of this, R&D indicators would not appear to be relevant in the context of activities undertaken in agricultural production (at least, not of the average productive unit).

Furthermore, as was also mentioned in relation to innovations achieved, there is the possibility that the same innovation activity may have a different nature and interpretation in the manufacturing sphere and in the agricultural production sphere. Such is the case with the acquisition of a “capital good”. While in the case of the manufacturing industry there is a consensus as to the mention of machines, equipment and installations when referring to capital goods, in agricultural activities this reference is more diverse and less clear than in the other case. Thus, for example, a capital good in agricultural production might be machinery, but it might also be a seed in the case of those with autogamous characteristics, that is, those that are capable of reproducing their genetic characteristics to successive generations, allowing the divulgation of a new variety without requiring any technical ability or specific knowledge. In this case, the seed assumes the same features as a capital good, as it is an input whose consumption does not end in one productive cycle. Both in this type of seed and in machinery, knowledge is incorporated into the capital good. Likewise, in livestock production, a bull may be considered a product or a capital good, depending on whether it is used for reproduction or not[25]. Taking into account these questions, it is worth inquiring whether all types of uses of the concept can be added into the same category, whether they are comparable, or whether they should be analysed and considered differentially.

Although the problem that arises with the above examples is different, it is possible to sustain the need for similar discussion regarding each of the innovation activities enumerated. These reviews are valid, even, for ruling out some of the activities considered in relation to the manufacturing industry and to incorporate others which are not currently taken into account.

By way of example, aside from the digressions made regarding the acquisition of capital goods and R&D expenditure, it is also possible to mention other examples which show the particularities acquired by categories of innovation efforts made in primary activities. The surveys analysed in relation to this type of production consider the importance of hiring technology or consultancy for undertaking specific tasks, such as pest monitoring and environmental care, among others. Also of relevance are activities oriented at the hiring of specialized staff to improve technical-administrative tasks which make it possible to register accounts and production, or calculate gross margin or gross income, which require the use of computers and/or specific software for agriculture. Likewise, the incorporation of trained staff is a relevant factor which may account for innovative dynamics of production units. In this particular case, these qualifications refer especially to veterinary doctors, agricultural engineers, genetic improvement consultants, farm staff and inseminators, who may be connected to productive units through a transitory salary relationship or permanently, via a family tie.

In particular, it can be sustained that innovation in the agricultural sector can be produced from three principal processes: i) intentional endogenous efforts aimed at obtaining a new product, process or form of organization or marketing, which in industrial activities translates, for example, into internal R&D development; ii) creative

[25] Another example of innovation effort is investment in genetics, which involves, in addition to the purchase of reproducers, the acquisition of embryos, doses of semen and new plant varieties. This type of activity is difficult to frame in the context established for activities associated with innovation efforts in the manufacturing industry, although they may find a certain parallel in the incorporation of capital goods or external R&D.

responses to unusual and unexpected circumstances which can arise from climate change, market changes or other changes, and iii) the diffusion of certain technologies provided by third parties, where innovation is of an exogenous nature due to the incorporation of knowledges and inputs (pesticides, seeds, food products, etc.) and equipment (machinery) used in undertaking productive activities. Both types of innovation, of a different nature, require certain prior knowledge and a learning process which makes it possible to produce and/or adapt innovations to local and specific conditions of agricultural production.

Lastly, in addition to identifying the type of relevant activities, it is important to quantify and estimate the monetary amount invested in this type of activity. In the case of these activities this represents a problem due to the absence, in many farms, of an accountable follow-up of activities, which hinders the capture of efforts in monetary terms.

2.3. Relationships in innovation processes

The systematic conception of innovation places at the centre of the analysis the dynamic of relationships among agents involved in these processes. In this framework, much has been written on the importance of relationships established by manufacturing enterprises with other economic and non-economic agents, oriented at increasing knowledges, acquiring complementary capacities and generating innovations in products, processes, organization and marketing[26].

