Technology Transfer as a Driver of Cooperation and Communication in a New Knowledge Management Methodology

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***Abstract*—The growing tendency of globalization and interdependency of economies is inferred in highly competitive and chaotic context for firms and universities. Due to the high competitiveness and changes that firms face, Technology Transfer (TT) is assumed as a key factor to success. A better management of innovation created in research units as well as a deeper and closer cooperation and communication of these units with the business sector are the biggest factor of hope and strengthening for the global economy. This study arises due to the growing necessity of the Electromechanical Department (DEM) of University of Beira Interior (UBI) to diffuse their studies and technology among their logistic, institutional and more importantly, enterprise partners.**

***Index Terms*—knowledge, technology transfer, universities, companies, innovation, management, DEM**

I. Introduction

Until the early 80s, Universities' background was mostly focused on teaching, and that was their main function. From that point, the government policies change allowed an unprecedented expansion of the research activities, which went hand in hand with the creation of structures which aim that development and the promotion of a growing connection with industry [1], [2]. After the year of 2000, universities opened their doors to what was outside, particularly to the productive sector.

In the second half of the last century, Universities faced the demand of an effective contribute to the economic growth, mission which has been added to teaching and research [3]. Hence, these institutions have been being encouraged to take a more active role in transferring knowledge in a perspective of commercial valuation [4].

Nowadays, due to the vertiginous process of technological innovation, the cooperation between Universities and business appears as a highly important arrangement between institutions so as to promote and keep the competitiveness of those companies. [5].

Universities are institutions which have an important role to play, with its teaching activities, research and community services, contributing for the growth and management of innovation, knowledge transfer and consequently, promoting the development of the regions in which they are found. It is of high relevance to know how well these Institutions are prepared to participate in such a complex process as the knowledge transfer and technology to the companies. [6].

The University-Company relationship maximizes the technological development, promoting advantages for both involved sides and helping them attain their objectives, even if they are of different nature. [3]. With the characteristics of today's market, it is necessary to know the technologies the department possesses, who their strategic partners are, and the areas in which it is a market leader.

In this study, a detailed analysis to the obtained results will be done, as well as to the policies and methodologies which have been being developed in DEM, regarding the knowledge management and the transfer of its technologies to its market partners [7].

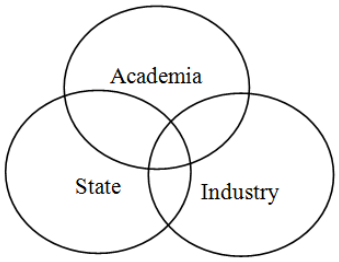

Figure 1. Triple helix model [adopted 3].

II. Tecnology and Knowledge Transfer

The European Union has been recognizing the importance of this University – Market connection, and, as a strategy, ask the Universities a greater participation in the economic development, having defined as one of the ten key areas for its action, the increase of knowledge transfer between RTD institutions and civil and industrial society organizations [8]. The better study for understand this needed relationship between University- companies and Society (state) is the Triple Helix Model adopted by Henry Etzkowitz [3]. This concept generates a strong

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innovative environment, with tri-lateral initiatives for knowledge-based economic development and strategic alliances among firms [3].

Today this model is the model most widely adopted by the majority of developed countries. However there are still countries that base their strategy on a Triple-Helix model where the government and its policies command the actions of universities and businesses. On the other hand there are countries with a Triple helix model where these three types of organizations work separately having no joint relationship which makes the process of innovation and development and too slow without much success [3].

A. *Universities' Mission*

The following table is a summary of the several stages Universities have gone through in their history. It shows that Universities keep a flexible and innovative attitude, being an active part of the constant sociocultural changes.

TABLE I. FUNCTIONS OF UNIVERSITIES [ADOPTED 7]

Univ. Missions	Traditional Modalities	Advanced Modalities
Education	Universities with postgraduate programs;	Universities with Doctoral programs; Universities with more than ten Doctoral programs assessed as "Excellent".
Research	State-of-the-art technological research	Standard academic research in an international framework; participation in international research networks and international publications.
Third Mission	Rendering of technological and educational services, with emphasis to *lato sensu* courses and consultancy activities. Incubators	Enterpreneuring university: cooperative investigation, intellectual property, investigation spin-off and technology centres. Third Mission: registration and patent licensing and I&D spin-off.
Fourth Mission	Erasmus, Internationalization of students looking for new experiences	Internationalization: autonomous internationalization university strategy, based on the search and sharing of knowledge, of education as social commodity and as a way of approximation between Nations and the Global Market.

