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BRIDGING ORGANIZATIONS BETWEEN UNIVERSITY AND INDUSTRY: FROM SCIENCE TO CONTRACT RESEARCH

Angelo Bonomi

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Bridging Organizations between University and Industry: from Science to Contract Research(*)

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ABSTRACT: Two bridging organizations, NIS and Agroinnova, formed both in 2003 internally to the University of Turin, have been studied through a good practice benchmarking in view to assess their validity in the science to business process especially concerning Italian SMEs. References for benchmarking have been established by suitable definitions of technology, technology innovation and a structured model of technology followed by a description of the innovation process as a sequence of steps. Benchmarking attention has been focused on contract research and technology transfer office activities. The results of the study show that such type of bridging organizations, and especially their spin-offs in contract research, may be a good possibility to foster the science to business process. However bottlenecks exist and concern the low diffusion of an entrepreneurial mentality that limits generation of innovative ideas for new technologies despite a large activity in scientific research. Bottlenecks concerning SMEs are mainly lack of experience in R&D and technology management. Fostering of science to business process by a simple increase of funds does not appear effective without a change in mentalities, adoption of suitable industrial policies and new concepts for bridging structures and financial aids to SMEs.

Keywords: R&D, technology innovation, bridging organization, contract research, SMEs

JEL Codes: O32, O38, I23

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1. INTRODUCTION

Bridging organizations are a range of intermediary structures whose aim is to lower the distance and search costs in knowledge transfer and commercialization between actors typically universities and industries. The OECD report on commercialization of public research (OECD 2013) indicates a total of eleven typologies of intermediary and bridging organizations that are nearly all external to universities with the important exception of technology transfer office (TTO) that plays a key role in channeling the science to business (Haour, Miéville 2012). However, considering the general process of transformation of scientific research into new technologies we may consider further types of bridging organizations formed internally to the university or existing externally such as contract research organizations (CROs). These types of organizations internal to university are the object of this case study and concern the Nanostructured Interfaces and Surfaces (NIS) center of excellence and the Agroinnova center of competence and innovation in the field of agro-industries, both formed internally to the University of Turin, and both having a spin-off in contract research, respectively the NISLabVCO and the AgriNewTech.

In order to study such types of organizations in the frame of the science to business process it is necessary to consider previously some specific aspects characterizing the Italian universities and the industry structure, in comparison with the situation occurring in other industrialized countries. In Italy high education in technological fields is not separated by general high education and submitted to the same legislation and regulations. Other countries have done such separation creating technological institutions with specific regulations favoring an entrepreneurial view in scientific research and relations with industry. On the other side the Italian industrial structure is characterized by the existence of a large number of small and medium enterprises (SMEs) conditioning the economy of the country. The core of Italian SMEs, often organized as industrial clusters, is characterized by conventional productions, high technology level and leadership in many markets. Such situation constitutes what it is sometimes called the Italian paradox characterized by low investments in research & development (R&D) but extended technological innovation obtained mainly by learning by doing (LbyD). However, such innovation is generally of incremental type often lacking of radical character that would be necessary to assure future competitiveness. In the medium or long term emergent countries, that are now making large efforts in R&D, would reducetechnological gaps or even enter the markets with radical innovative products threatening competitiveness of conventional Italian productions. As SMEs do not have normally research laboratories, contract research with universities may be a solution to increase their R&D activity giving a more radical character and competitiveness to their innovations. Universities are able to supply a valid scientific and technological support for innovations but not necessarily technology management. This is not a problem in relations with large industries having experience in management of their own research laboratories, but it is the case of SMEs that have mainly experience only in LbyD for technological innovations.

In this situation an organizational evolution in high education toward creation of research centers of excellence or competence, or even spin off of independent entities supplying contract research and technology management support to SMEs, might be a good solution in improving relations between university and industry boosting the science to business process in Italy.

After this introduction in a second section we present the framework of this study using a technological approach to the activities of bridging organizations involved in the innovation process and based on: a definition of what is a technology and a technology innovation, which are the relations between science and technology, a model for technology able to define the various types of innovations and the various types of activities leading to innovations, a description of the innovation process as a sequence of steps and a discussion about the technology transfer activity as carried out by bridging organizations under study. In a third section we describe the references used for benchmarking based on contract research practices as used in CROs and TTO practices taken as reference good practices as reported in books (Haour, Miéville 2012) and reports (OECD 2013). In the fourth and fifth sections we present the formation and activity of the two cases study of NIS and Agroinnova and their respective spin-offs in contract research: NISLabVCO and AgroNewTech. In the sixth section we discuss the activity of such bridging organizations in the frame of our benchmarking study and their involvement in the science to business process. Finally in the seventh section we present our conclusions about the results of the study in relation with the considered objective of improving R&D activity in favor especially of the Italian SMEs.

2. FRAMEWORK OF THE STUDY

Essentially the work is based on documentary studies, interviews with researchers of the bridging organizations and a benchmarking based on comparison of good practices and not of results of their activity. For the definition of good practices we have considered as main bridging activity the carrying out of research projects generating contractual incomes, technology transfer, patents and spin-offs. For such good practice we have taken as reference the R&D activity existing in CROs considering, however, that academic environment in which the bridging organizations are operating puts a certain number of limits to the use such practice. Furthermore we have considered for benchmarking the TTO activity supporting contracting, patent licencing and spin-offs taking as reference internationally good practices as reported in books (Haour, Miéville 2012) and reports (OECD 2013).

A fundamental aspect of this study is definition of the real goal of bridging organizations in term of success of new developed technologies and not simply in term of volume of contracts, number of patents or spin-offs characterizing their activity. That means to consider bridging activities in the frame of the entire innovation process from the generation of the innovative idea to the industrial use of the new technology. For this purpose we have considered the innovation process from a pure technological point of view in which science, specific technologies, social and economic factors are externalities of the process. For such task we need a suitable definition of the nature of technology and technology innovation, a description of relations existing between science and technology, a model of technology defining the various types of innovations and activities leading to such innovations. Finally, it is useful the description of the innovation process as a sequence of steps starting from the generation of the innovative idea to the industrial use of the new technology and a discussion on nature of technology transfer activities.

2.1 Technology and technology innovation

This study considers a definition of technology as an activity satisfying a human purpose (Arthur 2009). From this point of view such definition leads to consider, in a certain way, science as a form of technological activity satisfying the human purpose of knowledge of the nature. Beside the fact that modern research depends greatly on technology it should be considered that scientific research is characterized, as any technology, by a specific know how that is necessary to carry out this work. Such fact is important when discussing of transfer of technology as know how of research activity for the development of an innovation is not necessarily the same of that used in operating the new technology with implications in the meaning of what is a transfer of technology. A further aspect of technology innovation is that it may be considered also the result of a combinatory process of already existing technologies (Arthur 2009).