In their relationship with other dimensions associated with innovation dynamics (for example, structural variables which define the characteristics of the enterprises), indicators of relationships with other agents of the NIS shows the determining factors of different relationship models between firms and other agents. In turn, the objectives involved in interactions allow us to study the complexity of these: while unidirectionality shows a reduced complexity which may be associated with merely informative actions, bidirectionality makes it possible to establish more complex relationship structures (inbound diffusion vs. inbound-outbound diffusion).

So it is that the Oslo and Bogotá Manuals define a number of prescriptions aimed at revealing both the existence and the complexity of relationships established by enterprises. Therefore, not only the existence or otherwise of relationships is inquired into, but also a broad group of counterparts is considered –public laboratories, universities, public organizations, clients, competitors and suppliers– and various different objectives pursued in each interaction –financing, information, training, organizational consultancy, trials, technical assistance, design and R&D–. Traditional innovation exercises, when they inquire into relationships, are seeking to find out what class of relationship is established and with whom, as this will make it possible to estimate knowledge flows and sources from which enterprises feed to incorporate innovations.

[26] Both relationships and sources of information and financing for innovation which will be presented in the coming sections, tend to be treated in innovation surveys as knowledges for innovation, although **differentiating clearly between efforts and actual activities.** This type of input is related to the importance assigned to these elements in terms of complementary aspects that allow innovative activities to be consolidated.

The importance of each of these relationships for boosting the innovation dynamic of the enterprise differs in terms of characteristics and activity. As regards studies of articles between agents aimed at promoting the development of innovations in the manufacturing industry (Richardson, 1972; Pavitt, 1984; Malerba & Orsenigo, 2000; others), sectorial specificities can be identified in the systematic determining factors of innovation (Milesi, 2006). Consequently, it is also worth asking in this case about the specificities that this type of indicator acquires when considering the agricultural sector, particularly in terms of counterparts and objectives listed.

The introduction and the first section of this study sustained the importance in agricultural activities of "technological packages", supplied by a complex network of external suppliers who each provide some parts of the necessary technology. In this context, the relationships oriented at acquiring technical assistance or complementarity of capacities can take on greater importance than other productive activities. Furthermore, objectives such as design and R&D can show a lower relative relevance, while consultancy related with process innovations are not considered but take on great importance in these productive and innovation contexts. In this context, surveys analysed make it possible to identify some relevant objectives in the relationships with other agents in the context of primary activities, including contributing innovative ideas, providing and accessing opportune and relevant information, offering good prices, making certain resources accessible and providing know-how.

Something similar can be sustained regarding the counterparts involved. In the context defined in the above paragraph, inputs provided by specialized enterprises are highly relevant in producers' ability to develop innovations. Relationships can therefore be identified with some agents whose relevance is circumscribed to the activity[27].

It is also fitting to highlight that suppliers of critical inputs can receive contributions of knowledge from agents such as universities and public laboratories, even though the direct relationship between these agents and producers tends to be scarce or inexistent. Consequently, the relationship established is indirect.

Thus, in a similar way as in the manufacturing industry, it is important to consider informal contacts and relationships established among agents, but even more relevant are indirect exchanges oriented at the development of innovations formed, for example, between a producer and an R&D laboratory, mediated by the relationship between the latter and a specialized supplier.

2.4. Sources of information for innovation

The analysis of innovation processes in the manufacturing industry has highlighted the existence and importance of different sources of information for the generation of new knowledges. These sources provide information of a technical, commercial and productive nature, among others, which make it possible to define and undertake innovation activity. Some of these sources have been surveyed and included by the Manuals in the definition of guidelines for studying innovative dynamics. In particular, it is possible to distinguish internal and external sources. The latter are

[27] These include the "sellers" of agricultural products, veterinarians, artificial insemination centres, semen banks, grain brokers, and other brokers.

strongly heterogeneous, which is related both to the contents of the information and the agent supplying the information. In general terms, the Oslo and Bogotá Manuals concentrate fundamentally on the supplier agent and make an assimilation –not always accurately– between this and the contents of the information. They thus identify as relevant (and internal) information sources those that come from other enterprises, institutions, consultants, fairs, journals, databases and the Internet.