In this study it is still referred that the background in which the third mission has been gaining importance is particularly in the economic dimension, through patent increase and technology licensing, in the strengthening of University – Industry relationships and the growing participation of academics in entrepreneurial activities. The United States are the country with the most visible results in this subject [9].

The third mission of the Universities has encouraged distinct ways of pursuing the education and research functions. In 1998 and in 2003, the same author says that the development of a relationship with the Industry has maximized new dynamics in university research, such as its extension to development and the introduction of objectives and practices of entrepreneurial work [3], [9].

Basically, the third mission of University is knowledge and technology transfer to the market and to society, through a connection to the non-academic world (Industry, public and society authorities), from a utility perspective for attaining public interest objectives [8]. Hence, this mission integrates an economic dimension (cells 1, 2, 3, 4 and 5 from Fig. 2) and a social one (cells 6, 7 and 8 from Fig. 2), connecting itself through commercial and non-commercial activities-Fig. 2 [7].

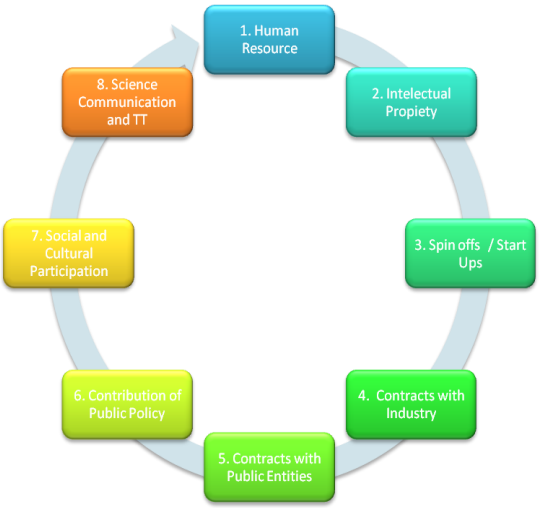

Figure 2. Dimensions and activities of the third mission of Universities [adopted 8].

The fourth mission of the universities intends to give universities a greater autonomy in their internationalization framework. It isn't forced due to economic reasons or state policies but to a perspective of broadening horizons, looking for new experiences, new ways of learning, cooperation and approach to partners. Universities are nowadays an agency open to community. However, they will not lose their essence and their historical guidelines. [10].

B. *Typologies and Concepts*

There are different conceptions of technology transfer (TT), varying from a very linear approach to a more holistic perspective. A dynamic conception of TT has been chosen for this study, which is defined as communication process, absorption and technology application by the receptor, occurring in an objective and successful way.

1) *Technology*

Technology is defined as an ordered set of all the systematized knowledge in production, distribution and use of goods and services. It is an active process which surpasses the frontiers of its entities, whether they are countries, organizations, or even people, depending on the observer's point of view [11].

Another author has classified technologies on a strategic perspective, according to the different typologies: a) – Base technologies – these are the key-technologies from the past, which nowadays are within the reach of any company of the sector. They do not constitute a strategic tool. b) – Key-technologies – are the ones that sustain the current competitive position of the company.

For this reason, they are the main responsible for obtaining profits and for the development of the company. c) – Emergent technologies – are the ones which are found in the first phase of application in the Industrial context, demonstrating a high development potential, accompanied by a high level of uncertainty. They may become, in the short term, the company's key-technology, this is the reason why they should be highly considered by strategic planning [11].

2) Innovation

"Innovation is any profitable change". This definition is related with the success in market, with improvement and change. Innovation is also synonym of producing, assimilating and successfully exploring the novelty of the economic and social domain. It carries with it unprecedented solutions for the problems and permits to address people's and society's needs [12].

