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FUNDEC: A Successful Experience in Academic Engagement in Civil Engineering

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Abstract

Academic engagement usually refers to involvement of academic scientists in the process of university-industry knowledge transfer, which includes collaborative research, contract research, consulting and informal relationships. Despite being a predecessor to efficient commercialization, academic engagement has already proven its capabilities not only in attracting significantly larger percentage of university researches, but also in generating more revenues when directly compared to the outcomes of pure commercialization. Although the empirical assessment of engagement effects is not an easy task, in this paper we focus on analyzing the efficiency of practically applied methods for both formal and informal knowledge transfer in one of the largest technical universities in Portugal. In particular, we specifically target the academic engagement mechanisms within FUNDEC association as a case study, where the knowledge transfer efficiency is evaluated from different aspects, by following the outcomes of organized specialized training courses and provided services that directly aim at fostering the links between university and industry. In brief, evaluation results show that, in the period between 1998 and 2011, the largest portion of course attendees originated from the industry sector (around 72%), whereas the largest number of lecturers (56%) originated from universities. Hence, an evident trend of knowledge transfer from university to industry can be observed, as well as an indisputably high interest of industry in this process, which can be mainly attributed to the high quality of FUNDEC courses and selection of topics.

Keywords: Knowledge transfer, Academic engagement, University-industry relations

1. Introduction

In addition to their traditional role in education, universities are organizations that also carry out research and technological activities to produce knowledge, innovation and to provide scientific and technical services to the community. In the current literature, one of the mostly considered channels to transfer university research to industrial domain is commercialization of academic knowledge. Commercialization mostly refers to patenting and licensing of inventions and academic entrepreneurship, whose practical realization is usually achieved via specially created and regulated structures at universities, such as technology transfer offices, science parks and enterprise incubators [1, 2]. Although very important, due to the measurable economic impact of academic

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research, commercialization is certainly not the only way to efficiently transfer the knowledge generated at universities [3, 4].

Academic engagement represents an important way for transferring university knowledge to industrial domain and it can be defined as knowledge-related collaboration by academic researchers with non-academic organizations [3]. Depending on its nature and practical accomplishment, academic engagement can be generally seen as *formal engagement*, such as collaborative research, contract research, and consulting, or *informal engagement*, which usually refers to activities such as advising, information sharing or networking. Although academic engagement can be pursued to attain multiple objectives, the main reasons for engagement (in general) can be found in securing the access to important resources for further university research (such as additional funds, equipment or support for students) or it can be motived by practical applicability and expansion of already developed research (such as field-testing, learning opportunities or obtaining the new insights) [5]. As such, the academia might not strictly seek for financial gains, but it might achieve non-financial benefits, such as access to materials or data for academic research projects, or it might get valuable insights and new ideas on how to direct further university research according to the market needs. For example, engagement might be motivated by the expansion of university research from pure academic publishing to the areas of its practical application and utilization by non-academic partners. On the other hand, the academics may offer the expertise to provide new ideas on application-oriented issues, solve problems and suggest solutions to collaborating organizations. However, academic engagement do not exclude financial aspects.

As previously mentioned, in contrast to commercialization that mainly exploits the academic inventions to achieve financial gains, academic engagement is usually broader. Engagement can be generally perceived as a natural extension of purely publication-driven academic research to non-academic domains. On the other hand, commercialization usually represents a disruptive approach in university research towards academic entrepreneurship. In addition to research activities, involvement of academics in commercialization requires to deal with industry and management related issues, and it also brings to practice subjective effects (such as fear of failure) cased by involvement in commercialization activities with higher risks of failure. In fact, several studies conducted in different European counties [6, 7] show that, during their professional career, more than half of academics usually pursue different forms of academic engagement, whereas about 10-20% of investigators are involved in commercialization-related activities. Therefore, it is not surprising that financial gains from academic engagement can significantly surpass the incomes from intellectual property [8] and that many companies consider the academic engagement as significantly more important than licensing [9]. As a result, academic engagement can be generally considered as the preliminary step towards commercialization, i.e., it precedes commercialization in time, and it can provide valuable inputs for establishing efficient technology transfer.