It is possible to think that the particularities of agricultural activities lead to the need to propose specific information sources for innovation, or at least assign to each one of those considered a relative importance which is different from that seen in the manufacturing industry. Thus, for example, it can be sustained that the strong basic science component existent in product innovations –which for the producer can become process innovations– from improvements in species and the development of animal and plant varieties, requires greater participation and a greater contribution of knowledges from scientific/technological institutions (such as national institutes of agricultural and/or agro-industrial technology existent in each country) or from suppliers of agricultural inputs, than from 'indirect' means such as specialized journals, publications, exhibitions, congresses, seminars, databases or the Internet. This is also due to the strengthening local specificities of each of the productions considered, where biome characteristics affect, and in some cases determine, the type of product supplied. In this context, the transfer of pre-existent knowledges in other regions is less probable than in other productive activities in which the natural productive environment has less relative impact in the definition of the final product.

In addition to these, from the surveys analysed it is possible to identify a group of particular information sources specific to this type of activity. Thus, there are agents and sources that are not normally included in innovation surveys intended for the manufacturing industry, such as extension services, family members, neighbours, specific TV or radio programs (rural channel), visits to other farms, publications of input suppliers and visits to experiment stations.

2.5. Sources of financing for innovation

Innovation is a costly process which demands time, so there has to be a guarantee that during development time there are the necessarily resources to sustain it. In this context, the way in which these activities are financed takes on importance. Financing forms part of a process of assigning resources which must be disposed between alternative uses. The means with which the development of innovations is financed may be varied and depend on different factors which are associated with innovative activity itself and with the characteristics of funding and funded agents.

The source of economic resources invested into the development of innovation activities is an aspect covered by the Oslo and Bogotá Manuals. Both instruments consider the importance acquired by different sources of funding to pay for the development of innovations. The first major differentiation established between internal funds (contributions of capital, reinvestment of utilities) and external sources (other enterprises, institutions, commercial banking and international organizations, among others).

Although this differentiation of sources may be useful to show the funding of innovation in the agricultural sector, the structure around which these activities are articulated also requires specificities in financing lines, hence it is necessary to evaluate what relevant mechanisms should be surveyed to understand the dynamic of financing of innovation processes in these activities, For example, the role played in the financing of each harvest by large suppliers of inputs who advance financing, and are then paid at the time of sowing, is highly relevant, as it plays a determining role in the technological package to be implemented[28]. In this context, suppliers of inputs and equipment are the source of financing par excellence in this type of activities. In turn, other sources considered in financing innovation in the manufacturing industry –such as banks and cooperatives- have a marginal importance in this case. On the contrary, there appears to be more relative importance in financing through friends and relatives and advance contracts (with future sales from production).

2.6. Objectives-Incentives and impact of innovation

The study of innovation processes not only involves the analysis of efforts and results obtained, but also implies understanding the motivations that lead to taking a decision to innovate and impacts expected from this process.

The guidelines established by the Oslo and Bogotá Manuals in relation to these dimensions establish that by objectives and/or incentives what is understood is the reasons why enterprises decide to innovate, while in the group of impacts evaluate the effects of innovations on different performance indicators in the enterprise. The fulfilment of these objectives pursued in the decision to begin an innovation process is estimated by measuring the impact of innovations attained. In this respect, objectives and impacts can be evaluated from the analysis of the same factors but from different analytical/temporal perspectives.