According to OCDE, Innovation can be divided into several types: a) Product innovation – Bringing new or improved products to the market, resulting from the use of new knowledge, changes in equipment and/or production organization; b) Processes Innovation - Adopting methods of new products, resulting from the use of new knowledge, equipment changes and/or organization of production; c) Marketing Innovation – Procedures renewal and methods of organizing companies, suppliers, production and commercialization of goods and services; d) Radical Innovation – Introduction of a new product or renewal of the way production is organized, which may result in a structural rupture with the technological pattern used till then, resulting in new industries, sectors or markets; e) Incremental Innovation – Introduction in a company, without changing its structure, of any improvement of the product, process or production organization; g) Technological Innovation – Introduction of products and processes which are technologically new [12].

3) Technology transfer

There are several authors who present the most varied definitions for such a vast concept as this. The one who best defines TT is Bessant and Rush, who define technology transfer as a set of activities and processes through which a technology (embedded or 'personified' in the products, new processes or still in an explicit way of knowledge, skills, legal rights, etc.) is passed on from a user to another, which could be individuals, organizations or countries [13].

Technology Transfer is a bidirectional flux of University to Industry and vice versa, with different degrees and academic involvement ways. [2]: a) The product originates from University, but its development is made by an existent company; b) Academic knowledge is used to enhance an existent commercial product; c) University is the source of commercial products and the academic researcher becomes highly involved in its commercialization through the establishment of a new company.

In the last years, a non-linear recursive interaction between theory and practice, University and Industry, individual and research group, has become an alternative to the traditional academic mode [13].

C. Companies in the New TT Stage

Evidence show that only the companies fully understand their own competences and technological needs can establish mature and long-lasting connections with Universities and obtain real profit through these same connections [5].

From the industrial perspective, relationships with Universities have been seen mainly as a human capital source, future workers and, secondarily, as a source of useful knowledge for their development. From this point of view, what Industry wants and needs is academic researchers and basic research knowledge; therefore, Universities must focus on its traditional missions of education and research, which are their original one. [2], [3]

The benefits for the company to undertake inter-organizational relationships with University are: a) To obtain information from the state-of-the-art; b) To hire human resources highly qualified in research activities in the state-of-the-art technologies; c) To give the chance for the internal research staff to make changes at a high scientific level and stimulate the creativity of the RTD human resources through exposure to academic investigation; d) To make the access more difficult to the competitors; e) To stimulate the development of mathematic modeling for the creation activities and problem solving; f) To gain access to university resources, such as: laboratories, instrumentation and libraries; g) To achieve the scale of effective management of research facilities; h) To gain quick access to new knowledge areas [7].

D. University – Company Relationship

The most important in the relationship between Companies and Universities is in which fields the cooperation will be profitable. This decision making may be defined as a choosing process which identifies solutions, assesses the courses of action and implements the preferred plan to solve the problem. It is a slow process, much thought about, which is based on a series of interaction mechanisms, enabling the technology acquisition from the companies, as quoted below: a) University Cooperation; b) Informal personal relationships; c) Personal and institutional formal relationships, when the University is not involved; d) Formal personal relationships, with agreements between Universities and companies; e) Involvement of an intermediation institution; f) Formal agreements with a defined purpose; g) Creation of special structures [14].

The steps which constitute the cooperation process in TT may be the following: a) Identification and problem diagnosis; b) Alternative solutions elaboration; c) Alternatives assessment; d) Choice Making; e) Decision Implementation; f) Decision Assessment. These steps must be supported by a constant flux of information, creating the necessary feedback for the next steps [14].

E. Members and Mechanisms of the TT Process

The following table presents, in a summarized way, the three main interested parties in the TT process, its role in the process and at last the reasons why they are led to be involved in the process.

TABLE II. PROCESS MEMBERS OF TT [ADOPTED 14]

Organizat.	Action	Principal Reasons	Secondary Reasons
Scientist University.	Discovery of new knowledge	Recognition within the scientific community, publications and awards	Financial benefits, new funding forms: for Research Labs; Equipments Scholarships
Offices of TT	working with Professors and scientists; Negotiating with Companies	Protect the University intellectual property from the market	Facilitate the diffusion of technology and research funding
Businessman Companies	Commercializati on of a new technology	Financial Profit	Maintaining control of technological property

As for the main mechanisms of Technology Transfer, we can find: a) Academic Exchange, conferences and publications; b) Provision of services, technical assistance and counselling; c) Extension Courses and university specialisation; d) Use of public institutions means; e) Counselling for the RTD institution; f) Counselling by the RTD institution staff; g) Staff exchange program; h) Contracts (research on demand); i) Contracts with cost sharing; j) Prize and educational support; k) Cooperative RTD agreement; l) Intellectual Property Licensing; m) Commercial test agreement; n) Companies incubators; o) Pre-Companies; p) Start-up companies and academic spin-offs [15].

F. TT Operationalization

In order to describe the way University may internally sort the knowledge transfer process, a diagram which summarizes the whole process has been drawn.

III. DEM CHARACTERIZATION

DEM is a small department, which is geared towards teaching, investigation and provision of services. In order to accomplish its fundamental purpose, its teaching staff is only constituted by 29 professors with a high degree of specialization, from which 28 are Doctorate.

The Department of Electromechanic Engineering (DEM) is one of the five constituting departments of the Faculty of Engineering and only by itself possesses 16 laboratories and covers a wide range of subjects, such as Electrotechnics, Electric Machines and Power Electronics, Instrumentation and Data Acquisition, Telecommunications, Automation and Control (including planning and electric system control) , CAD/CAM, Prototyping and Product Design, Material Mechanics, Energetics Thermal Machines, Thermodynamics and Heat Transfer, Hydrodynamics, Fluid Mechanics and Hydraulic Machines, Mechanical Systems, covering, in this way, the main scientific areas of the courses coordinated by the Department [16].

Its research activities are developed in several centres, internationally assessed and financed by the The Foundation for Science and Technology (FCT) and by the European line of funding FP7: a) C-MAST: Center for Mechanical and Aerospace Sciences and Technologies; b) Remote Detection RTD Unit; c) Centre of Actuators and Electrical Systems (CAES); d) Research Unit in textile material and stationers; e) Centre of Material and Constructive Technologies; f) Communication and Multimedia Laboratory – Telecommunications Institute.

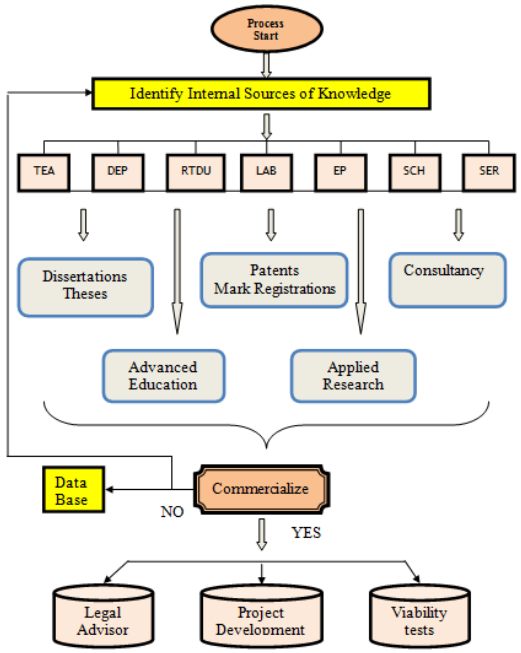

Figure 3. Complete process of TT [7] – Legend - TEA – Teach, DEP – Department, RTDU – RTD Unity, LAB – Laboratory, EP – External Partners, SCH- Scholarships, SER- Services; [adopted 15].

IV. ADOPTED METHODOLOGY

A. Research Objectives

Following the literature review performed in previous chapters, it was soon realizes that the future of universities and companies through the deepening relationship between the two. With the approach of these two organizations everyone wins, not only their own universities and companies, but also all the stakeholders of the environment, from the civil society, economic partners and the entire political system [17].

In this sense, the present study aims to understand the mechanisms which DEM has in regards to how does the transfer of its technology and knowledge. Therefore this study aims primarily those set out below: a) Analyze the documents that the DEM has with regard to the scientific output of its faculty and researchers; b) Analyze whether the policies implemented in the DEM TT, create an conducive environment to generating a stream of relationships between the University and its partners

environment; c) Identify the main obstacles faced by researchers and the DEM when studies are intended to promote and establish partnerships among firms or responsible for TT between universities and companies.

B. Study Methodology

The case study is defined by Yin, as an empirical research that observes a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly defined [17].

The work of exploratory research is developed with the aim of providing an overview of approximate type, about certain fact. This type of research is appropriate when the research topic chosen is underexplored, making it difficult to formulate operationalized hypotheses. This work was applied to exploratory research, as the aim of providing a comprehensive and approximate view of reality [18].

C. Methodology Schematization

After they announced the engagement objectives, proves to be necessary to define an appropriate methodology so that they can be implemented. The beginning of the study began by rigorous survey of the literature that underpins all the work. Then we have a series of steps that passes since the revision of the concepts that underpin the subject of research, followed for a documentary collection and documents analysis which DEM has, and will give a detailed idea about the scientific and technological potential of the department.

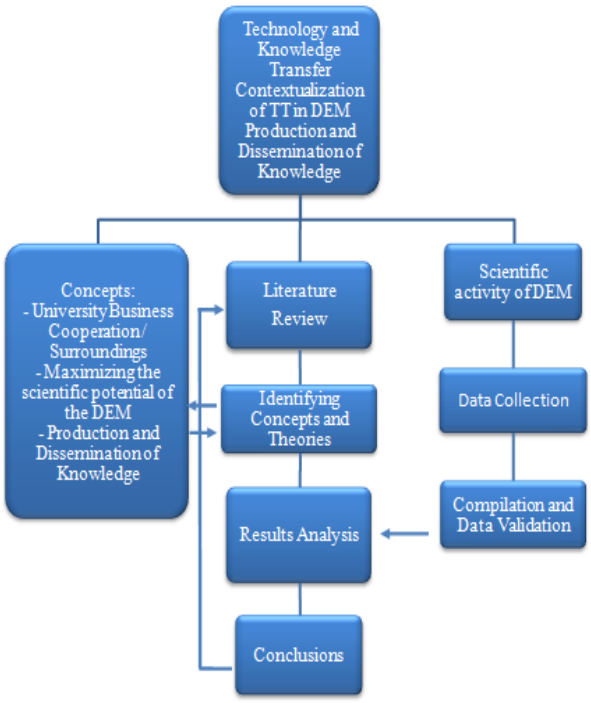

Figure 4. DEM methodology [adopted 19].

V. Results

The Present data were taken from the activity reports of DEM from year 2008 to 2012 [19]-[24]. Until the date hereof the report of 2013 had not yet been published, we only have the budget of project from 2013-2015 [23]. These reports were only removed the content that were related with DEM potential in terms of knowledge production and transfer and dissemination of this Knowledge.

More important than look at the numbers of the following charts, is to highlight the results that are new methodology has brought to the Department.

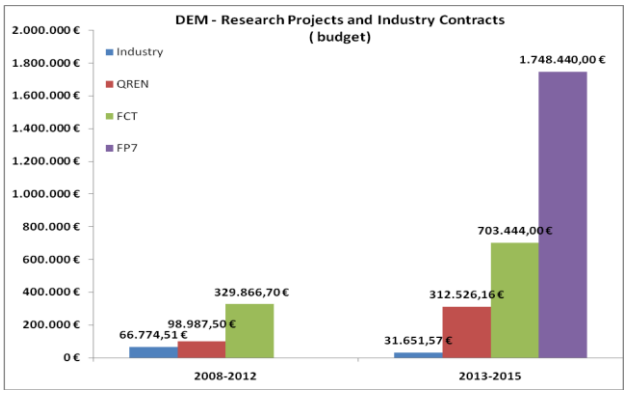

Chart 1 – DEM Research Budget [19]-[23].

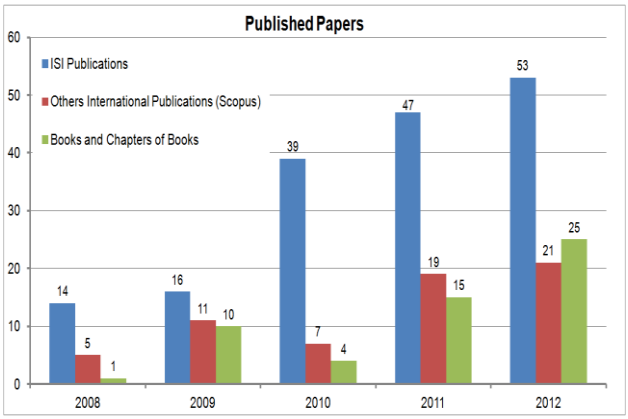

Chart 2 – Published Papers [19]-[24]

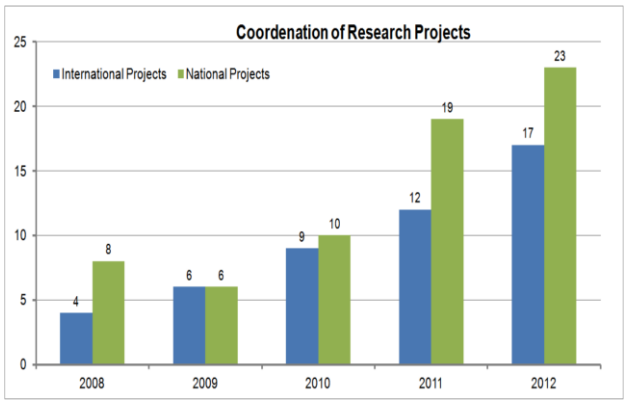

Chart 3 – Evolution of the R&D activities of DEM [19]-[24]

Nowadays it ś possible to develop partnerships that bring research scholarships funded by companies like “Galp Energy” or “Portugal Telecom”. These new networks allow developing more and better projects in certain key areas such as energy, sustainability, industrial automation or telecommunications. However as we can see in Chart 1, the direct partnerships with companies have decreased, this is due to the geographical position of Covilh ã and the weak corporate power of interior region

of Portugal, but this decrease is due to the but above all this decrease is due to the contraction of the Portuguese economy in recent years [19]-[23].

Also in Chart 1 we can see that the bet in international consortia have produced good results, due the large financial amounts that DEM has received from abroad. The focus on internationalization and high quality of scientific production, are clearly visible in chart 2 and 3, where we see a steady increase at every level [19]-[23].

VI. Conclusions

Nowadays it is increasingly important that a university department has a strong potential production of technology and knowledge. No less important is that department knows as transfer this technology. The truth is that having only the technology does not enrich or bring support, it´s crucial to use a strategic methodology that can internationalize it, leading the market its scientific knowledge and its associated technologies. It is also important that the transferred technology provides feedback to the institution, both on the form of economic benefits, public recognition or high level of international prestige.

Regarding the scientific production of the DEM in recent years (2008 to 2012) there has been a sharp growth in the number of scientific publications in capturing international research projects, support for enterprises, in the number of signed protocols with other institutions, as well as the help that DEM has given to its students who are involved in business or are launching their own businesses [19]-[23].

The implementation of this methodology as the success of the efforts is the result of a strong communication strategy between the different agents of the TT process. The responsible for the coordination, planning and dissemination are GAPPI (internal office to support projects) and Project Managers. They make the connecting between the several variables of this complex process [24].

In a conclusion we can say that the bet that DEM as made on a methodology focused on technology and knowledge transfer is producing remarkable results, even with all the constraints that the economic contraction has brought to universities and national scientific system.

Now university is producing high quality scientific results, where the relationship with the state was fundamental. This work shows us the results and the true impact of the change in strategy of the university (DEM in particular), being a fundamental study and should be repeated in 2016. Without this work would not know the real impact that this strategy has had on the development and innovation of the DEM.

As future work DEM need to be focus on relationship with the company, this is the weakest point verified at this time in DEM. In 2016 we intend to repeat the study to assess the relationship between State and UBI and Companies. A questionnaire will be applied to these actors as a way of gathering the maximum of information in a credible way [24].

Acknowledgment

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