In [3], Perkmann *et. al.* survey the existing scientific studies to analyze the antecedents of academic engagement from several aspects, namely: *i) individual characteristics*, such as demographics, age, previous commercialization experience and researchers' seniority; *ii) organizational context*, which is investigated trough quality of university/department, peer effects or organizational support and commercialization experience; *iii) institutional context*, which analyzes the affiliation to a specific discipline and the effects of specific national regulations and policies; and *iv) consequences of academic engagement* via scientific and commercial productivity, research shift towards applied sciences, and increased secrecy and collaborative behavior at the level of individual academics. The key findings from [3] indicate that efficient academic engagement is more related with individual characteristics of researches (such as higher scientific productivity and seniority), than with specific country regulations/policies or organizational support structures at universities/departments. Furthermore, it is observed that institutions with higher rankings are usually less engaged in this knowledge exchange process, thus suggesting that academic engagement can serve as a very effective substitute to achieve similar scientific productivity and research quality at lower ranked institutions, by mobilizing needed resources and learning opportunities from non-academic partners. Finally, the authors in [3] conclude that, although academic engagement is more widely practiced than commercialization, it is more difficult to empirically detect and measure the effects and outcomes of academic engagement due to the lack of standardized methodology for its assessment and public availability of statistical data (if it is even possible to record it in practice).

In this paper, the authors provide a highly practical analysis regarding the efficiency of academic engagement in civil engineering at one of the largest technical universities in Portugal, i.e., Instituto Superior Técnico (IST), by examining the methods for fostering links between university and industry offered by FUNDEC [10] association

(followed herein as a case study). The paper is organized as follows. Section 2 presents a brief overview of the organizational and basic engagement principles adopted within FUNDEC association. Evaluation of the adopted knowledge exchange principles is provided in Section 3 by examining their efficiency at different levels of granularity and from different aspects, in period from FUNDEC creation in 1996 until 2012. Furthermore, concluding remarks are given in Section 4.

2. FUNDEC: Basic Engagement Principles and Organization

Instituto Superior Técnico, founded in 1911, is the largest and most reputed school of engineering, science and technology in Portugal. Despite its traditional role in higher education trough the organization of teaching programs and award of degrees and titles, one of the main goals of IST is to carry out research and technological activities in order to produce knowledge, innovation and to provide scientific and technical services to the community. In order to disseminate the produced knowledge one of the applied methods is to create specialization, as well as vocational and lifelong training programs, either in the context of IST itself or of other national or international academic and non-academic institutions. These programs can additionally provide the practical means to establish and further strengthen the university engagement with the industry, which greatly exceeds the purely educational purposes. To this respect, with the major support and participation of IST, FUNDEC (*Associação para a Formação e o Desenvolvimento em Engenharia Civil e Arquitectura*) [10] was created in 1995 to deeply relate the activities and provide cooperation between the Department of Civil Engineering, Architecture and Geo-resources (DECivil) from IST, on one side, and some of the most important Portuguese civil engineering companies, on the other side.

FUNDEC is a nonprofit association and one of its main objectives is to institutionalize training and development in the area of civil engineering and architecture, i.e., it is intended to supplement, update and upgrade the training of civil engineers and architects through innovation in materials and contents in order to ensure a real professional development. In order to achieve these goals, FUNDEC is responsible for promoting, organizing and providing professional training and specialized courses, as well as studies and services, aiming to fulfill the needs of the technical community and to improve professional skills and attributes. Therefore, the training courses organized by FUNDEC aim to cover all areas of expertise not only in the field of civil engineering but also in architecture, namely, *(i)* Construction; *(ii)* Structures; *(iii)* Geotechnics; *(iv)* Hydraulics, Water Resources and Environment; *(v)* Geographic Information Systems; *(vi)* Systems and Management; *(vii)* Transportation and Transport Infrastructures; and *(viii)* Urban Planning and Architecture. Besides the standard specialized courses, FUNDEC is also able to respond to the needs of companies through training and tailored specialized courses, which either represent the adaptation of already existing courses or development of completely new courses. Furthermore, innovation and improvement of the processes and activities is usually conducted following the state-of-the-art developments in European Union and international markets that are perceived as the most relevant to the progress of civil engineering in Portugal. In addition, FUNDEC is also devoted to promotion of the international cooperation, in particular with Portuguese-speaking countries.