In the case of the manufacturing industry, the definition of objectives and the evaluation of impact is done by taking into account different aspects related to products, productive processes, market position and workplace organization, among other questions. In contrast, motivations to innovate in agricultural producers may follow changes in climate conditions or environment, market reasons (changes in patterns of demand), changes in the prevailing techno-productive model, changes in environmental regulations, or other motives particular to agro-industrial production. In this context, it is interesting to research types of more frequent reasons which motivate innovations in the sphere of agricultural activity.

2.7. Obstacles to innovation

Similarly to what we saw in the objectives for innovation and expected impacts, it is possible to make some clarifications related to the obstacles that agents find to develop the innovation process. By obstacles, the Manuals analysed consider all those factors or reasons which delay or prevent the development of innovations. These factors may take different forms, including obstacles of a micro-economic nature, cost-related,

[28] This financing type has a lock-in effect of the technology used, as the funder (supplier) defines the technology to be used, instead of the enterprise that produces it.

market related or stem from legal-institutional aspects that govern economic functioning and relations between agents.

It is also recommendable in this case to make a detailed analysis of the relevance to the agricultural sector of factors considered in the analysis of the manufacturing industry, adopting it to the particularities of the sector, the assumption of the existence of different questions which have a negative impact on the decision to innovate. A starting point derived from the surveys mentioned can be found in existent difficulties for using/incorporating a technology or specific productive process (direct sowing), or on particularities of agricultural production (such as certain specific obstacles related to soil problems and saving fertilizers).

2.8. Protection of innovations

The last dimension to be taken into account in analysing innovative processes is associated with the forms in which agents protect new generated knowledges. In particular, the capacity of enterprises to appropriate the benefits derived from their activities and results obtained.

Patents are an excellent instrument for showing, simultaneously, the existence of results and the protection of innovations in the manufacturing industry. However, their limited application to new products or processes conditions their functionality in the case of less-developed countries in which, as mentioned above, the most frequent innovations tend to be expressed in forms of organization or marketing, or adaptations of existing products or processes, all situations in which the patent is not applicable. In this context, the use of different indicators sustained in the patents –application and granting, patenting rate and place of patenting, among others– have restrictions for showing the results of the innovation process and for protecting knowledge generated from this. Consequently, countries in the region need other instruments (formal and informal) which allow them to protect new knowledges from possible imitations which, in spite of this, have still not been incorporated specifically and recurrently in innovation surveys in the region. These include other intellectual property mechanisms (utility model, industrial design, brands) and non-formal mechanisms (secret, coming first, control of distribution channels).

In the case of agricultural activities, the inclusion of alternative protection mechanisms which exceed patents is particularly relevant, for different reasons. Firstly, due to the previously mentioned complementarity between different types of innovation that take place in the context of formal organizations that are not centred on one agent in particular, but on a group of interrelated agents. Consequently, it is necessary to explore the use of innovation protection mechanisms which are not restricted to ensuring benefits derived from innovation in a segment of a chain, but which guarantees the rights of all agents involved in the innovation process.

Secondly, the productive and developmental characteristics of innovations from these activities requires specific knowledge protection mechanisms. Innovative activity applied to plant improvements has economic properties and repercussions which differentiate them from the industrial sphere. Firstly, innovations happen to non-inert beings and the innovative process is based on the modification of pre-existent entities in nature through the implementation of a group of known techniques. These characteristics broaden the concept of invention of products which are not totally new to man, but are improved versions of existing products in nature which allow a technical or economic advantage over the originals and which, in addition, are living beings which can be modified or altered in time. Secondly, there arise problems of appropriation and dissemination different from those which habitually are seen in industrial goods cases. The possibility of a producer who improves plant varieties (plant breeder) obtaining the economic benefit sought when investing economic and technical resources into obtaining new cultivated varieties is threatened by:

- the reproductive nature of some plant varieties (autogamous species) which in reproducing their genetic characteristics to successive generations allow the dissemination of a new variety without this requiring any specific technical ability or knowledge from humans;
- the traditional farmer's practice of setting aside seeds to ensure subsistence –peasant population– or sowing the grain from harvest in subsequent sowing –modern agriculture– without having to pay additional rights to the breeder of the variety;
- the possibility of third parties making new varieties and using their own without paying rights for it.

