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WORK PACKAGE 2: Best practices of HEI-company cooperation

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HEI expert – Company Cooperation Models

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1. Introduction

Document 2.2 describes the activities completed in order to achieve T2.2 goals:

- State of the art about HEI expert - company cooperation models.
- Pre selection of at least 10 good models.
- Selection and description of 5 models.

The document is structured in 5 Sections. Different classifications and cooperation models are presented in Section 2. According to the review and our project objectives, we pre-select, in Section 3, several models and propose a list of indicators to assess them. In order to accomplish the next step, we prepared and distributed among our partner experts, and their contacts, an opinion survey about the pre-selected models. The results of this survey were used to conduct a ranking procedure by means of the Analytical Hierarchy Process. This procedure, described in Section 4, identifies the best 5 cooperation models, which are described in Section 5.

2. Review of the existing cooperation models

Despite university-company interactions is the main topic of many sociological studies around the world; there is not a closed classification about these relations. They can be also referred to as University-Business Cooperation (UBC) models.

Cohen, Nelson & Walsh [1] consider "channels" that contribute to improve industrial innovation in the US, such as technology transfer of intellectual properties, informal information exchange, publications, joint research, and personnel exchanges.

In Europe, Schartinger et al. [2] define the term "knowledge interaction": all types of direct and indirect, personal and non-personal interaction between organizations and/or individuals from both the company and the university sides, with the aim at exchanging knowledge within innovation processes. They distinguish between 16 knowledge interactions (Table 1) grouped in 4 categories: joint research, contract research, mobility, and training.

Schmoch [3] compares university-company interactions in Germany and US. He points out that there are formal and informal relationships. While informal knowledge exchange is similar, there are differences in formal relationships. In Germany research contracts, application-oriented external institutes and local networks support short-term problem solving, while in the US, internal institutional arrangements and networks in emerging areas are more inclined towards long term programs.

Table 1. Modes of university-company interactions according to several authors. Same colour indicates similar cooperation style. Black colour means no similarities found.

University-company Interactions		
***Rapini et al. Brazil* [5]**	***Schartinger et al. Austria* [2]**	***Perkmann & Walsh US* [4]**
Short-term R&D collaborative projects	Employment of graduates by companies	Research partnerships
Consultancy	Conferences or events with university & firm participation	Research services
Training and courses	New firm formation by university members	Academic entrepreneurship
Technical evaluations, project management	Joint publications	Human resource transfer
R&D projects that complement innovative activities in companies	Informal meetings, talks, communications	Informal interaction
Long-term R&D collaborative projects	Joint supervision of Ph.D. and Masters theses	Commercialization of property rights
Temporary personnel exchanges	Training of firm members	Scientific publications
Technology transfer	Mobility of researchers between universities and companies	
Product Tests	Sabbatical periods for university members	
R&D projects that substitute for innovative activities in companies	Collaborative research, joint research programmes	
Engineering services	Lectures at universities, held by firm members	
	Contract research and consulting	
	Use of university facilities by companies	
	Licensing university patents by companies	
	Purchase of prototypes, developed at universities	
	Reading of publications, patents, etc.	

Instead of channels or interactions mechanisms, Perkmann & Walsh [4] deal with "links" (Table 1) because there are informal and formal relationships.

Through a survey among research groups in Brazil, Rapini et al. [5] summarize a set of university-company interactions (Table 1) and highlight the most important ones: short-term R&D collaborative projects, consultancy, training and courses and, less importantly, 'technical evaluations/project'.

3. Pre-selection of 10 models

Hereafter 10 interaction models are defined, based on the previous classifications, besides our own proposals. The classifications listed in Table 1 have different dimensions. Our selection is focused on the HEI expert-company level. Moreover, we check similarities between classifications to select more common modes (coloured interactions at Table 1), and take into account how easy is to quantify their effect. Note that, based on the interactions between University and Company summarized in Table 1, we propose several models of interaction and indicators that allow to evaluate quantitatively each model.

Other references reviewed, with similar information and additional data regarding to the quantification of cooperation performance, are listed in the references section [6-20].

Finally, Table 2 shows our proposed models and the indicators that can provide quantitative information about the effect of the interactions between experts and companies.

Next, we briefly explain each interaction model showed in Table 2:

1. Research collaborative projects: they include Short-term and Long-term R&D collaborative projects, considering regional, national, or international research projects, financed by public or private funds.
2. Collaborative innovation: research contracts that aim at developing innovative activities in companies.
3. Spin off - entrepreneurship: companies founded by the university staff, developed as a consequence of the research and teaching activity and partially financed with public funds, and whose exploitation has the university institution some rights recognized by the legal framework [6].

Table 2. Proposed HEI Expert-Company models

Models	Potential Indicators	
	HEI Expert	**Company**
1. Research collaborative projects 2. Innovation collaborative contracts 3. Spin off - entrepreneurship 4. Seminars and workshops taught by company members 5. Seminars and workshops taught by HEI experts 6. Joint supervision of students 7. Consultancy and engineering services 8. Personnel exchanges 9. Joint spread of knowledge 10. Philanthropic contributions by companies to HEI experts	● Number of patents ● Number of papers conferences workshops ● Number of new spin-off ● Specific formation seminars ● Novel techniques implemented in industry ● Number of student enrolled in courses, internships and diploma projects related with the cooperation. ● Number of R&D contracts ● Application for joint company-HEI expert R&D projects ● Number of Royalties ● Number of contracts regarding to: product tests, projects review, projects management, and use of university facilities by companies.	- Reduction of time in the engineering process - Number of patents - Resignation rates - Growth rate - Seminars/courses - Application for joint company-HEI expert R&D projects - Number of industrial PhDs

4. Seminars and workshops taught by company members, with the target of improving the expertise of academic staff.

5. Seminars and workshops taught by HEI experts, with the target of improving scientific knowledge of company members.

6. Joint supervision of students: Ph.D., masters and graduate theses, internships, etc.

7. Consultancy and engineering services: product tests, projects review, projects management, and use of university facilities by companies.

8. Personnel exchanges: Mobility of researchers between universities and companies.

9. Joint spread of knowledge: spread of knowledge either democratized (i.e. spread of knowledge amongst the common people) or privileged (i.e. spread of knowledge amongst elites such as academics).

10. Philanthropic contributions by companies to HEI Experts: grants offered to HEI Experts by private companies, which support academic staff research and training.

4. Selection of 5 cooperation models and indicators

Opinion survey

To select the best models, we prepared a list of 9 questions about the information availability, benefits and management issues of the pre-selected models. The list was distributed as a likert scale survey (link [21]) among the experts involved in this project and some of their contacts.

We received 32 answers from HEI experts of different countries and universities (Fig. 1). Survey questions and the statistical median of the selected likert values were used to determine the global weights of a selection procedure described below.

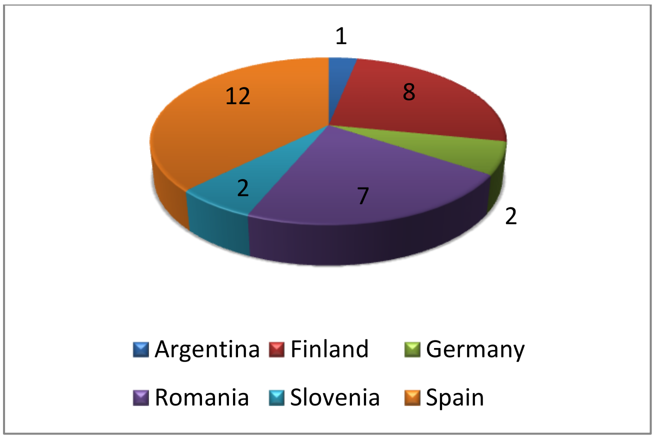

Fig. 1. Amount of HEI-experts, who fulfil the survey, classified by their origin country.

Ranking procedure via Analytic Hierarchy Process (AHP)

The pre-selected models should be classified in order to obtain the 5 best models. Due to we want to consider several selection criteria and we have many candidate models, we should be applied a multi-criteria selection procedure.

A well-known multi-criteria procedure, widely applied in different selection problems, is the Analytical Hierarchy Process (AHP) described by Satty [22]. Regarding to our ranking problem, we apply the AHP considering three criteria: information availability, cooperation benefits and management issues. The comparison matrices for criteria and candidates (cooperation models) were carried out with the help of the opinion survey median values.

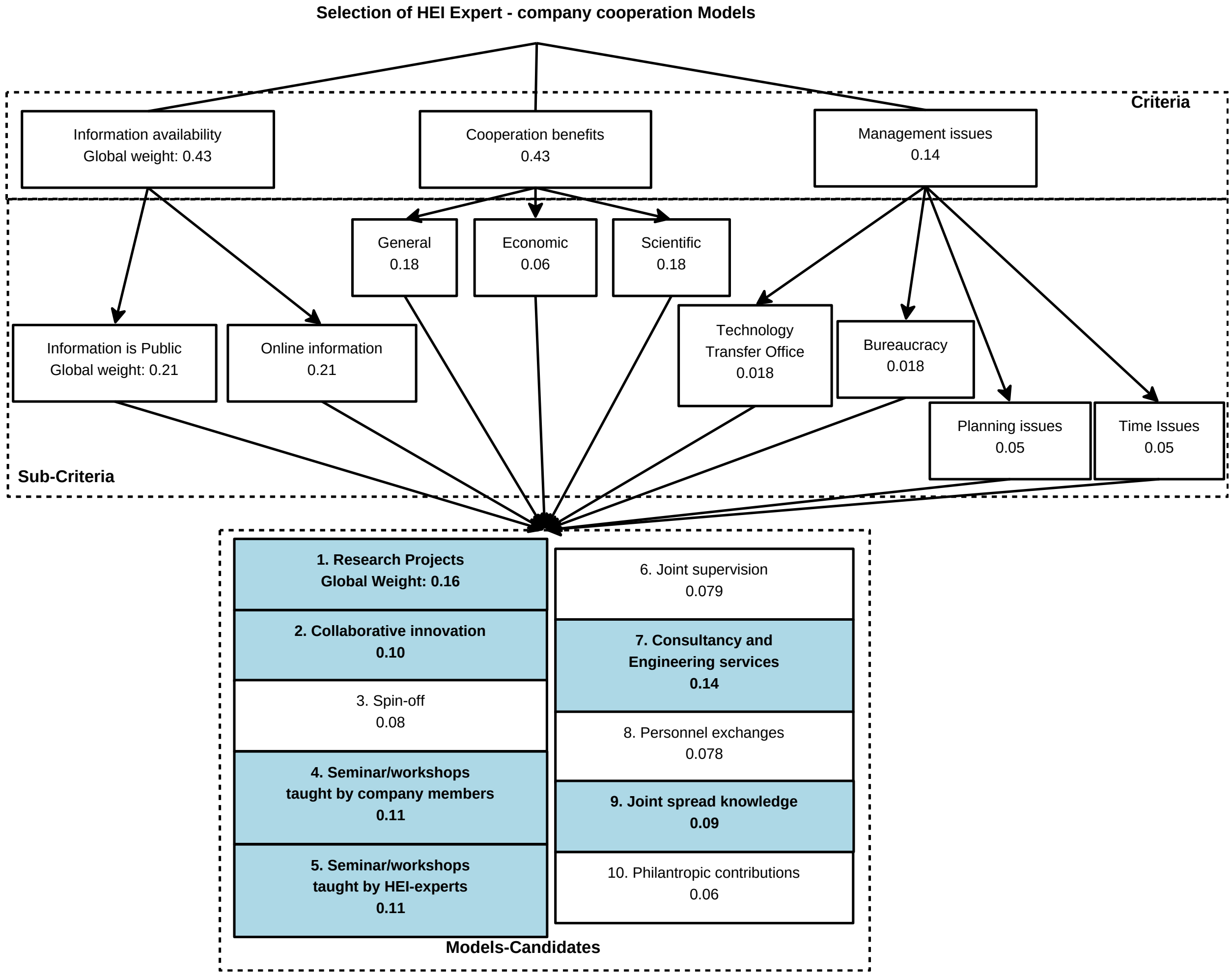

Fig.2. AHP selection tree with the global weights of criteria and cooperation models.

Fig. 2 portrays the AHP tree with the criteria and candidates as well as the resulting global weights: the larger weights point out the best models.

Results

According to the AHP tree (Fig. 2), the best models, ordered by the global weight, are:

1: Research collaborative projects → hereafter M1

7: Consultancy and engineering services → M2

4 - 5: Seminars and workshops → M3

These models have the same weight and we consider that it is better to blend them in a unique model.

2: Collaborative innovation → M4

9: Joint spread of knowledge → M5

Table 3 summarized the models chosen and indicators to quantify them.

Models	Indicators	
	HEI Expert	**Company member**
M1	- Application for joint company-HEI expert R&D projects - Number of papers, conferences and workshops including an acknowledgment to the project	- Application for joint company-HEI expert R&D projects
M2	- Number of contracts regarding to: product tests, projects review, projects management, and use of university facilities by companies.	- Reduction of time in the engineering process
M3	- Number and type of instruction activities developed by HEI experts - Number of students (company members) enrolled	- Number and type of instruction activities developed by Company members - Number of students (HEI experts) enrolled
M4	- Number of R&D contracts - Number of Royalties - Novel techniques implemented in industry	- Growth rate - Reduction of time in the engineering process

M5	- Number of patents - Number of joint conference papers, invited lectures or workshops, - Number of scientific outreach events, Number of scientific publications jointly written between company members and HEI experts.	- Number of patents

5. Selected cooperation models

M1. Research collaborative projects.

These kinds of models include Short-term and Long-term R&D collaborative projects, considering regional, national, or international research projects, financed by public or private funds.

The Research and Development projects have the objective of generating knowledge, sometimes even without a predefined thematic scope or any orientation. These can be constituted by the actions of an individual research group or several groups working together, which strengthens the research capacities and capabilities of the whole through the complementation between the groups. The reach of the project will depend upon the level of development on the state of the art on the matter, as in the case of the European Projects, within the EU Framework Programme for Research and Innovation [23]. Most of these research projects are publically funded through research grants (also through private sources), being their relevance one of the main characteristic features. As a consequence, these kinds of projects are conducted by young researchers with promising scientific paths, or research groups with a solid background. The grants can be generally used to finance personnel costs, small equipment, materials and other costs related to the project objectives.

With regard to the collaborative approach, this presents many advantages, fostering skills and techniques, speeding up the scientific milestones, particularly in the case of complex researches, thus increasing the effectiveness of the transfer of knowledge between the parties, which usually present different points of view or interests. An outcome of the latter might be the opportunities for joint publications (model M5), which constitute the most important channel for the dissemination of scientific knowledge. This kind of relationship is based on some of the following principles:

- Common definition of objectives and tasks.

- Trust and transparency.
- Sharing of knowledge, results, resources, staff and responsibilities.
- Joint monitoring and evaluation of the tasks and main outcomes.
- Joint dissemination of results.
- Application of the main results.

M2: Consultancy and engineering services.

This HEI expert-firm interaction model includes product tests, projects review, projects management, and use of university facilities by companies.

In this model, on one side, companies ask for help to HEI experts in solving many distinct multidisciplinary research and consultancy projects. On the other side, HEI-experts offer their specialist services in order to provide answers to many of the challenges that can be faced nowadays. These services consist of their own skills or the equipment developed as a result of their research [24]. Often, this HEI expert-firm interaction is supported by the Technology Transfer Office (TTO), which is an organizational entity that most Universities incorporate to their organization.

This cooperation model is one of the most common and important instruments by which HEI experts can incorporate their academic knowledge and expertise to external organisations, such as private companies, public sector entities, or even the government [25]. Moreover, working on consultancy with companies, can make HEI expert to learn additional skills and specific knowledge from companies, which may help to exploit their technologies [20].

Bessant and Rush [26] identified the importance of consultancy services in their pioneering work on this matter, where they classified the consultancy activity as a function of the user needs: technology, skills and human resources, financial support, business and innovation strategy, knowledge about new technology and implementation. Particular examples of consulting services within technological need are samples tests, experimental - theoretical - numerical analysis, prototyping, or giving advice as consultants.

Moreover, different ways of consultancy services have been identified [26], and, within the context herein studied, the following can be mentioned:

- Direct consultancy, in which HEI experts directly transfers their specialised knowledge as consultants to the companies.
- Experience sharing, where HEI experts can carry experiences from one experience to other different context.
- Diagnostic consultancy, where HEI experts can help the companies to identify their particular requirements or problems in order to innovate. Once the needs are defined or diagnosed, HEI experts can also suggest the means to solve the problem. This way of consultancy is similar to a medical diagnosis.

The role and impact of consultancy and engineering services is being recognized as increasingly important in the process of developing new technological products and processes. As a result, this cooperation is key in technology transfer activities across a wide range of users.

Regarding to the evaluation of this model, the indicators in Table 3 can be used, specifically the novel techniques implemented in industry as a result of consultancy services and the number of contracts regarding to product tests, projects review, projects management, and use of university facilities by companies.

M3: Seminars and workshops

Scientific and professional instruction taught by company-experts or HEI-experts are included in this model. We blend the preselected 4 and 5 models because they are quite similar and they got the same weight in the AHP procedure (Section 3).

Instruction tools, such as seminars and workshops, contribute to life-long education and to improve the scientific knowledge of company members and the expertise of academic staff. On the one hand, HEI experts should be up to date of the real engineering problems addressed by the companies. On the other hand, scientific knowledge can foster the innovation in companies.

Seminars and workshops can be formal activities within the framework of an official agreement between university and company, or informal presentations and meetings.

Regarding to the evaluation of this model, we will consider (Table 3) the number and type of instruction activities, and the number of students (HEI experts or company members) enrolled. Additional factors to control the quality of the courses could be the availability of a guide with the course goals, contents and schedule, needed resources (lecture room type and size, specific software, specific machines and tools), and instructor profile and curriculum [27].

M4. Collaborative innovation.

This model comprises research contracts that aim at developing innovative activities in companies.

In a knowledge-based economy, which comprises mainly all the developed countries, adequate protection of innovation, generated both in universities and public research centres and in companies, needs to be complemented by an efficient transfer to the production system. The latter can be established by means of a contractual relationship between the participating parties, i.e. a HEI and a company, which adequately reflects the mechanisms and regulations of such collaboration.

In this regard, a generic definition of this type of collaboration would involve a contract between a company and a HEI, in which a research group or expert belonging to a HEI are requested for the realization of a scientific or technical work in return for a specific financial consideration. The transfer of technology, technology or works involved are usually aimed at obtaining a commercial performance of the knowledge, tasks and results of R&D&I (a review on this matter can be found in [10]). Such goals generally carry the need of establishing contractual relations in which the special characteristics of knowledge transmission must be taken into account, i.e. the terms and conditions under which specific tasks are to be conducted by the parties. Thus, these collaborative models present restrictions regarding the dissemination of results, regulated by non-disclosure agreements, which sometimes are protected as licensed patents. This means that the transmitter of information or knowledge must take the utmost precautions to avoid complex situations, which might lead to the breaking of a contract or a legal suit, with the corresponding legal and economic consequences.

It is worth mentioning that, these kinds of approaches constitute a major collaborative relationship in highly industrialized regions, thus, being an important source of incomes for the HEI. More precisely, the manner in which this HEI–firm R&D collaboration impacts firm product and process innovations depends largely on the distance between HEI and companies and firm's size [28], in such a way that a higher likelihood of innovation is attained when a medium/large firm is located in the vicinity of the HEI. However, young and small companies are characterized by a higher degree of flexibility and may be more easily oriented to sources of technological knowledge at HEI [29], although innovation channels may be weaker, what can be counterbalanced by some support from HEI TT offices.

Table 3 shows the indicators for assessing the success of this model.

M5: Joint spread of knowledge.

This is a form of collaboration where at least one university researcher and one industrial researcher cooperate, and where it is assumed that there are strong bi-directional flows of knowledge over a limited period of time because it is based on close and face-to-face contacts. This collaboration is characterized by having some degree of formalisation (or some formal output) [2].

In this section we consider spread of knowledge either democratized (i.e. spread of knowledge amongst the common people) or privileged (i.e. spread of knowledge amongst elites such as academics). It is difficult to measure the diffusion of knowledge because it is intangible activity [30]. Nevertheless, it is possible to focus on those aspects of knowledge flows which are relatively easy to be measured, such as: citations of university publications in patents or publications by companies, licensing of university patents by companies, joint conference papers, invited lectures in conferences or workshops, number of joint patents, scientific outreach events, and number of scientific publications jointly written between company members and HEI experts [31]. Some of the indicators above mentioned have been chosen to quantify the present model (see Table 3).

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