In order to ensure the efficient cooperation and knowledge transfer between the university and industry, FUNDEC relies on the support of its associated members, not only for organization, presentation and participation in the training courses, but also for the discussion and approval of the administrative aspects and activity plans. In detail, associated members are classified in four distinct groups, i.e., full, founding, observer and honorary members. The members of each group are designated by FUNDEC and involve not only universities and public institutions, but also companies and individual members (with IST as the only permanent full member). In contrast to the observers and honorary members, full and founding members play an active role in shaping the activities, organization and administration of FUNDEC. Currently, the list of 14 founding members include different education and public institutions, design offices and construction companies, as well as 11 individual members. The financial sustainability is ensured with annual fees for founding members, participation fees for the course attendees and FUNDEC-provided services. The tight relations with IST and participation of the university staff in the training courses is granted by automatically promoting all DECivil coordinators and presidents of specific departments to observer members, which are exempted from paying the annual fees. On the other hand, the members usually benefit from the full support and special discount rates not only for training courses, but also for provided services and developed specialized studies, plans and reports. The additional FUNDEC services are usually related to

innovation and development of the new methods, as well as the application of the already existing techniques developed at the university to the real-world problems. The special relations between FUNDEC and the other public institutions and companies are regulated with collaboration protocols, which usually require mutual support and cooperation in terms of organizing and promoting the specialized courses.

As previously referred, one of the main goals of FUNDEC association is to connect university and industry in such a way that they can transfer knowledge, share information and make collaborations trough the organization of specialized courses. In practice, this transfer is not strictly tight to a particular transfer direction, e.g., strictly from university to industry, but it rather follows the bidirectional and mixed knowledge transfer mechanisms. In detail, depending on the origin of the research and innovation, as well as the affiliation of the lecturers, the courses can be classified in three separate groups: *(i)* purely university-based courses; *(ii)* purely industry-based courses; and *(iii)* mixed university-industry courses. The courses from the first group are aimed at promoting the outcomes of purely university-based research to the industry, in order to investigate the opportunities for its further extension or to sustain its applicability to the real-world problems. Purely industry-based courses usually present the open problems and needs for the efficient solutions related to the highly practical problems, which can serve as valuable inputs for shaping university research or to establish university-industry cooperation. Furthermore, mixed university-industry courses are aimed at either presenting the results of the research conducted with direct involvement of both university and industry, or they are made in order to further extend the knowledge of both parties in fundamental areas of civil engineering (such as training courses that present current technical rules and standards, and analyze their practical application). Finally, it is worth to emphasize that according to the analysis presented in Section 3, the type of the course does not significantly influence the overall affiliation share of the course attendees, i.e., the trainees attendance is usually governed by the practical interest, thus they come from different areas of affiliation irrespectively of the course type.

3. Evaluation of FUNDEC-based University-Industry Engagement

In order to assess the practical impacts of the methods for university-industry engagement presented in Section 2, the statistical analysis conducted herein relies on the data derived from the official and publicly available FUNDEC records. In particular, we specifically focus on engagement at two different levels of granularity: *(i)* engagement at the level of a single training course; and *(ii)* the overall influence of FUNDEC engagement methods in the period from 1996 to 2012. It is worth to emphasize that although the academic engagement (in its formal and informal sense) is more widely practiced than commercialization, it is more difficult to empirically measure and detect its outcomes. In contrast, the effects of commercialization are usually easily tractable (e.g., via the number of created spin-offs, submitted patents etc.). Moreover, in a recently published study by Perkmann *et. al.* [3], the authors clearly demonstrate the lack of standardized methodology to empirically assess the academic engagement in the currently available state-of-the-art and they also express the need to develop further methods to improve the quality and comparability of studies. To that respect, the authors attempt herein to detect and evaluate the effects of academic engagement by analyzing the statistical data that can be tightly coupled with its practical occurrence.