The problems of dissemination and appropriation which arise in the case of plant improvement leads to a search for suitable instruments to encourage the technological progress of this activity. There are at present two possible alternatives for protecting plant varieties, depending on whether it is a gene or a living being: patents and Plant Breeders' Rights (PBR) (protection of idiosyncratic type). The former is simply the application of a pre-existing mechanism devised for other types of goods in the sphere of plant varieties, while the latter was specially created for these activities. In both cases, it is necessary to design specific mechanisms that guarantee the certain appropriation of knowledge in relation to agricultural production.

3. Conclusions

This study has presented different elements which show both existing difficulties in measuring and specificities of innovation in agricultural activities. To do so, we began by describing the main transformations in the productive and organizational context of these activities, picking up fundamentally on changes derived from the incorporation of technology and the implementation of network production models.

We then analysed the main instruments used to show different dimensions involved in measuring innovation activities according to guidelines established by the Oslo and Bogotá Manuals, in parallel with the evolution of the treatment of innovation specifically in the agricultural sector. As highlighted above, these tools have to date been applied mainly in the manufacturing industry, while in agricultural activities and service activities use has been considerably lower.

Subsequently, and after presenting the dimensions and variables considered for measuring innovation processes, especially in the Latin American context, these were discussed, taking into account the particularities of agricultural activities. This was done by considering a group of surveys developed in Argentina which inquire into the productive dynamic of this sector and, in this regard, provide some initial considerations for measuring innovation in agricultural activities.

The main conclusions which arise from this analysis are as follows:

- Although the guidelines established by the Manuals mentioned provide basic and fundamental elements for showing measuring of innovation, in the particular case of the agricultural sector it is necessary to make some adaptations which will capture the specificities of these activities.
- There are difficulties in defining "the" characteristics of innovation processes in agricultural activities, given the great heterogeneity of productions and situations included in these. Consequently, it is possible to identify innovation dynamics and measuring elements associated with those which are specific to each of the activities included traditionally in the idea of "agriculture". Although similar differences can be found in different productive sectors, in the case of these activities they are particularly relevant because within the same premises usually more than one type of production occurs.
- The biological nature of production requires a consideration of the importance of local specificities, given the specificities of climate and biome in which these activities are carried out. In addition, it is necessary to take into account the particularities of innovation systems, in as much as they have an impact on the way in which technologies are adopted and disseminated which make it possible to increase productivity, quality and, therefore, the competitiveness of these activities.
- Some indications of how to measure innovative processes in the agricultural sector can be taken from surveys previously conducted with other aims, such as the capture of the production dynamic and specific demands of these activities on the public system. However, in the same way that traditional innovation surveys present difficulties for picking up information on the sector, these exercises were not designed for this purpose and are no substitute. The challenge remains to construct an appropriate tool for measuring innovation in the sector.
- Therefore, it is necessary to expand the set of questions given that certain key dimensions, such as type of efforts, obstacles and necessary relationships for the development of innovation, are still absent or are addressed insufficiently in these surveys.

As a consequence of the above, this study shows the need to generate specific indicators which make it possible to analyse the way in which innovations in biology-based activities are developed and disseminated. To do so, it is not only necessary to develop the methodology, but also the creation of surveys that seek to capture the specificities of these over other productions, which implies recognising their importance as a productive activity that generates value.

BIBLIOGRAPHY

Anlló, G., Bisang, R. & Campi, M. (2010) "Organización del agro. La transición de un modelo de integración vertical a las redes de producción agrícolas", in: Reca, L.; Lema, D.

& Flood, C.., El crecimiento de la agricultura argentina. Medio siglo de logros y desafíos, Editorial Facultad Agronomía, Universidad de Buenos Aires, Buenos Aires.

