Technological Transfer in Public Research Centers: The Peruvian Case

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***Abstract*--The public research centers were created to research activities and knowledge generation. Some studies, around the world, have been developed about this problematic and the opportunities for technology transfer, from these institutes. In the Peruvian case, until now, the national institutes of research have structured and applied its programs and models of technology transfer in an incipient form. Some of difficulties perceived are: the lack of studies on technology management, ignorance about other local experiences on technology transfer, the lack of comparison with technology transfer models. In this context, this paper aims to identify and analyze the technology transfer experiences since the public research institutes in Peru. The methodology consisted in the literature review over the technology transfer topic, followed by a diagnostic of the technology transfer at the Peruvian public research institutes, its discussion and analysis. Major results from the study showed a disordered sector, with lack of mechanisms for technological transfer, and scarcity of codification the few experiences. However the potential knowledge is substantial.**

I. INTRODUCTION

The public research centers in Peru emerge since the military government era in the decade of 70´s, when were developed proper spaces for research far from the universities. With the exception of the National Institute of Health (INS), that dates of the year 1896, that has as forerunner an institute dedicated exclusively to the study of vaccines.

The results of the research in these public research centers - that notwithstanding be codified and published - does not impact nor even reach the sectors where are necessary. There is some kind of divorce between the offer of knowledge and the demand of this, furthermore the ostensible "gap" between both.

The Peruvian rector body of science, technology, and innovation (CONCYTEC) searches to identify and map this problematic to define mechanisms of support the actions of technology transfer since of the public institutions of research and universities to the productive sector.

Hence, it is necessary major knowledge on problematic of technology transfer as well as the opportunities and organizational mechanisms that assist or avoid them. It is also important to identify the potential of knowledge and technologies available in the research institutes.

Some antecedents of technology transfer are in the work of authors as [3], [10], [4], among others. Harris & Tanner [9], who have studied the technological transfer in two health research centers, one of them in San Francisco - USA and another in Tanzania, conclude in the necessity of cooperation north - south in health, as well as the interactions south - south, to assign funds for research in developing countries and the necessity of translating research into action.

Silva & Ramirez [13] carried out a comparative studies of the public research centers of Brazil and Spain. Preliminary independent variables were determined as the inclined to interact with researchers, dependent variables as the number of contracts of technology transfer, and control variables as the number of researchers in each center. This study, that shows the peculiarities of technology transfer from the public research centers in different countries, drives to think about the necessity of specific studies for each national reality.

In Peru few studies on this problematic theme were carried out. So, Alvarez & Hatakeyama [2] studied technology transfer in the public research center for health. In another study NESST [11] developed a study about as some inventions become in innovations.

Oriondo et al [12] developed a technology transfer model based on the literature, which has been applied in the National Institute of Research and Qualification in Telecommunications of the Universidad Nacional de Ingeniería - UNI with two action focus, one internal (assessment of technology products and protection of intellectual property), and one external (technological intelligence and the promotion of creation of companies).

In this context, the objective of this study is to determine, applying the model of Bozeman [4], the effectiveness and the potential of the technology transfer from the public research centers for the productive sector, as well as why technology transfer was not successful. The study was limited to three public research centers in Peru.

II. METHODOLOGY

The methodology consisted in semi-structured interviews in public research centers followed by the application of questionnaires elaborated in accordance with the theoretical framework over the issue.

In the preliminary questionnaires were included the following questions:

- Which are the difficulties to perform technology transfer in Peru?
- What technology have been transferred by your institution (to other organizations and/or subsidiaries)?
- Who is in charge to promote and/or coordinate technology transfer for other institutions since your institution?
- What is the technology and/or knowledge required by your institution?

These preliminary questionnaires permitted to identify general aspects in the research on technology transfer. After

that, the study focused in the second questionnaire about the technology that the institution has transferred. Here, it was adapted some questions from the model of Bozeman [4] with other specifics to the technology on issue.

- How many scientific papers, patents, and license have generated?
- Had the technology transferred impacted in the sales and profits of the receiver company?
- Did the efforts of technology transfer influence regional economic development?
- How the receiver organization benefited from the technology transfer?

III. TECHNOLOGY TRANSFER FROM THE PUBLIC RESEARCH CENTERS.

Bozeman [4] did the analysis of the technology transfer from the university and from the public research centers to the companies and other organizations. This author point out that the universities as well as public research centers have common characteristics about the work of research performed. Only the difference it's regarding to the organizational structure that in the public research laboratories is more hierarchical.

Also this author marks the correspondence between the actions of the public research centers with the policies of science and technology which dominate in the national level. Particularly could be the cooperative research model that contributes to reinforce the technology transfer since the public research centers.

An theoretical approach for technology transfer since university laboratories as well as since public research institutions was proposed by Bozeman [4]. The dimensions considered in it are: 1) characteristics of the organization that will transfer technology; 2) mechanisms of technology transfer; 3) technology to be transferred (object of transfer); 4) characteristics of the organization that receive the technology; 5) the environment of the technology demand. Such dimensions of the technology transfer are presented in the Table No 1.

The process of technological transfer has an analogous behavior to a heat transfer process. So the organization that generates the technology is analogy to the heat source, the organization that receives the technology is equivalent to the cold source, and the technological transfer media are analogous to the interface between the hot source and cold source. This analogy is completed with the transfer object and environmental demand in the Bozeman model.

Bonaccorsi & Piccaluga [3] proposed a model that performed the measurement of knowledge generated (inside the transfer agent), the transmitted knowledge (through transfer means), as well as propagated knowledge (to inner of the receiver of technology). This model, which includes the motivation of receiver organizations to interact with the academy, it's complemented with the variables: object of transfer and demand of environmental of the model proposed by Bozeman [4].

Coccia [5] introduced one model with Fourier´s series that studies the spatial dynamics of the technology transfer process.

Abe et al [1] state the need to cross functional stakeholders such as, administratives, financial, universities, and businesses for the success of the partnership project. It's necessary an effective communication among them to understand the value for the project to make plan and creative proposal based each member's knowledge, then build consensus to visualize and to share. Lack of poor goal setting, message and governance, especially poor communication and consensus are main reasons for partnership project failure.

Estep & Daim [6] state that is important to acknowledge the interdependencies among the different perspectives. The organizational characteristics that are necessary for a successful technology transfer can be identified as commitment, communication, trust, dependencies, and sharing of resources. However, these characteristics cannot be achieved without consideration of the personal perspective – individuals within the organizational culture have to adopt attitudes of trust and collaboration. Similarly, the interaction between technical, personal and organizational perspectives seems to be apparent. They suggest that successful demonstration projects help to establish the market and this market is made up of individuals who will be technology recipients.

TABLE NO 1. DIMENSIONS OF THE TECHNOLOGY TRANSFER

Dimension	Agent	Examples
Agent of transfer	Institution that generates technology that could be transferred.	Government agency, university, private firm, characteristics of the place, organizational culture.
Means of transfer	The vehicle, formal or informal, for technological transfer.	License, copyright, cooperative research, person - person, formal literature.
Object of transfer	The contents and form of the transferred technology.	Scientific knowledge, technological arrangements, processes, know how, specific characteristics of each one.
Receiver of transfer	The organization or institution that receives the transferred object.	Organization, consumer, informal groups.
Demand of the surroundings	Public sector as a user of the technological innovations.	Price of the technology, substitutes, relation with present technology, subsidies.

Source: Bozeman [4]

A. Agent of transfer

Bozeman [4] establishes relationships between the characteristics - as its organizational culture - of the institution that will transfer the technology with their research activities. To him, institutions with diversified agenda of research are more prone to technology transfer.

Levin [10] states that the administrative function of the program involves the administration of process including the overall coordination and control, that could be administrated in two different forms: hierarchical and bureaucratic, or in a flexible form.

Authors as Etzkowitz [7] show triple helix model, which integrates the government, university, and enterprise. In addition, Vergara [14] who uses this model to analyze some Chilean technological transfer cases, considers that public research centers belong to the academic helix.

B. Means of technological transfer

Bozeman [4] sustain that cooperative research and development agreements - CRADAs - are important mechanisms of technology transfer, that have contributed to reinforce the technological capacity in general more than to benefit one specific product. Also he found that the difference between organizational culture of the research centers and collaborator organizations is a obstacle to the effectiveness of the technology transfer. Technology parks, where are companies that are nourished with knowledge of the public research center or since the university that manages the park, are also important mechanism of technology transfer.

According Levin [10] the transfer media kept relation with the mediating process when the technological organizations receivers are called and are motivated to participate. Some programs follow a traditional applications model where there is an open call. In addition a variant in this process considers a decentralized mediating process, with participation of consultants.

Similarly, patents and intellectual property are converted in important elements to be considered during the technology transfer processes.

C. Content of transfer

Bozeman [4] pointed out the interest that has had the tacit component of the knowledge transferred. This author also said that initiatives of technology transfer proposed by the managers and/or directives of the companies will have more commercial success that initiatives the intermediation office or from the research centers.

In addition this author, in a study performed in the United States with 219 interactions among laboratories of public research centers with companies notifies that only 22 % result in saleable product.

D. Receiver Organization

Regarding to the organization that receive the technology, it must consider not only companies but also the public sector. Bozeman [4] found difference in processes, barriers, and effectiveness in technology transfer inside the receiver organizations, according if the receiver belong to private or public sector.

According Geisler & Clements [8] companies that very often interact with public research center its search for knowledge more than for specific products and/or licenses.

E. Context of the demand

Bozeman [4] considers that not only the market shapes the demand, but also the participation of the public sector, as user of the innovations, that encourages such dynamism. Based on a study carried out in Canada where 25% of inventions from the public research centers had the first application in the public sector, this author highlight the importance and influence public sector in the technology demand.

Likewise, the author agree with the manifested by other authors in the sense that, quite often the public research centers only make available the technology waiting for the users.

IV. CASE STUDY

The Peruvian institutes of research studied are: National Institute of Health - INS, Peruvian Institute of Nuclear Energy – IPEN, and the Institute of Sea of Peru - IMARPE.

A. Difficulties to perform technology transfer

After performing the preliminary survey with researchers of several universities and public research centers, were found that they identify the difficulties to perform technology transfer in Peru, as appear in the Table 2:

TABLE NO 2. DIFFICULTIES TO PERFORM TECHNOLOGY TRANSFER

Difficulties to perform technology transfer	Frequency
Lack of interaction between center and company	12
Lack of specialists in technology transfer	9
Starts with the offer ignoring the demand	8
Lack of budgeting	7
Lack of researchers	6
Do not coordinate inter-institutional research	4
Lack of laboratory infrastructure	4
Logistics difficulties	3
Lack of time	2

Source: elaboration from the interviews

B. Technology transferred

Some technologies that have been transferred since the public institutions of research to other organizations and/or subsidiaries are showed in the Table No 3:

TABLE NO 3 TECHNOLOGY TRANSFERRED

INS Method to determine the iodine in salt. Reading of radiographies for pneumoconiosis with the techniques of the ILO 2000 Kit “tariqui dengue”
IPEN Nuclear applications in medical physics transferred to the clinics. Irradiation of foods to a private company. Industrial radiography to several companies.
IMARPE Systems of growing seaweeds biomass to the private company. There is a technology package to grow the micro-seaweeds. The production of micro-seaweeds at the pilot experimental level in the institute is from 8,000 liters per week. It has produced 01 kg of dried biomass per month.

Source: Authors

C. Coordination of technology transfer

The unit in charge to promote and/or coordinate technology transfer (to another organizations) in the institutes in the study are:

The INS has the Technology Transfer Unit that belongs to the General Office of Technology Transfer, which coordinates with each of the centers that composes this institute: Occupational Health and Environment Protection for Health - Censopas, Quality Control - CNCC, Feeding and Nutrition - Cenan, Public Health- Cnsp, Biological Products - Cnpb, Intercultural Health - Censi.

This institute has the guidelines of technology transfer which contemplates 04 phases, whereby the fourth phase is the formalization of transfer in accordance with established guidelines. Presently the technology transfer is carried out without establishment of more formal procedures.

The role of the Director of the Technology Transfer in IPEN is to facilitate contact the researchers of the institute with companies that demand technology. The procedures for technology transfer is shown in Table No 4.

In the IMARPE there isn´t as such because the institute centralized only in research; nevertheless there was one unity of research and development that was substituted by the department of promotion of projects and researches. Usually there is one answer following an specific demand from the productive sector, to which one professional of the IMARPE, said that (G. Sotil, personal communication, Janeiro 28, 2014): *"Generally come to IMARPE companies and/or universities interested to develop one theme"*.

D. Technologies and/or knowledge required by the institutes

Technologies and/or knowledge that will require catch the public research centers to augment its potential of transferable knowledge are:

According to the Director of the Office of Technology Transfer and Qualification of INS (M. Curisinche, personal communication, Janeiro 24, 2014) it will be required *"technology to better the sanitary interventions in the public health aiming to reduce costs, improve the quality and the effectiveness of the interventions in the health"*.

IPEN (M. Montoya, personal communication, Janeiro 10, 2014) will require *"support the technology to make applicable accelerators to produce the radio isotopes for the medicine, more knowledge on study of materials, new developments in nuclear medicine, therapy of the cancer, and environment applications"*.

To the person in charge for the aquaculture, the IMARPE will require knowledge on *"recomendations in what is the technology transfer, of intellectual property and development of patents"*. Similarly, another researcher of the institute perceives that the requirements of knowledge are *"Aquaculture technologies and aquatics biotechnologies. Also oceanographic information technologies"*.

In addition another professional said that (G. Sotil, personal communication, Janeiro 28, 2014): *"It is needed level sequencing technology at he molecular level for genome analysis. Also the technique for mass chromatographic analysis"*.

E. Indicators and economic impacts in the technology transfer

The INS had 02 patents submitted, one for a kit of quality control of quick assessment to detect malaria disease, and another for an apparatus to reduce the water contaminates. It has published approximately 100 scientific papers since the year 2000. In another hand, according to the Director of the Office of Technology Transfer and Qualification (M. Curisinche, personal communication, Janeiro 24, 2014):

> *"technological transfer to regional laboratories imply reduction of cost of samples transport to Lima with an important economic impact. There is reduction of mortality because the diagnosis is faster"*

Meanwhile, from the year 2001, IPEN has applied for 02 patents, and published approximately 50 scientific papers. About the impact of the transferred technology, the Director of Technology Transfer (M. Montoya, personal communication, Janeiro 10, 2014) declared that:

> *"All that we do is applied, for petroleum industry, agriculture, mining, among others. It has generated much SME´s of graduates from our courses, who build shields for accelerators and irradiators"*

IMARPE, although account with scientific publications, has no patents applications of invention; thus, has no experience in licensing. Regarding to the economic impact of technology transfer performed, particularly on the technology of farming micro-seaweed, this is still in implementation by the receiver company.

F. Impacts of the technology transfer in the regional level.

The regional impact of the technology transferred since the INS, according to the person in charge of the center Cenan (C. Legua, personal communication, Janeiro 16, 2014) *"it's look for that regions could adquire the capacity to solve problems without need to depend of the city of Lima"*.

TABLE NO 4. PROCEDURES ON TECHNOLOGY TRANSFER

	Unit that manage technology transfer	Procedures on technology transfer	Licenses / patents	Transfer of knowledge	Record of cases of technology transfer
INS	Technology Transfer Unit	Codified	0/2	Yes	Partialy
IPEN	Technology Transfer Direction	Tacit	0/2	Yes	No
IMARPE	Department of Promotion of Projects and Researches.	Not defined	0/0	Yes	No

Source: Authors

Regarding to the impacts of technology transfer since IPEN at regional level, the director of Technology Transfer pointed out that:

> *"The isotopic hydrology is used by SEDAPAL (fresh water company) to manage better the aquifer resources of Peru. The genetic improvement technology of some grains (barley) transferred to la Universidad Nacional Agraria La Molina served to generate new type of barley (skinless) that has diffused throughout Peru.The irradiation technology of foods has made possible the export of products. The industrial radiography technology has used for the inspection of gas pipelines which are currently operating".*

In the offshore laboratories of IMARPE, that are presented also at the national as the regional level, it's analyzed the biomass amount and the determination of dissolved oxygen, among others. Particularly the technology on the micro-seaweed farming it is producing in pilot scale by PSW company in its plant of Lurin in the south of Lima.

G. Benefits of technology transfer in the receiver organization

Regional laboratories are the receiver organizations of the technology transfer from the INS. According to the Director of Technology Transfer and Qualification:

> *"Over 70% of the technology transfer is concentrated in transferring the diagnostic methods in different phases of advance. The main benefit is the access to the diagnosis in the illness avoiding in sending the sample to the institute in Lima. The opportune diagnosis implies an opportune treatment, moreover to better the capacity to solve problems in the laboratory that receive the technology".*

Regarding to the benefit for the organization that receive technology since IPEN, the Director of the Technology Transfer states that:

> *"Allows that the technology receiver companies could to sell and perform the tasks better than before"*

The receiver company of technology of seaweeds cultivation transferred from IMARPE was benefited with the incorporation of knowledge to the core business, as after the qualification and the scheduled visit of professionals of the institute, now the company are using the cultivation system.

It is important to point out that in all cases the voice over benefits come from the agent of transfer and not from the receiver organization.

V. RESULTS FROM ONE OF PUBLIC RESEARCH CENTER

The INS due to its seniority has larger technological path than other institutes, particularly its center - Cenan that came from the merger of the former ministry of food and the Nutrition Institute. Some technologies transferred by the National Institute of Health - INS, over which has broadened in the present study are:

A. The determination of the iodine in salt.

The determination of iodine in salt consists in the volumetric method developed in the center Cenan of the INS that permit to determine the amount of iodine contents in salt, that must be iodized by the Peruvian regulations. It's a volumetric method that, according to one of researchers of the center (C. Legua, personal communication, Janeiro 16, 2014), *"is not harmful neither to the analyst nor to the nature"*. This method results more complete than the kits from India that determine only the presence or absent of iodine.

By legal mandate was given to INS the responsibility at nationwide the control of the level of iodine in salt. In this case there is a clear participation of the state in the shaping of the demand and the market for this technology.

This technology was learned through the international interaction with organizations as the Inter-American Network of Laboratories for Analysis of Foods - RILAA, the participation in tests inter-laboratories, and the exchange of researchers.

B. Interpretation of radiographs for pneumoconosis with techniques of the ILO 2000

The interpretation of the films is the diagnosis methodology based in the chest radiographies to discard pneumoconosis that is done according to standardization established by the International Labor Organization - ILO.

This illness, the pneumoconosis, has appeared several years in Peru, but only since 2006 started to participate in the international program to eradicate the silicosis in the year 2030 by the ILO and the World Health Organization - WHO.

This technology was learned through qualification with experts of the ILO that came in 2008 to standardize the interpretation of films. The way to transfer this technology and the knowledge inherent has been through courses of qualification with the participation of experts of the ILO and the national experts. Until 2013 has performed 07 courses in Lima, Arequipa, and Cajamarca, with 124 professionals that had been approved in the course and are registered in the INS.

C. Kit "tariqui dengue"

This kit, to diagnose the disease of dengue fever, has been developed by the National Center of Public Health of INS. However it could not be patentable due to the restrictions to the products and/or processes of benefit to the public health. It is in the process of technology transfer for the regions where the problem of dengue is endemic. For that aim, the INS looks for develop technology qualifications and get equipments for its regional laboratories. Presently the institute is producing the kit, which is distributed to regions.

VI. CONCLUSIONS

It has perceived the need that the public research centers execute the technology intelligence to avoid the duplication of efforts, and monitor the science and technology worldwide level to feed and become sustainable the generation of base knowledge after the transference.

The knowledge transfer mechanism requires to be mapping, codified, and learn the lessons to reinforce good practices.

It is necessary to flexible the process of technology transfer, without the condition of the application of intellectual property and patents, for the cases that there are knowledge demand only at pre-competitive level. Additionaly, the intellectual property management is complex, for that it's suggested publish after to patent.

That the interaction with international organizations would stimulate favorably to technology transfer, and also according to recommended by Harris & Tanner [9] should be incentived the interactions South - South.

The public research institutes in Peru are concentrated in Lima, that provokes the cognitive dissymmetry against the regions. It also could provoke that the finance given by the government for research and development remains only for some institutions in Lima.

There is no inter-institutional coordination among existing institutes aiming to share better practices and experiences of technology transfer.

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