3.1. Engagement at a single course level

As an example of a purely university-based course, the FUNDEC training course held in February 2012 by some of the authors of this manuscript "*Nonlinear Static Methods (Pushover Analysis) for Design/Assessment of Structures*" [11] is herein specifically focused on. The main goal of this course was to provide the theoretical overview of the current and extended nonlinear static methods for the seismic assessment and design of structures, which was followed by a step-by-step explanation of the applied procedures when modeling the real-world examples. The course was organized in order to favor the direct involvement of the trainees and lecturers not only in discussion, but also in the process of practical modeling with SAP2000 [12]. Since the major contributions of the university-based research within the 3DISP project [11] were presented, the course was naturally thought by lecturers with the predominately university background, i.e., one professor and two researchers from IST, and one invited professor from a foreign university. On the other hand, around 20 trainees who attended the course were from different provenances, with very balanced share (around 50/50) of attendees originating from university and

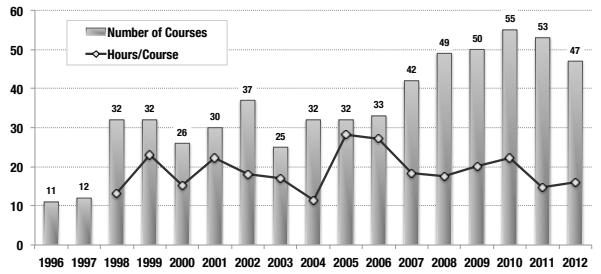

Fig. 1. Number and intensity of organized courses per year.

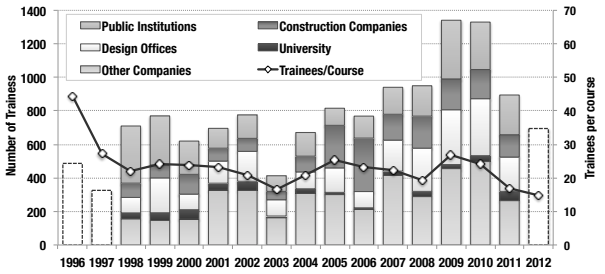

Fig. 2. Total number and average number of trainees per course.

industry. The relatively large number of trainees from industry is not surprising, since the presented research is highly related to the practical problems, i.e., it can provide the means to the seismic assessment and retrofitting (repair) of structures. In fact, this course resulted in an informal engagement of the course coordinator with the representatives of one of the most successful construction companies in Portugal, which is expected to expand from professional consulting into the official project collaboration in the very near future.

Following the success of the above-mentioned training, an additional course is planned in 2013, i.e.,"*Seismic Evaluation and Reinforcement of Ancient Masonry Buildings*". The main goal of this course is to present the latest findings from the university-based research in the scope of SEVERES project [13], which aims at identifying the mechanical characteristics and seismic behavior of old masonry Portuguese buildings trough extensive experimental testing. Due to the limited number of experimental studies currently available in the literature, the results of this research are very important for analyzing and retrofitting the old buildings, since they are still used for housing and services, and especially important for the companies that preform these reparations. In fact, this course is expected to expand existing and create new collaborations with industry, mainly by confirming and applying the laboratory-based methodology to the in-situ testing on real buildings. Hence, different solutions for rehabilitation and strengthening of masonry buildings will be discussed at this course in order to help companies when choosing the best solution for retrofitting. Finally, the presentation of this course will be held by three professors and three researches from IST, one professor from a foreign university and one invited speaker from the industry.

3.2. Overall Statistical Analysis of FUNDEC-based Engagement

In order to further evaluate the efficiency of the methods for university and industry engagement within FUNDEC association, this paper focuses herein on statistical analysis based on the official and publicly available records regarding the number and intensity of courses, the total number and affiliation structure (share) of both trainees and lecturers, as well as the number of provided services, in the period from FUNDEC creation in 1996 until 2012.

Figure 1 presents the total number of organized courses per year, in the period between 1996 and 2012. As it can be observed, the number of courses shows an overall increasing trend, which can be evidenced in the peak number of 55 courses held in 2011 versus 11 (12) courses organized in the first years of FUNDEC creation in 1996 (1997). Furthermore, in the observed period, in average 35 courses are prepared per year. In order to depict the intensity of the organized courses, the average number of hours required to complete a course in a certain year is additionally presented (see line in Figure 1). The course intensity measure is adopted herein in order to represent the average course duration, which shows the amount of time devoted for involvement of both lecturers and trainees. As it can be noticed, the courses of lowest intensity were organized in 2004 (in average 11.5 hours per course), immediately followed by two years period of the most intensive courses that required in average 28.3 (in 2005) and 27.1 (in 2006) hours to complete a course. The intensity of the courses in all other years is near the average intensity of 19 hours per course (in the period between 1998 and 2012).