Anlló, G., Bisang, R. & Campi, M. (2009) "Cadenas de valor en la agro-industria", in: Kosacoff, B. & Mercado, R.., La Argentina ante la nueva internacionalización de la producción. Crisis y oportunidades, PNUD-CEPAL, Buenos Aires.

Anlló, G., Bisang, R., Campi, M. & Albornoz, I. (2009) Innovación y competitividad en tramas globales. Project document. CEPAL, Santiago de Chile.

Arrow K (1968) "Classificatory Notes on the Production and Transmission of Technical Knowledge", American Economic Review, 81, 29-35

Barsky, O. & Dávila, M. (2008), La rebelión del campo. Historia del conflicto agrario argentino, Buenos Aires, Ed. Sudamericana, Buenos Aires.

Bisang, R. (2008), "La agricultura argentina: Cambios recientes, desafíos futuros y conflictos latentes", Fundación Real Instituto Elcano, España, August.

Bisang, R., Gutman, G., Lavarello, P., Sztulwark, S. & Díaz, A. (comp.) (2006), Biotecnología y desarrollo. Un modelo para armar en la Argentina, Prometeo, Buenos Aires.

Bisang, R. & Sztulwark, S. (2009), "Rentas económicas e inserción en cadenas globales de valor. El caso de la agro-industria argentina", in: Dabat, A., Pozas, M. A. & Rivera Ríos, M., Redes globales de producción, rentas económicas y estrategias de desarrollo. El papel de América Latina, UNAM, México, forthcoming.

Campi, M. (2008), Cambios históricos en la frontera agraria pampeana. La tecnología y el uso de la tierra, Master's Thesis in Historical Research, Universidad de San Andrés.

CEPAL, 2009, La sociedad de la información en América Latina y el Caribe. Desarrollo de las tecnologías y tecnologías para el desarrollo, edited by Peres W. & Hilbert M.; Santiago de Chile.

Cloquell, S. (coord.), Albanesi R., Propersi, P. Preda G. & De Incola M. (2007), Familias rurales. El fin de una historia en el inicio de una nueva agricultura, Buenos Aires, Homo Sapiens.

Cohen, W. & Levinthal, D. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation." Administrative Science Quarterly 35: 128-152.

Dahlman, C. & R. Nelson (1993), "Social Absorption Capability, National Innovation Systems and Economic Development", presented at the UNU/Intech Research Conference, Maastricht, June.

de Martinelli, G. (2008), "Pools de siembra y contratistas de labores. Nuevos y viejos actores sociales en la expansión productiva pampeana reciente". in: Balsa, J., Mateo, G. & Ospital, M. (Comp.), Pasado y Presente en el Agro Argentino, Buenos Aires, Luminere.

Dicken, P. (2003), Global shift: transforming the world economy, Guilford Press, Nueva York.

Ekboir, J. & Parellada, G. (2002), "Public-Private Interactions and Technology Policy in Innovatrion Processes for Zero Tillage in Argentina", in: Byerlee, D. & Echeverría, R. (Eds.), Agricultural Research Policy in an Era of Privatization, London, CABI.

Farina, E. & Zylbersztajn, D. (2003), "Economics of Networks and Partners of Competition un Food and Agribusiness", Faculty of Economics, Administration and Accounting, Department of Administration, Universidade de São Paulo, Work Document N° 03/027.

Freeman, C. (1988) "The economics of technical change". En: D. Archibugi; J. Michia (eds). Trade growth and technical change. Cambridge University Press.

Freeman, C. & Perez, C. (1984), "Long waves and new technology", Nordisk Tidsskrift for Politisk Ekonomi, 17: 5-14.

Gereffi, G. (1996), "Global Commodity Chains: New Forms of Coordination and Control among Nations and Firms in International Industries", Competition and Change, Vol. 1, N° 4.

Gereffi, G., Humphrey, J. & Sturgeon, T. (2005), "The governance of global value chains", Review of International Political Economy, Volume 12, Issue 1.