2.2 Relation between science and technology

This study considers as key relation between science and technology the exploitation of new, or already known but never exploited, phenomena, discovered by science, using already existing technologies through a suitable combinatory process as cited previously (Arthur 2009). An example is the case of laser technology based on a new combination of known electronic components able to exploit the phenomena of coherent emission of light (Arthur 2009). This fact makes insignificant, from a technological point of view, the distinction between pure or applied research because discovery of new exploitable phenomena is possible in both activities while the study of combination of existing technologies for the exploitation of the phenomena is the typical activity of R&D. There is another important relation between science and technology consisting in the use of available scientific results in orientating technical research in a specific range of variables with the purpose to find optimal conditions for an innovation (Fleming, Sorenson 2004). For example thermodynamic data are of great importance in carrying out metallurgical research in order to find for example the limited range of temperature in which a new metallurgical process under development probably occurs. Such use of scientific results as a map is characteristic not only of R&D but also of other types of activities leading to technological innovations such as LbyD or combinatory developments not linked to exploitation of new phenomena (Bonomi, Marchisio 2014).

2.3 Model of technology

Technology may be modeled as a structured sequence of technological operations and this model has been used to study LbyD (Auerswald, Kauffman, Lobo, Shell, 1998). Such approach may be also extended to the entire innovation process including R&D (Bonomi, Marchisio 2014). In Fig. 1 we have reported an example of such modelling of a technology considering the production of valves and faucets, and consisting in a graph presenting the main technological operations. Each operation is in fact itself a technology and, for example, chroming operation is actually composed by sub-operations such as degreasing, deposition of nickel followed by deposition of chrome and finally cleaning of the treated part. In this way a technology may be modeled in terms of gross or fine structure depending on purpose. In this model technology innovation is seen as a change of the structure and operations of a pre-existent technology compared to a new technology with the same purpose. Such view allows a definition of various types of technology innovation in term of minor of major change of the technology corresponding to definition of incremental or radical innovations (Nelson, Winter 1977). In such a way it is also possible to define the various types of activities generating technology innovations in which R&D represents an activity leading to radical innovations by exploiting new phenomena discovered by science, LbyD an activity leading to incremental innovations not exploiting new phenomena and combinatory development an activity able to produce radical innovations without exploiting any new phenomena (Bonomi, Marchisio 2014). Such last type of innovation offers an explanation of Italian SMEs paradox cited previously concerning development of new highly competitive technologies (Bonomi, Marchisio 2014). Another possible consequence of the model view of technology innovation is the possibility to measure the entity of change and then the radical degree of an innovation. Such degree may be linked to the technological competitiveness of an innovation offering an extended point of view beyond a simple classification in radical or incremental innovations. Furthermore the model sees technology evolution as a sequence of incremental changes followed by a radical one representing the evolutive trajectory of a technology (Dosi 1982). Finally the radical degree of a new technology defined by the model may be a valid substitute of diffused terms of high or low technologies and related taxonomy (Pavitt 1984). In fact the radical degree is a measure independent of specific technologies and historical evolution of technology that in fact modifies the definition of what it is high or low tech. Furthermore the radical degree of new technologies offers explanation of observed success of new technologies that might not be necessarily classified as high tech and characteristic of the cited SMEs paradox.

2.4 The technology innovation process

Technology innovation is the object of a large number studies and many of its aspects are well known by academics and policymakers alike, however, the process of generation of innovative ideas converted in successful new technologies is highly complex, poorly documented and little studied (Auerswald, Branscombe 2003). The technology innovation process may be seen as a sequence of steps. One of the first sequential view of the innovation process included various phases concerning basic research, applied research, experimental development and industrialization (Freeman 1974). Such view is characteristic of a technology innovation process generated by scientific research but it does not take account of innovations that may be generated by activities that are not necessarily R&D. A general process including all types of activities leading to technology innovations may be described as a sequence of steps independently of financing or structure in which the process occurs and it is reported schematically in Fig. 2. This sequential process is not substantially different from other models given in the literature (Auerswald, Branscombe 2003) although we name differently the various phases taking account of the technological point of view we see the process.

The Fig. 2 indicates also the phases that are mainly concerned by the various types of innovation activities and those involving the bridging organizations that are essentially in the feasibility phase and in minor measure in the development phase but able to give an important contribute to the generation of innovative ideas. We report the main aspects of the various steps as follows:

- *Generation of innovative ideas*

We consider the generation of innovative idea as a combinatory process that, in the case of R&D, involves exploitation of new or never used phenomena as cited previously. Such generative process combines scientific and technical factors with economic, market and environmental inputs, and it is supported by past experience in successful or abandoned research activities. Individual creativity and generative relations are of main importance in generation of ideas. Actually only a very minor number of generated ideas have in fact the possibility to enter in a feasibility phase.

- *Feasibility phase*

Such phase represents the beginning of the innovation process and concerns the feasibility of the innovative idea and involves typically an R&D activity. In this phase scientific and technological factors are of major importance in determining the continuation or not of the innovation process.

- *Development phase*

This phase concerns mainly improvement of level of performance and specification compliances of innovation and evaluation of its economy starting from results of the feasibility phase or of combinatory developments. Operation of pilot plants or construction of prototypes is a typical activity of such phase and the new technology in this phase assumes its first concrete operational structure. Socio-economic externalities have the major impact for the future of the innovation, and performances and specifications compliance shall be cleared before evaluation of the economic aspects of innovation. This phase is known to be the most selective for developing technologies and it has been called metaphorically the “Valley of Death” of innovation projects and the path of an innovation process seen as a crossing of a “Darwinian Sea” (Auerswald, Bransomb 2003).

- *Industrialization phase*

This phase includes final development work and planning of industrialization of the technology. It should be noted that the level of projects survival in this phase is far higher than in the feasibility and, especially, in the development phase.

- *Technology use*

With the industrialization phase normally the technology development process is considered terminated. However, the innovation process, following our technology model, goes on also during the use of the technology that it is continuously modified by searching new optimal conditions and by responding to appearing of externality factors influencing the efficiency of the technology. Such improvements are typically the result of LbyD. The life of a technology and its innovation process terminates with arrival of more efficient alternative technologies.

An important aspect of the innovation process is represented by risk of failure and how such risk changes during the development activity of a new technology (Branscombe, Auerswald 2001). When discussing about innovation processes we shall separate the concept of risk from that of incertitude (Knight 1921). In fact incertitude represents the impossibility to evaluate a risk that it is seen as the estimation of probability of success or failure of an innovation. In fact the R&D activity transforms incertitude into risk making possible decisions to continue or not the innovation process. There are various types of risks or incertitude accompanying the innovation process (Scherer 1999). These types of incertitude concern technology, performance, economy and market. Technical incertitude decreases principally in the feasibility phase. Performance incertitude decreases principally in the development phase just before economy one. Market incertitude is the most difficult to eliminate and it may be substantially reduced only in the industrialization phase and during the use of the new technology. Another aspect of the innovation process linked to risk is the degree of success of a new technology in terms of return of investments. Studies carried out on this aspects (Scherer, Haroff 2000) has shown a skew distribution of such success characterized by few cases of very great returns and a large number of cases with marginal results.

In conclusion the described innovation process shows, as far as bridging organizations are concerned, how important is the generation of a high number of innovative ideas from scientific research in order to overcome the strong selection barriers and to produce a positive return despite the skew distributed results in the use of new technologies.

2.5 Technology transfer

Most of activities of our bridging organization, beside scientific research, concern what it is called technology transfer and it is at the base of relations between university and industry. As this study considers as final goals of bridging organizations the success of new technologies, especially in favor of SMEs, it is important to define which kind of technology transfer is really effective for such goal. Following previous discussion on the nature of technology it might be argued whether the term technology transfer is accurate in describing this activity. It may be observed that: a technology is in realty inexistent if it is not associated to a know how for its use. The know how associated to the various phases of development of an innovation is not the same as know how necessary to use the new technology and for these reasons a real technology transfer from R&D is not possible and a specific know how shall be developed starting the use of the new technology. In fact what it is called technology transfer might be better defined as a transfer of knowledge. A great part of technology transfer activity in fact it is useful only for incremental innovation and only a minor part of transfer concerns innovations with a higher radical degree and competitiveness with strong patent positions. Most of technology transfer and consequent incremental innovations leads industries in what it is called a red queen regime in which we assist to a continuous innovation without real firm developments. In a red queen regime a firm develops an incremental innovation and acquires a certain competitive advantage, however, another similar firm in competition has the same competences and may easily develop an alternative destroying the existing advantage and, after that, the same cycle restarts. In fact the possibility for a firm to assure a durable competitive advantage for its development lies in the realizations of a continuous and rapid innovation to maintain the gap with the other firms or trying the development of innovations with higher radical degree, strong patent positions and new competences that the other firms cannot easily overcome. Such considerations show the importance of development of technologies with a certain radical degree in the frame of activities of bridging organizations in order to assure future competitiveness, especially in the case of SMEs facing global market competition as previously discussed in the introduction.

3. BENCHMARKING

As cited previously benchmarking of bridging organizations is based on good practice and not on results using as reference contract research practice, as carried out in CROs, and TTO international best practices as described in books (Haour, Miéville 2012) and reports (OECD 2013).

3.1 Contract research

Contract research practice based on R&D projects following the rules of project management is reasonably one of the best ways to develop new technologies in the frame of the science to business process. Such practice has been developed in USA, outside universities, in the first half of the XX century with the aim to favor technology innovation for industry and its development has been described in a previous study (Bonomi 2013). Contract research practices in private organizations, grew with the aim of reaching a self sustaining activity, free of any academic conditioning, emerging from a Darwinian selection of various experiences. In an academic environment it is not always possible to follow fully such practice because of existence of various restrictions, however, taking account of these limitations, this practice may be considered a good reference for benchmarking. We may present the important points characterizing such good practice as follows:

- A contract for research shall cover supply of competences but not guarantees of results
- Selling R&D projects through proposals of innovative ideas to potential industrial clients is a source of financed projects

more effective than waiting for industrial contacts searching competences and collaborations
- R&D projects are more easily saleable when accompanied by prefeasibility and preliminary market studies
- Development of R&D projects should be carried out with an entrepreneurial mentality developing the figure of researcher-entrepreneur that does not mean a researcher becoming an entrepreneur but a researcher that considers his work also from an entrepreneurial point of view.
- Patent rights should be granted gradually maximizing the amount of obtainable contract research
- Multi-client projects and studies are an interesting alternative to single-client ones and that is particularly important in the collaboration with SMEs (Rolfo, Bonomi 2014)

Limits to such practice existing in academic environment will be discussed by benchmarking our cases study.

3.2 Technology Transfer Office

The TTO is an internal organism of universities that plays an important role in relations between university and industry. There are three important tasks characterizing a TTO (Haour, Miéville 2012) that can be resumed in:

- Contracting for collaborative research between companies or other entities and universities
- Licencing of university technology to companies
- Promotion of spin-off and generation of start-up

All these activities are in fact strictly connected as university collaborative research is often at the origin of patents and spin-offs.

- *Collaborative research*

Collaboration between university and industry may occur in various ways (Haour, Miéville 2012) that can be resumed in:

- Unilateral or multilateral firm – university collaboration
- Students or university researchers in industrial R&D laboratories
- Long term consortia
- Common structures for collaboration between universities and firms

Unilateral collaboration consists normally in specific R&D projects within contract research agreements and becomes multilateral when it includes various firms and universities carrying out a common R&D project. The presence of students in industrial R&D laboratories is an important vehicle of technology transfer. Long term consortia are typically agreements between university and industry dedicated to R&D in relevant areas and suitable laboratories. Common structures for collaboration are of various types and include co-location of firms and university laboratories in local clusters, innovation campuses and even joint laboratories supporting specific research areas co-owned by university and industry. Although the various forms of collaborations appears quite different, in fact the innovation process is normally carried out in form of R&D projects in the frame of research contracts that establish financing and ownership of industrial property rights.

- *Licencing university technology*

Patents rights licencing by universities may be an interesting source of money for their activities.

Generally patents rights originated by R&D projects with industry are regulated contractually following the various forms of collaboration, however it is possible that internal or public financed research may also be at the origin of patents whose property depends on specific regulations existing in the various countries. In most of these cases the property is attributed to universities but in certain cases, as in Sweden and Italy, it is attributed to researchers (Haour, Mièville 2012). Such different policies are the object of discussions about efficiency in commercialization of public research (OECD 2013), however, considerations about competence and financial availability necessary to sell and exploit successfully patent rights seems to indicate that university property or suitable agreements between university and researchers are a more valid practice than a simple researcher’s property alternative (Haour, Miéville 2012). The experience on patent licencing shows that financial income from such activity does not generally cover costs of TTO in this task (Haour, Miéville 2012).

By consequence a strategy of TTO just to maximize such type of income is doubtfully effective.

A better strategy may be the use of licencing in maximizing contract research activities instead of incomes. Such strategy is largely used in CROs and OECD report on commercialization of public research gives the example of Fraunhofer strategy in this field (OECD 2013). The general strategy used in contract research organizations for this purpose may be resumed in the following points:

- Contract research shall be based on guaranties about competences and work within contractual budget and time limits not about generation of patents
- Cession of patent rights should be gradual in term of exclusivity and territorial extension as a function of the various steps of the research in order to recover the maximum amount of work that can be done by the laboratory in the development process of the innovation
- The scope of ceded patent rights should be limited to the actual fields of interest of the industrial partner avoiding arising of limitations in the freedom of right cession to other industrial partners for patent exploitation in other fields not in competition with the former partner.

Such suggestions, that are coherent with contract research good practices, can be considered a good practice for TTO enabling the successful integration of activity of contract research with patent rights licencing.

- *Spin-off and start-up*

Spin-off is a process characterized by people leaving an organization, in our case the university, forming a separate entity, called a start-up, dedicated to a specific business. Spin-offs and start-ups are an effective way to transform science to business and a TTO may help such process in various ways. In fact there are three types of spin-off concerning universities with quite different consequences in term of business. These may be defined as follows:

- Spin-off concerning the formation of an entity supplying testing, consulting and other services to specific industrial sectors
- Spin-off concerning the creation of research laboratories dedicated to R&D activity and studies for industry, selling of technologies and exploitation of patent rights
- Spin-off concerning development of a new technology generally protected by patents

The first case is relatively frequent but, although being an effective support to industry, it does not have important potential returns in term of business, employment and other positive socio-economic impacts. Spin-off for creation of research laboratories dedicated to industry and patents exploitation is less frequent, however, it may have important indirect effects through contract research with industries in development of new technologies. Spin-off based on patents and developing new technologies are real actors in the science to business process possibly generating start-up with potential important returns and positive socio-economic impacts. TTO is not of course a source of financing of possible start-up but it may supply a favorable coaching by giving hosting, information, relations with sources of financing such as venture capital and contractual support to researchers willing to create a start-up. However, when considering the typical case of SMEs with conventional productions in industrial districts it may be argued the suitability of venture capital for such type of industry. In venture capital the financial objective consists in adequate return of investments and profits assured by selling a relatively low number of successful start-ups in respect to the total financed number as consequence of the highly selective characteristics of the innovation process (Morgenthaler 2001). Another aspect is represented by the skew return of capital characterizing new technologies (Scherer, Haroff 2000) and by the fact that typical portfolio strategy used in finance is not relevant as a single venture capital cannot finance a so high number of projects constituting a representative sample of such activity (Morgenthaler 2001). The consequence is that venture capital tends to finance projects that are in a relatively advanced development, low incertitude and characterized by very high returns of investments, conditions not necessarily always existing in the typical technological innovations suitable for SMEs

4. NIS

The Nanostructured Interfaces and Surfaces or NIS has been created in 2003 as center of excellence by the Italian Ministry of Education, University and Research. In 2008 it was transformed in an interdepartmental center of the University of Turin, and reformed in compliance with the new statute of the university in 2013. At the origin of NIS and obtainment of statute of center of excellence there was the initiative of a professor of the Department of Chemistry acting as a leader coagulating rapidly a network of researchers coming from various departments of the university in the fields of chemistry, physics and biology with a general interest in nanostructures and nanotechnologies. The initial structure included a research council with ten members, a president and a secretary while presently there are 21 council members, a president, a director and a secretary. The number of researchers involved in NIS increased rapidly and in 2006 was of 63 professors and researchers assisted by 8 technicians, all belonging to the university structure, and about 90 people involved in research education and post doc research. The group was quite stable with time and only about ten researchers abandoned NIS during the reform due to the new university statute but rapidly substituted. Presently the NIS is composed by about 80 researchers and technicians belonging to the university structure and about 80 people involved in research education and post doc research. Research members are coming from different university departments including chemistry, physics, pharmacy, life science and biology and earth science. Adhesion of researchers to NIS is based on contractual agreements and administrative and budgetary functions are provided by the department of chemistry. Activities were funded at the beginning by a governmental support as center of excellence between years 2003-2006. Terminated the governmental support, financing was obtained by a foundation, the Compagnia San Paolo, and various regional, national and EU projects funding and industrial contracts. Presently NIS is requesting further funding to Compagnia San Paolo, that now cannot be obtained directly but only through the University of Turin. On the other side it is looking for a certain degree of independence within the university structure to improve the efficiency of its activity. There are various advantages for researchers in participating to NIS including favorable interdisciplinary approach, better critical mass in obtaining funds and participating and coordinating public and industrial research projects. A major advantage given to researchers is the access to an existing common laboratory with suitable instrumentation of high level. Main activities of NIS are in fact in scientific research resulting in the 2004-2013 period in about 950 publications and technology transfer generating 5 patents and 3 spin-offs. Other activities, beside research and technology transfer, concern education with organization of courses in specific area of research and organization of meetings, the NIS Colloquia. Concerning technological transfer, inquiries have shown that in fact only about 10% of NIS researchers are really interested in developing industrial applications of their research. It appears that many of the researchers consider their activity as a cultural development with marginal interest in industrial applications and new technologies a byproduct of science. Activity concerning industrial projects is about 10-20% of the total activity depending on the research sectors and it is relatively high in particular in the field of life science. There is a difficulty to obtain specific quantitative data about NIS as they are accounted by departments together with other activities. Cooperation with SMEs is practically possible only in large projects of EU programs when SME has specific niches of competence, or in presence of public aid as in the case of the Innovation Poles organized by Piedmont Region. From the point of view of TTO assistance NIS researchers does not supply a major help as researchers have just available a certain number of contract types and prepare themselves contract agreements. Patent assistance is limited to verification of compliance of legal and university regulations about the industrial properties and about spin off they have contacts with the incubator of the University of Turin.

4.1 NISLabVCO

The creation of NISLabVCO as research laboratory for industry was not an initiative of NIS but of ARS.UNI.VCO, a local association in the Verbano-Cusio-Ossola Province, with the aim to favor also local university courses. In fact the purpose of NISLabVCO was not simply contract research with industry but also a support to courses for the obtaining of a bachelor degree in chemistry organized locally by the University of Turin, such courses existing since 2003, but discontinued in 2007. For operating the laboratory it was founded in year 2006 a cooperative company with a capital of 176.000 Euro, the Nanoireservice S.c.p.a, with the aim to manage various future research laboratories but in fact, with the closure of local university courses in 2007, management was limited to NISLabVCO for contract research to industry. Major associate of the company is ARS.UNI.VCO with 39.8% of capital followed by other local public and private entities and with the University of Turin participating with the 2.8 % of capital. NIS was charged to assure the scientific compliance of the activity with the NIS secretary assuming a position as Scientific Director. The activity of NISLabVCO has been described in detail and discussed in a previous work (Bonomi 2013) and we will present here only its major aspects. In 2007 it was carried out a brief investigation about potentiality existing at NIS in term of industrial applications related to its scientific research with the purpose to establish relations with NISLabVCO. In Fig. 3 we have reported the various applications that might be potentially derived from the various scientific areas covered by NIS research. Although such figure presents a situation monitored few years ago, it gives a still valid representation on how scientific research may be a major source of potential applications. Following such investigation a proposal to consider the use of NISLabVCO for a development phase of a research project concerning the use of catalytic carbon nanotubes for the reinforcement of fibers and other materials by finding a group of industries financing the work was not taken in consideration. In fact the use of NIS research for projects development for NISLabVCO was quite limited and major projects carried out by the laboratory were obtained with local industry in the field of cellulose acetate as protecting film for LCD screens and a certain number of projects involving the use of nanoparticles in various materials and coatings. Many of these projects concerned R&D assistance to technology developments of external partners and did not result in any patent application. At the maximum of expansion the laboratory included two full time researchers and an administrative assistant. Laboratory turnover in years 2008 – 2012 was in the range of 150.000 Euro and balance sheets relatively equilibrated, however such equilibrium was obtained with the support of the University of Turin that paid the cost of the two researchers not included in the balances. Such support ceased in 2012 and that loss, accompanied with a sensible reduction of the activities due to the end of some important projects not substituted by new ones, resulted in major difficulties in operating the laboratory with layoff of personnel. Presently the laboratory has still some limited activity with a part time researcher but it has important economic problems that should find a solution to avoid closure. In this situation it cannot be excluded that the University of Turin would consider an exit from the laboratory closing the scientific relations existing with NIS.

5. AGROINNOVA

Agroinnova was created in 2003 by initiative of two professors of Department of Agriculture of the University of Turin joined by other six researchers of the department with an activity retracing that of a similar Swiss centre of competence. Differently from NIS it was constituted as centre of competence, and not as centre of excellence, enjoying of funds coming from various governmental departments as answer to various needs existing in Italian agro-industry. Differently from NIS it obtained immediately a status of autonomy from the budgetary and administrative point of view although remaining a structure within the University of Turin. That made possible an autonomous management of received funds and freedom in hiring administrative and technical personnel, this last possibility very important in carrying out technology transfer work for agro-industry. Its organization includes a president, a director and a scientific council of about 25 members many of them external to the University of Turin and from foreign and international institutions. There is also a management board composed by the president, the director, the administrative secretary and research, technical and administrative representatives. Agroinnova has conserved with time the six initial researchers and presently enjoys of further 23 collaborators on projects, 7 being from foreign countries. The main activities of Agroinnova concern research and technology transfer reported schematically in Fig. 4. Other important activities concern: permanent education with organization of national and international courses, communication with organization of national and international conventions, publishing scientific reviews and educational material. Transfer of technology activity is carried out in various facilities including a centre on seeds pathogens, a laboratory for molecular diagnostic and a testing centre. Both research and transfer technology activities are a source of projects, patents and scientific publications. Present annual budgets are around two million euro and 30-40% of funds are coming from EU programs with projects most of them in which Agroinnova assures the coordination, about 20% from various governmental departments, about 20% from foundations and industry, 25% concern the transfer of technology. Agroinnova activity has generated 5 patents and there is a further spin off in preparation after AgriNewTech described below. The number of publications made by Agroinnova in the period from 2009 to 2012 is over 1100.

5.1 AgriNewTech

AgriNewTech S.r.l. is a spin off of Agroinnova created in 2009, in the frame of a funding program of Piedmont Region, with the objective to exploit commercially results and patents of Agroinnova research and technology transfer especially in the field of compost and biologic fighting against pathogenic microorganisms. AgriNewTech includes the activity of one researcher and management is assured directly by Agroinnova. Patents originally obtained by Agroinnova, and then property of the University of Turin, were all transferred to AgriNewTech after a negotiation of their value between management of Agroinnova and the university.

6. DISCUSSION

A necessary premise to our discussions on benchmarking should take account of some studies concerning TTO, spin-off and start-up as well as patent generation in Italian universities. In Italy there is an association acting as a network for the valorization of university research www.netval.it that includes nearly all the Italian universities. Such association publishes yearly a report containing detailed statistics and data about TTO activities, patents and spin-off generation, the last published in 2014 and referring mainly to university activities updated to 2012 (Netval 2014). It includes also a benchmarking that it is based on relations and reciprocal consideration by the various TTO but it does not present in detail any TTO good practice referred to the science to business process. A study on boundary spanning of technology transfer centers in North East of Italy has shown the importance of technical skills and networking competence in such task (Comacchio, Bonesso, Pizzi, 2012). Other studies concern spin-off generation in Italian universities showing the importance of local contexts of support mechanisms (Fini, Grimaldi, Santoni, Sobrero 2011), and importance of TTO external relationships involved in technology transfer (Nosella, Grimaldi 2009). Another study considers the different factors influencing the decision of founding academic start-up in Italy showing that often the academic's involvement in creating new ventures is not driven by an entrepreneurial attitude but rather by expectation of results enhancing the academic position (Fini, Grimaldi, Sobrero 2009). Finally we may cite a study on Italian university patenting activity in the frame of the existing legislation and university owns patent regulations (Baldini, Grimaldi, Sobrero 2006).

Benchmarking of our cases study also necessitates previously the highlighting of some important differences existing between Agroinnova and NIS activity. Agroinnova is involved in research and transfer of technology concerning specific agro-industrial and environmental sectors and covers large needs for example in diagnostic and improvement of cultivations. NIS has a wider science oriented activities and industrial sectors that may be potentially involved are very numerous because of the large spectrum of possible applications concerning nanotechnologies. From this point of view NIS has a larger potential for development of radical innovations and patents from its activity than Agroinnova. In Tables 1 and 2 we have reported strength and weakness respectively of NIS and Agroinnova. Taking account of such difference we proceed in benchmarking considering at first contract research and after TTO activities followed by relations with SMEs.

6.1 Contract research benchmarking

Contract research best practice has been presented previously noting in fact it cannot always be fully applied in university R&D because of academic limitations. From one side private CROs have a large freedom in organizing efficiently R&D activity but it is in universities in which it is generated the large amounts of potentially exploitable scientific results for R&D. From this point of view it is useful to discuss the limits of our bridging organizations in carrying out R&D work and to see whether it is possible to reach a good compromise that takes account of both limiting aspects. Academic research is carried out in a great part not only by researchers belonging to the university structure but also by students working on experimental thesis and researchers with fixed term post doc contracts that in fact carry out most of the experimental work for research and R&D (Latour 1987). Collaboration periods in these last cases are generally of about one year for master degrees, three years for doctorates and one or two years for post doc positions. Such times are well suitable for scientific research and long term cooperation with industry but not for feasibility phases that are the key initial point of any innovation process. In fact R&D project management tends to split feasibility and development phases in small steps with durations that are often lower than one year. Such choice is a consequence of incertitude accompanying R&D, as discussed previously about the innovation process, leading to planning of research for transformation of incertitude into risk enabling a decision to stop or continue the project with a minimum amount of expenditure. Such stop and go of R&D is not well adapted to an academic environment with fixed periods for research and publications need. Although it could be thought to devote some university researchers to such task, there are other raising limitations concerning the necessity for university researchers to make publications, feasible only after patents publications, and by the fact that a researcher career depends at a great extent on such publications. This situation may be better managed in the case of technological universities or high professional schools with regulations favoring an entrepreneurial view of research and importance of contract research, and not only publications, in personnel's career. Another aspect limiting the science to business process is a diffused mentality that scientific research is essentially a cultural activity not considering that it can be also a service to mankind (Boehm, Groner 1972). Such considerations, derived from discussion with researchers of our bridging organizations, are also in agreement with a study on the University of Turin, compared with the Polytechnic of Turin, in which the culture of collaboration with external actors in scientific departments of the university has been found quite lower than that it is observed in the Polytechnic (Rolfo Finardi, 2014). Lack of entrepreneurial motivation has been also observed by the study cited previously on academic's involvement in Italian universities, based on the case of 47 spin offs, appearing dictated more by enhancing academic positions than for entrepreneurial attitude (Fini, Grimaldi, Sobrero 2009). Concerning creation of external organizations of our bridging organizations we may note that AgriNewTech is fully integrated in Agroinnova activities and oriented especially to exploitation of patents coming from research and technology transfer activities, while NISLabVCO had a disappointing evolution regarding contract research activity. NISLabVCO, differently from AgriNewTech, has never had strong relations with NIS and it is ruled by a management external to the university. As observed in a previous work

(Bonomi 2013) the lack of financial and human resources and policies far from good practice of contract research combined with weak relations with NIS researchers are probably the cause of its failure.

6.2 TTO benchmarking

Following interviews with researchers of NIS it does not appears a real existence in the University of Turin of a TTO coordinating contracts, patent licencing and spin off generation as described in our TTO best practice. NIS researchers have available various types of contracts but negotiate themselves when allowed with external entities. Concerning patents it exist an office that simply verifies that a patent respects existing national laws and regulations specific for the University of Turin. Concerning spin-off it exist an incubator of the University of Turin, presently including about 40 spin-offs, that in fact carries out a scouting activity in university research responding also to search of competences for industrial partners. It seems that this incubator covers in fact the typical TTO activity in the field of spin-off. In the case of Agroinnova the situation is different as such organization assumes itself the TTO activities having also the necessary administrative personnel to carry out such tasks. The lack of coordination activities for TTO in the University of Turin is of course unfavorable to the science to business process especially in the case of NIS.

6.3 Relations with SMEs

Both NIS and Agroinnova have relations with SMEs but NIS, with its large spectrum of potential applications coming from research, is in a particular favorable position to help Italian SMEs of various sectors. Discussion with researchers has shown that contract research with SMEs is practically possible only in presence of public aid and in certain case of UE projects in which the SME may offer specific niches of competence. It could be argued whether the policy of direct public aid to SMEs, and especially the condition of access to funds when it exist a joint agreement of collaboration of a SME with a university laboratory, is really efficient. For example Switzerland does not grant any direct funds for R&D to industry but only to university laboratories and in particular to the two federal polytechnics and high professional schools that make contract research with industry. Nevertheless Switzerland is considered a country with one of the best knowledge and technology transfer policy (Haour, Miéville 2012). There are many reasons in favor of such Swiss policy. In fact, it may be observed in Italy that direct aid to SMEs has the perverse effect to induce such industry to make R&D only in presence of public financing. On the other side bureaucracy tends to grant a fund deciding: how much to finance, when to start and terminate the work, when to make the payments and sometime with which laboratories it is possible to collaborate. In these conditions we may argue whether it is industry or bureaucracy to manage funded R&D projects. The direct funding of university laboratories for R&D purposes has the advantage to favor exploitation of research results by prefeasibility studies that would boost the industrial interest in financing, and that facilitates also the finding of a suitable industrial partner for the proposed innovation. It should be noted, however, that such approach in funding universities and not industry is effective only in presence of an entrepreneurial mentality in the university research activity.

7. CONCLUSIONS

In conclusion the study shows that, beside a certain number of limitations, the studied bridging organizations, and especially spin-offs in contract research, may have good possibilities to foster the relations between university and industry by introduction of flexibility and entrepreneurship as well as an R&D closer to good practices. Such bridging organizations may constitute a valid evolution toward an improvement of the science to business process that can be realized in compliance with the present regulations and respect of existing legislation for Italian universities. We may observe as Agroinnova has an activity well satisfying its initial objectives and may foster contract research and patents exploitations through AgriNewTech. On the contrary NIS is faced to a choice whether to continue a prevalent scientific research activity or to develop also contract research and transfer of technology exploiting its large availability of research results. In this last case the experience of Agroinnova shows the importance of some form of independence from the university structure for this purpose. Also the creation of a contract research organization, well integrated in NIS activity, as the case of AgriNewTech, may be of great interest especially for contract research with SMEs. The failed experience of NISLabVCO should not be a prejudice for such choice as failure reasons of this laboratory are well known and may be easily avoided. An external contract research laboratory would be useful in particular for SMEs opening the possibility to supply a further support, beside the scientific and technological aspects of an innovation, to an industry that has not a great knowledge in R&D. Experience in cooperation of universities with Consorzio Ruvaris, a network of firms in valves and faucets production devoted to R&D, has shown as the lack of state of the art, market and patent intelligence studies accompanying the R&D work is a cause of failure of contract research (Bonomi 2013). There are however some bottlenecks in development of the science to business process from both university and industrial side. In the case of universities the primary bottleneck concerns lacking of an entrepreneurial vision limiting generation of innovative ideas for feasibility studies despite of a consistent amount of scientific research carried out. On the industrial side, especially in the case of SMEs, we may observe a low propensity to take risks in R&D due to a diffused bad knowledge of such type of activity and technology management. Such bottlenecks are accompanied by a scarce knowledge by university about technological industrial problems and scarce knowledge by industry of potentiality of research. It should be noted that historically relations between university and industry in Italy were much stronger in the 60’ and 70’ of the past century, we may cite just the example of collaboration of Montedison with Prof. Giulio Natta of the Polytechnic of Milan, Nobel prize of chemistry in 1963, but such collaboration with industry degraded since the 80’ at the same time with the disintegration and downsizing of the Italian large industry. That may be a cause of present weak relations between university and firms in an industrial structure composed prevalently by SMEs that have difficulties in such relations as already explained in our introduction. Such situation may suggest the necessity of an industrial policy that takes account of such evolution of Italian industrial structure. The simple increase of research funds through forms of aid, actually recalling the European procedures based mainly on experience with large industries, would not be probably effective, and new concepts of bridging organizations and forms of aid suitable for SMEs should be considered.

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APPENDIX

TABLE 1. Strength and weakness of NIS

STRENGTH	WEAKNESS
Great activity in research with a large potential in generation of innovations	Lack of interest for R&D and poorly diffused entrepreneurial mentality
Diversified and synergic research activity	Absence of autonomy in management of budgets
Experience in contract research with industry despite failure of NISLabVCO	Scarce support of University TTO

TABLE 2. Strength and weakness of Agroinnova

STRENGTH	WEAKNESS
Great activity in research and technology transfer	Necessity to replace researchers at the origin of the centre now close to retirement
Autonomy in management of the centre	R&D limited to agro-industry not including other industrial sectors
Direct management of AgriNewTech	Limited potential in generation of spin-off

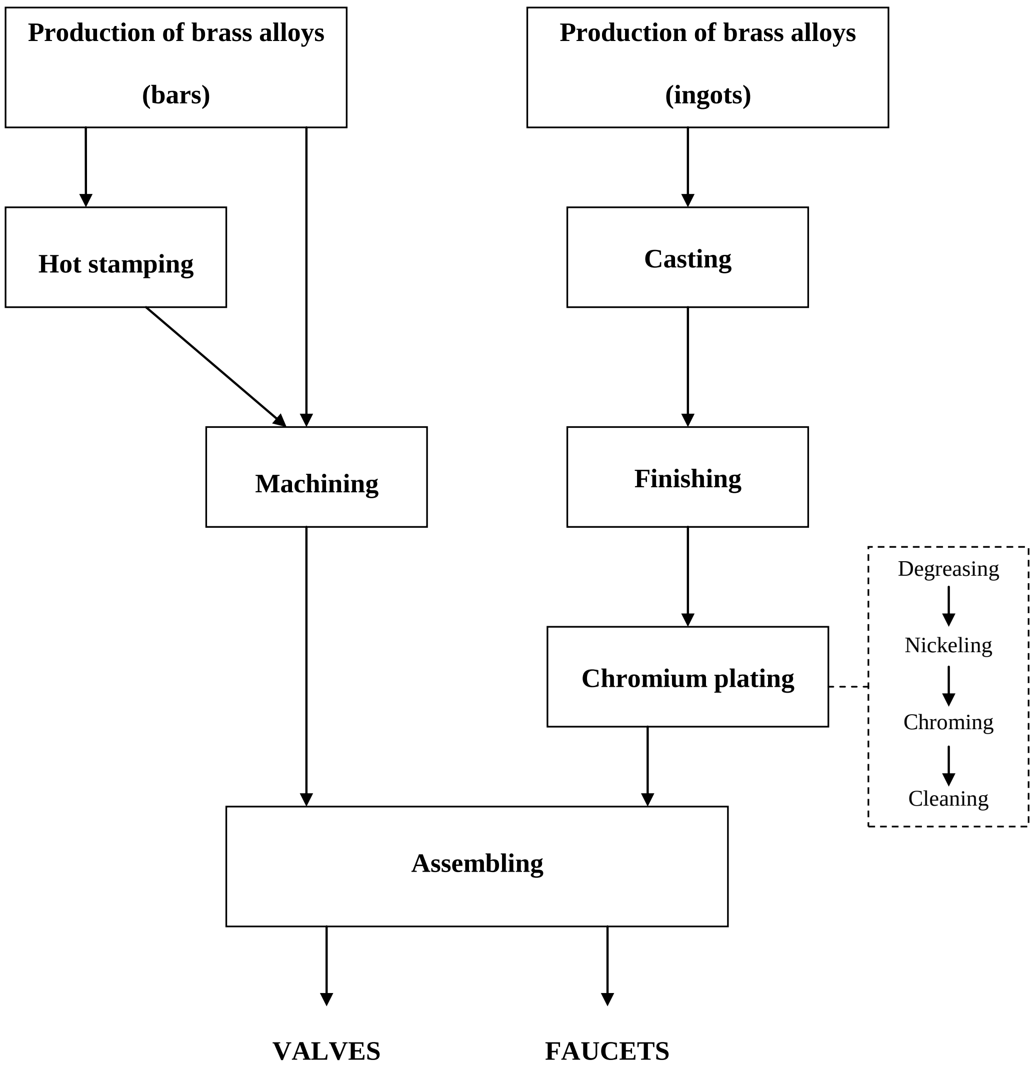

Fig.1. Example of structured technology model of production of valves and faucets

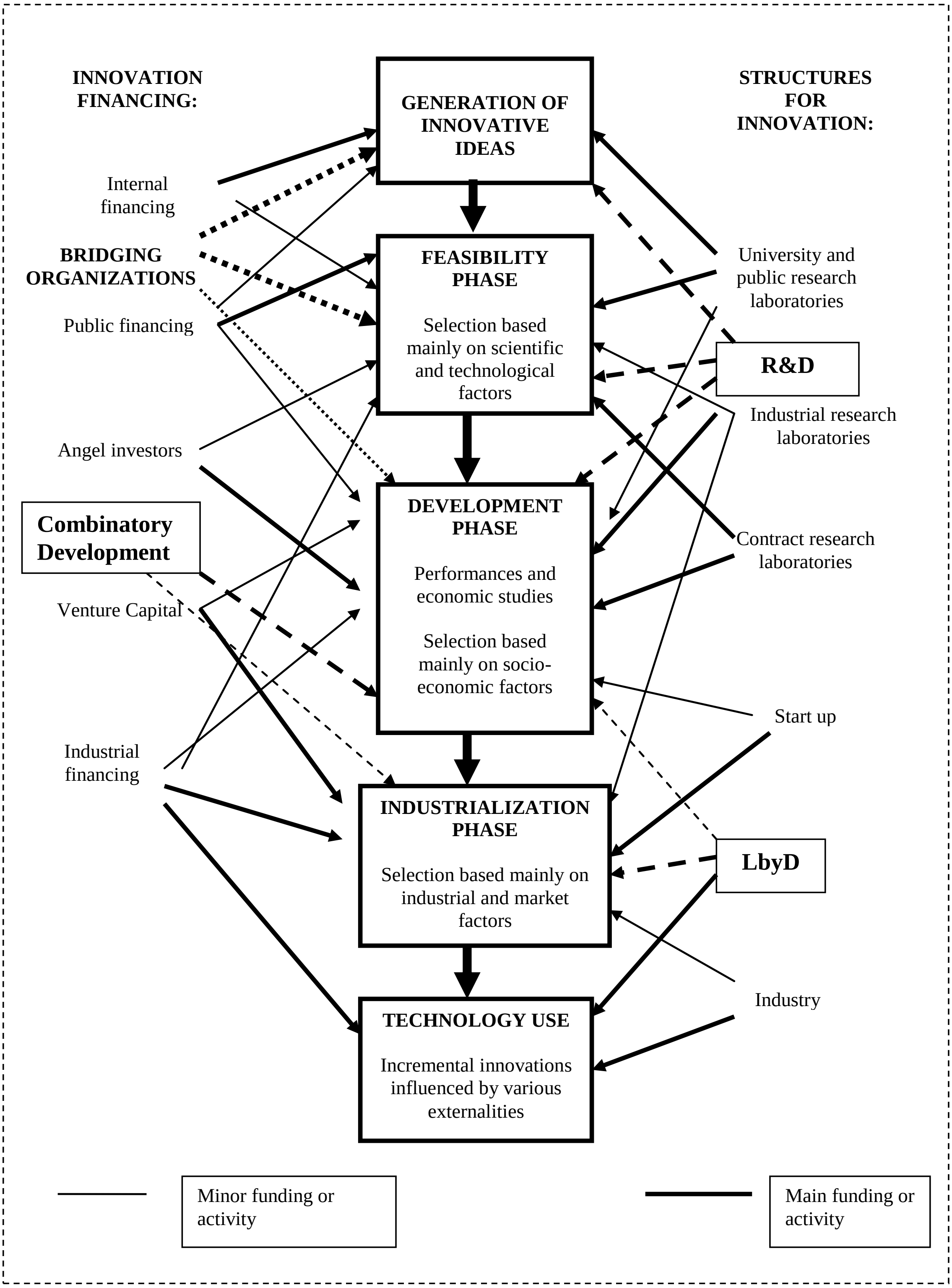

Fig. 2. Sequence steps of the innovation process

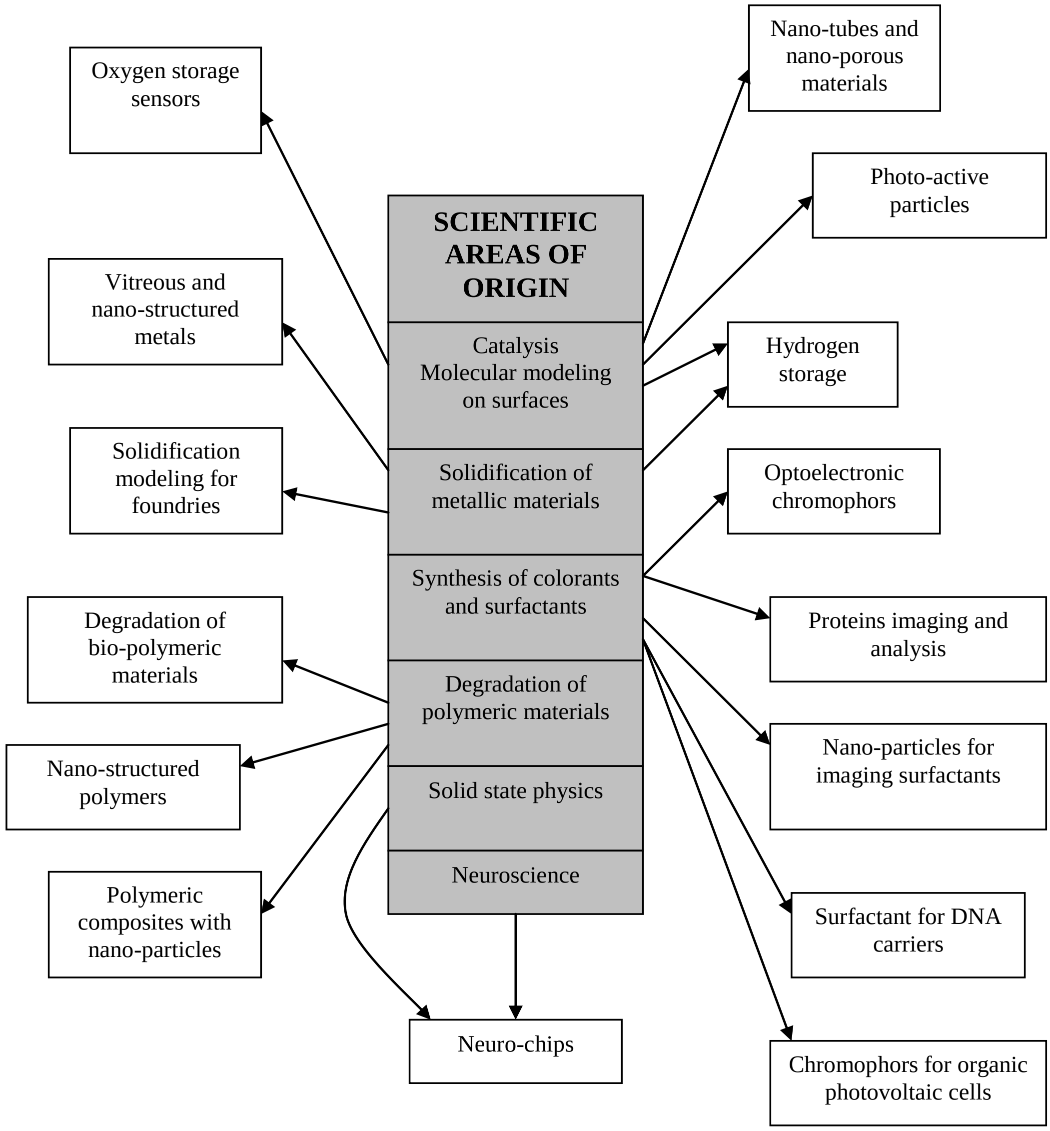

Fig. 3. Relation between NIS scientific research and technological applications

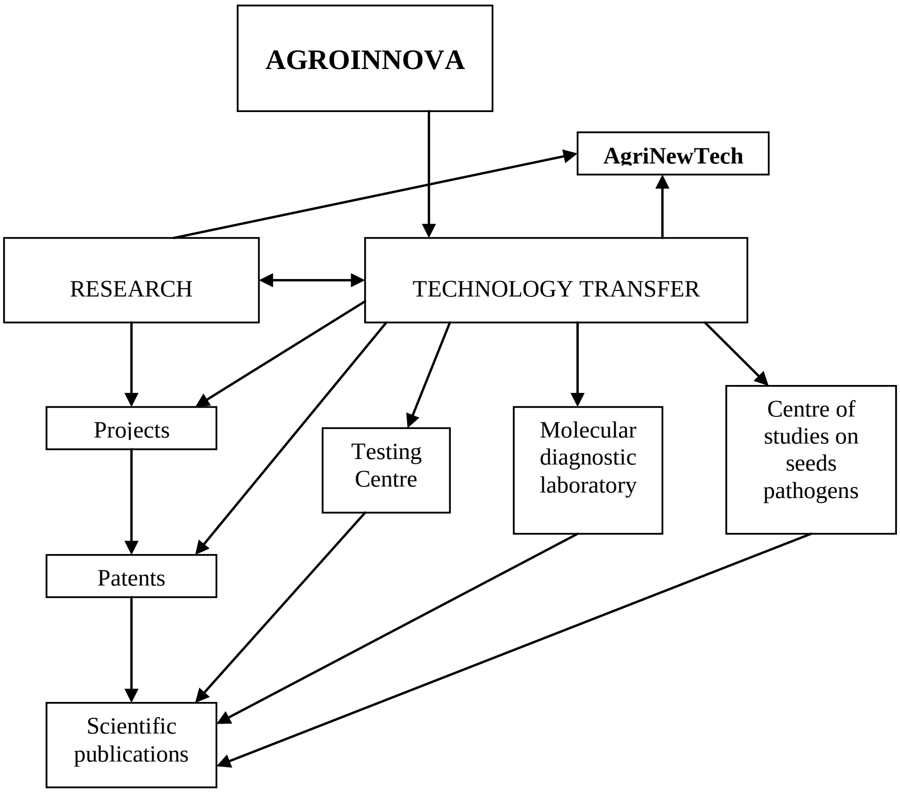

Fig. 4. Schematic view of research and technology transfer activity of Agroinnova

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