Figure 2 shows the total number of trainees that attended the courses organized in each year, their affiliations and the average number of trainees per course. As expected, the number of trainees usually is proportional to the number of organized courses in each year (see Figure 1), thus reaching the maximum of 1330 attendees in 2010. In the observed period between 1996 and 2012, 777 trainees attended the organized courses in average

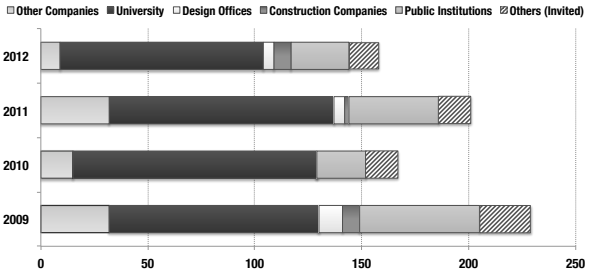

Fig. 3. Total number and affiliation of lecturers per year.

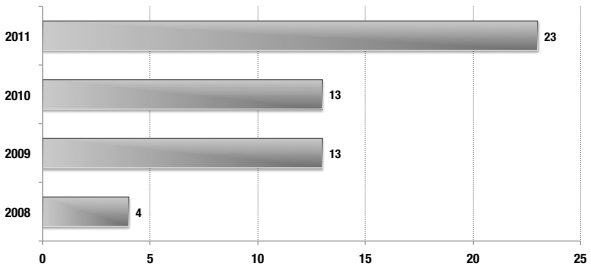

Fig. 4. Total number of provided services per year.

per year. It is interesting to observe a decreasing trend in the total number of trainees for the last two years, i.e., in 2011 and 2012, which is expected and can mainly be attributed to the economic slowdown in the sector of civil engineering due to the overall crisis in Portugal. This slowdown has an immediate effect on financial availability of companies to promote, participate and use FUNDEC services. Furthermore, in Figure 2, the total number of trainees per year is sub-partitioned according to the their affiliation, thus representing the number of trainees belonging to University, Public Institutions, and industry sector (Construction Companies, Design Offices and Other Companies). In addition, the average number of trainees per course for each year is presented (see line in Figure 2). Despite an obvious outlier for 1996 when the courses were introduced for the first time, thus resulting in the greatest interest, for the subsequent years an average attendance rate of 23 trainees per course can be observed. It is worth to note that no clear relation between the course intensity and the number of attendees can be spotted, which suggests that the high quality of organized courses is actually more important for attracting the trainees from different sectors than its duration. However, the above-mentioned financial crises also influenced the achieved results for the last two years, i.e., 2011 and 2012, where large number of courses with moderate intensity resulted in below average attendance.

In Figure 3 the total number of lecturers per year is presented and, as expected and evidenced in Figures 1 and 2, their total number directly depends on the number of organized courses. In addition, the lecturers are subdivided and represented according to their affiliations, in order to depict whether the teachers originate from Universities, Public Institutions or they belong to the industry sector (Construction Companies, Design Offices and Other Companies). An additional group of lecturers can also be spotted, i.e., Others (Invited), that represents the invited independent researchers or experts for the presentation of certain courses.

Figure 4 presents the total number of services provided by FUNDEC in the period between 2008 and 2011. These services designate the engagement of FUNDEC and its members in performing evaluations and analysis, feasibility studies, reports, project developments or actual construction works, which are usually requested by third parties (such as companies, public institutions, or individuals). In contrast to the decreasing trend in the last two years regarding the total number of courses and trainees (see Figures 1 and 2), the number of provided services is significantly increasing in the observed period. This can be explained by rapid expansion of FUNDEC area of activities that includes not only provision of training courses, but also the means for practical engagement of university and industry in solving the real-world problems.

Finally, Figures 5 and 6 present the average share of trainees' and lecturers' affiliations in the organized courses, respectively. As it can be seen, in the period from 1998 to 2011, the largest portion of course attendees originated from the industry sector (around 72%), in contrast to 24% from public institutions and only 4% of trainees from universities. On the other hand, in the period between 2009 and 2012, the largest number of lecturers (56%) originated from universities, followed by 19% from public institutions, and around 16% of presenters from the industry sector. Although the presented charts do not cover the same period, it is worth to emphasize that the affiliation share of trainees does not significantly vary even when narrowing down the period of observation. Hence, it can be concluded that the quality of organized FUNDEC courses and especially selection of topics was capable of attracting a very large percentage of trainees from the industry. This is even more important when taking into account that the largest portion of these courses is held by the university staff, thus an evident trend of knowledge transfer from the university to the industry can be observed, as well as an indisputably high interest of

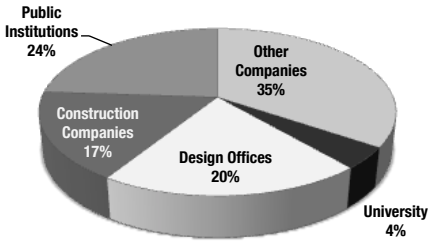

Fig. 5. Average share of trainees affiliations (period: 1998-2011).

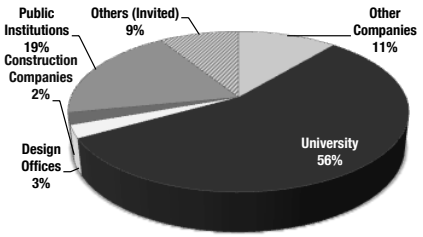

Fig. 6. Average share of lecturers affiliations (period: 2009-2012).

industry in this process. It is also worth to note that this knowledge transfer does not only reflect the presentation of university research, but it also includes the specialized courses for enhancement of fundamental knowledge in different areas of civil engineering and architecture. As a result, organization of training courses and provision of services in the scope of FUNDEC association can be perceived as very efficient methods for establishing university-industry engagement in both formal and informal sense. However, the lower number of lecturers from industry sector suggests that purely industry-based courses are covered to a smaller extent comparing to purely university-based or mixed courses, which are crucial to establish even more efficient knowledge transfer in the other direction, i.e., from industry to university, and also to shape further university research according to the industry needs.

4. Conclusions

Academic engagement, as one of the most efficient mechanisms for transferring academic knowledge to industrial domain, represents knowledge-related collaboration by academic researchers with non-academic organizations. In formal terms, it mainly refers to collaborative research, contract research and consulting, while informal engagement involves activities such as advising, information sharing or networking. Its importance can be evidenced in the ability to attract a large portion of academics and in generating more financial gains, when directly compared to the pure commercialization. Moreover, academic engagement is generally considered as the initial step towards the efficient commercialization.

Although it is more difficult to empirically assess the effects of engagement, in this paper the authors specifically focused on analyzing the efficiency of practically applied methods for both formal and informal knowledge transfer in one of the largest technical universities in Portugal. In particular, the academic engagement methods within FUNDEC association as a case study were targeted, which aims at strengthening university-industry relations through organization of specialized training courses and provision of practical services. In order to assess the efficiency of these mechanisms for university-industry engagement, the statistical analysis was conducted by relying on the data derived from the official and publicly available FUNDEC records. In detail, the analysis provided herein covered the engagement at two different levels of granularity: *i)* engagement at the level of a single training course; and *ii)* the overall influence of FUNDEC engagement methods in the period from 1996 to 2012.

Evaluation results show that, in the observed period, the largest portion of course attendees originated from the industry sector (around 72%), whereas the largest number of lecturers (56%) originated from universities. Hence, an evident trend of knowledge transfer from university to industry can be observed, as well as an indisputably high interest of industry in this process, which can be mainly attributed to the high quality of organized FUNDEC courses and selection of topics. On the other hand, a significantly lower number of purely industry-based courses suggests that, in order to provide more efficient bidirectional knowledge transfer and to further shape university research according to the industry needs, the presence of lecturers from industrial domain should be increased.

Acknowledgements

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