Giuliani, E., Pietrobelli, C. & Rabbellotti, R. (2005), "Upgrading in global value chains: Lessons from Latin American Clusters", World Development, 33 (4), 549-573.

Gregg J., Hassell C. & Richardson J.T. (1964) "Mathematical Trend Curves: An Aid to Forecasting", Oliver and Boyd, Edinburgh.

Griliches Z (1957) "Hybrid Corn: An Exploration in the Economics of Technical Change", Econometrica, 25, 501-522

Hall, A. (2007) "Challenges to Strengthen Agricultural Innovation Systems: Where do we go from here?, Paper presented at the Institute of Development Studies, University of Sussex, UK.

Jamison D & Lau L (1982) "Farmer education and Farm Efficiency", Johns Hopkins University Press.

Kaplinsky, R. (2000), "Globalization and Unequalization: what can be learned from value chain analysis", The Journal of Development Studies, Vol. 37, N° 2.

Kaplinsky, R. & Morris, M. (2000), "A handbook for value chain research", Prepared for the IDRC.

Kline, S. and N. Rosenberg (1986). "An Overview of Innovation". "The Positive Sum Strategy: Harnessing Technology for Economic Growth". R. Landau and N. E. Rosenberg, National Academies Press, Washington D.C.

Lattuada, M. (1996), "Un nuevo escenario de acumulación", Realidad Económica, Nro 139.

Lin, JY (1991), "Education and innovation adoption in agriculture: evidence from hybrid rice in China"; American Journal of Agricultural Economics, Vol. 73, No. 3 (Aug., 1991), pp. 713-723;:Blackwell Publishing on behalf of Agricultural & Applied Economics Association.

Lundvall, B.A. (1992) National Innovation Systems: Towards a Theory of Innovation and Interactive Learning, London, Pinter Publishers.

Maddala, G.S. "Econometrics" McGraw-Hill, New York, 1977.

Malerba, F. & Orsenigo, L. (2000). "Knowledge, Innovative Activities and Industrial Evolution." Industrial and Corporate Change 9(2): 289-314.

Milesi, D. (2006) Patrones de Innovación en la Industria Manufacturera Argentina: 1998-2001. Work Document N° 1. LITTEC-UNGS.

Norris P & Batie P (1987) "Virginia Farmers' Soil Conservation Decisions: An application of Tobit Analysis", Southern Journal of Agricultural Economics 19, 79-90.

OECD (1992), Technology and the Economy: The Key Relationship, Paris.

OECD (2003) Frascati Manual, Proposed Standard Practice for Surveys on Research and Experimental Development, Paris.

OECD (2006) Oslo Manual, Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 3rd Edition, Paris.

Pavitt, K. (1984) "Sectoral patterns of technical change: towards a taxonomy and a theory". Research Policy, 13, 343-374.

Pérez, C. (2009), "Technological revolutions and techno-economic paradigms", TOC/TUT, Working Paper N° 20.

Posada, M. & Martínez de Ibarreta, M. (1998), "Capital financiero y producción agrícola: Los pools de siembra en la región pampeana", Realidad Económica, Nro 153.

Rahm M & Huffman W "The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables", American Journal of Agricultural Economics 66, 405-413.

Richardson, G. (1972). "The Organisation of Industry." Economic Journal 82: 883-896.

Rothkopf, G. (2008), A blueprint for green Energy in the Americas. Featuring: The Global Biofuels Outlook 2007. BID, Washington.

Schumpeter, J. (1912/1934) The Theory of Economic Development. Cambridge, MA: Harvard University Press.

Schumpeter, J. (1942) Capitalism, Socialism and Democracy. New York: Harper.

Sharif M & Ramanathan K (1981) "Binomial Innovation Diffusion Models with Dynamic Potential Adopter Population" Technological Forecasting and Social Change 20, 63-87.

World Bank (2006); Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems.