ACTIVITIES AND MODELS OF UNIVERSITY TECHNOLOGY TRANSFER

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Abstract

Universities perform different technology transfer activities to fulfil their 'third mission' of contribution to economic development: research commercialization, academic engagement, support to start-up creation and growth, funding support for technology development, entrepreneurship education for students and creation of entrepreneurial climate within the university. We investigate the heterogeneity in the accomplishment of these activities with a quantitative survey undertaken within a Task Force on Innovation of the association of universities CESAER and we found three main models of university technology transfer. A first one focus on research commercialization. A second with a more balanced approach. A third one focus on start-up assistance but with a moderately balanced approach.

Keywords: universities technology transfer activities, models of university technology transfer, entrepreneurial university

Introduction

In the last 40 years, universities are increasingly using the knowledge from research and teaching to fulfil their so-called "Third Mission" in society and economy. Through knowledge generation and technology transfer activities, universities are indeed considered the engine of social, cultural and economic development (Etzkowitz et al., 2000). Within the academic debate, it is widely acknowledged that universities play a crucial role in the creation and development of local ecosystems for innovation. Different perspectives like Regional Innovation Systems (RIS) (Cooke, 1997), Triple Helix (TH) (Etzkowitz and Leydesdorff, 2000), industrial district (Beccatini, 1990), clusters (Porter, 1998) and entrepreneurial ecosystems (Isenberg, 2010) largely converge on the idea that the local development is spurred by a central player, i.e. the "anchor tenant", which is usually fulfilled by local universities (Agrawal and Cockburn, 2003).

In this respect, knowledge-related collaborations among three institutional overlapping spheres i.e. university, industry and government (Etzkowitz and Leydesdorff,

2000) are increasingly important to the local development. Acknowledging this important role, policy-makers have tailored specific initiatives and programmes to foster linkages between university, industry, government and society (e.g. science parks, incubators, competence centres, living labs).

Universities contribute to economic development mainly with three mechanisms associated with the three missions of universities: provision of appropriately skilled human capital via teaching ("*first mission*"), advancement of scientific and technical knowledge via academic research ("*second mission*") and transfer of knowledge and technology from academia to industry and society via technology transfer ("*third mission*").

Regarding the third mission, universities perform several technology transfer activities including patenting, licensing, spin-off, research collaboration, consulting, networking, entrepreneurship education and start-up assistance. In this respect, the concept of entrepreneurial universities has been recently conceived (Etzkowitz et al., 2000).

Despite several studies acknowledge entrepreneurial university as a global phenomenon, most of them consider either explicitly (Etzkowitz et al., 2000) or implicitly that universities undertake to the same extent the UTT activities, and thus embrace a similar model of entrepreneurial universities, ignoring that they could have different approaches to the entrepreneurial paradigm. Thus, the objectives of this paper is twofold. Firstly, to map university technology transfer (UTT) activities. Secondly, to identify the different models of universities technology transfer. Thus, the research questions of this paper are: (1) What are the UTT activities? (2) Do universities follow a similar model of technology transfer or do they adopt different ones?

We investigate these research questions by administrating a questionnaire to universities' technology transfer offices belonging to the CESAER association (the European association of doctorate-granting specialised and comprehensive universities of science & technology). We employed a cluster analysis to check the existence of different model of UTT.

The paper is organized in four parts. Firstly, we review from literature UTT and the related activities. Secondly, we provide the methodological part and the results of the cluster analysis. Thirdly, we conclude with theoretical contributions as well as managerial implications. Finally, we provide limitations and further research.

Literature Review

University Technology Transfer

University technology transfer (UTT) has long been investigated in academic literature given its relevance to foster entrepreneurship and innovation, and thereby to contribute to national and regional economic development. UTT or university "third mission" include the set of activities and processes to transfer knowledge and technology from university to industry and society (Bozeman, 2000).

As they embarked on their new 'mission' of economic development, universities employed a range of new activities. They are involved in research and technology commercialization, incubation programs or start-up assistance, more recently they also invest heavily in entrepreneurship education programmes (O'Connor, 2013) and provide funds for the technology development process (Markman et al., 2008), along with traditional collaboration, networking, consulting and face-to-face communication with industry and society (Geuna and Muscio, 2009).

Scholars recognize different UTT activities (Philpott et al., 2011). However, they do not always use the term 'activity', and refer to concepts like channel (Grimpe and Hussinger, 2008), mechanism (Bradley et al., 2013a; D'Este and Patel, 2007; Link et al., 2007) and mode of governance of UTT(Alexander and Martin, 2013) .

Accordingly, scholars distinguish between hard and soft activities, formal and informal channels or mechanism, relational and contractual based governance. On the one side of the spectrum, scholars include patenting, licensing, spin-off, in formal UTT activities also identified with *Research Commercialization* (Perkmann et al., 2013); while training, networking, contract research, consulting, face-to-face communication in informal UTT activities also identified with *Academic Engagement* (Perkmann et al., 2013). In the following, we will briefly review these formal and informal activities, as well as the other UTT activities found in literature. In particular, we look at support to start-up creation and growth, funding support for technology development, entrepreneurship education or students and creation of entrepreneurial climate of university entrepreneur.

Research Commercialization

Research commercialization has been also identified with *academic entrepreneurship* (Siegel and Wright, 2015), referring to either the founding a firm by faculty members with the objective to commercially exploit a patented or non-patented invention (Perkmann et al., 2013), or the licensing a patented or otherwise protected invention in return of royalties (Jensen and Thursby, 2001). Commercialization is regarded as a first measurable and tangible impact of UTT (Markman et al., 2008; Philpott et al., 2011). These activities are *institutionalized* (Geuna and Muscio, 2009*)* into a specific knowledge intermediary organization, the Technology Transfer Offices (TTOs), created to support researchers to consider commercializing their research results and to provide assistance along the process.

Academic Engagement

Academic engagement, defined as "*knowledge-related collaboration by academic researchers with non-academic organisations*" (Perkmann et al., 2013, p. 424) include collaborative research, contract research, consulting, training and other forms of knowledge exchange (Perkmann et al., 2013).

Research commercialization and academic engagement have different objectives and organizations (Perkmann et al., 2013). Research commercialisation means an academic invention is exploited with the objective to gain financial rewards; by contrast, academic engagement is broader and pursued for different objectives. These are access to additional financial resource, data and knowledge to conduct further research and to obtain new insights. Academics do not limit to the scope to publishing, but they seek to provide utility to non-academic partners as well (Perkmann et al., 2013). In this respect, academic engagement is not new, representing a natural extension of their academic activities (Geuna and Muscio, 2009; Philpott et al., 2011). Regarding organizations, research commercialization is performed with the involvement of TTO, while academic engagement is pursued on individual discretionary basis.

Support to start-up creation and growth

Research Commercialization may be considered has an old and consolidated form of university technology transfer activities. Support to start-up creation and growth or simpler *Start-up assistance*, defined as a set of activities aimed at increasing the emergence and survival rates of entrepreneurial firms, is emerging as new perspective of academic entrepreneurship (Siegel and Wright, 2015). The university ecosystem support to start-up includes a diversified range of activities: (1) incubators/accelerators either as programs or institutions (2) entrepreneurship courses (3) space provision to connect students, faculty or external firms and to organise student business plan competition (Siegel and Wright, 2015). These activities have two objectives. Firstly, to protect already created enterprises from the liability of newness (Singh et al., 1986), the difficulties associated with establishing necessary resources and social relationships with the external environment (Amezcua et al., 2013). Secondly, to foster the growth of an entrepreneurial team to form a start-up. Amezcua et al. (2013) refer to these activities with *organizational sponsorship* defining it as any attempt to mediate the "*relationship between new organizations and their environments by creating a resource-munificent context intended to increase survival rates among organizations*" (Amezcua et al.,2013; pp 1628).

Funding Support

Funding support is a relatively new UTT activity originated in US universities with the establishment of Proof of Concept Centres (POCC) and the deployment of university seed funding (USFs). These centres have been spread in Europe as well, although not always with the establishment of such centres but frequently has complemented with the traditional activities of TTO. With funding support, universities fund the technology development process and in particular the most critical phase between invention and product development when viable commercial concepts have to be created and proved. This phase has a funding gap caused by information and motivation asymmetries, high risky projects regarding project outcomes and institutional gaps between Science and Business (Bradley et al., 2013b; Hayter and Link, 2015; Maia and Claro, 2013).

Maia and Claro (2013) found that PoC, in addition to have a critical role in commercialization of new technologies, has a clear contribution on entrepreneurship education, by developing entrepreneurial skills to academics. This study suggests that exists complementarities among the different UTT activities.

Entrepreneurship Education

Entrepreneurship education has become an important activity for university managers, professors and researchers (Kuratko, 2005) because of the positive benefits associated of having students with entrepreneurial attitude, skills and intention which could foster entrepreneurship and innovation, and therefore, stimulate economic growth (Rauch and Hulsink, 2015). Entrepreneurship education can be taught in several different ways. Béchard and Grégoire, (2005) present three different entrepreneurship teaching models: supply, demand, and competence models. These can be further into theoretical-based entrpreneurship model where students are passive, and teachers act as in classic academic lectures, and action-based entrepreneurship model where students take active participation and often are requested to provide ideas or develop business plan.

Creation of an Entrepreneurial Climate

Another UTT activity, internally oriented, is the creation of an entrepreneurial climate within the university. Borrowing the *organizational climate* construct defined in the context of innovation implementation (Klein and Sorra, 1996), we define entrepreneurial climate as the extent to which entrepreneurship is *rewarded, promoted*

and *supported* and we include all the activities that create such entrepreneurial climate including entrepreneurship training to faculty, training staff (academics and non-academics) in the commercialization of new technologies and assist research to find investors which can help them to recognize the commercialization potential of their research results. The creation of entrepreneurial climate is particularly important for universities to achieve the third mission. Philpott et al. (2011) argue that: "*For universities embarking on the journey towards the entrepreneurial university ideal, they must first undertake education and training of their academic community*." (pp168). This training can be conducive for certain academic disciplines to the full range of entrepreneurial activities that can contribute to economic development, not only related to research commercialization. Philpot et al. (2011) acknowledge that without such entrepreneurial training, university risk to have a "*schizophrenic entrepreneurial divide within their institution" (pp 169)*.

Methodology

In order to collect data on the different UTT activities, we design a questionnaire that was provided within the CESAER (the European association of doctorate-granting specialised and comprehensive universities of science & technology) Task Force on Innovation (TFI), that that was formed to study the UTT activities of Science and Technology (S&T) The respondents are involved in the technology transfer offices of universities belonging to the CESAER association. The preliminary findings were discussed and validated with two internal workshops held in Budapest and Turin, with some of the universities participating in the survey. In total 19 answers were collected with a response rate of 39%. The questionnaire was organised into the following sections. The first section aimed at identifying the most important UTT activities performed by universities. This allow us to check the diversity of approaches of universities. In the second section of the questionnaire, each institution was required to provide information on their engagement with the ecosystem. In this section, Universities were also asked to indicate at which stage of the innovation lifecycle they collaborate with industry. The third section focus on funding support and in particular on the main sources of innovation funding in the ecosystem. A specific sub-section was devoted to universities. The final section aimed at collecting information on the execution of more specific activities to start-up assistance and entrepreneurial orientation of the faculty. The first set of questions uses a four-point Likert scale, while the remaining use Binary variables to check the collaboration with ecosystem's actors and the execution of specific activities. The final questionnaire was composed of 11 questions.

In order to group the different activities performed by universities in macro-dimensions we used an exploratory factor analysis (EFA). We employed an exploratory approach to detect the structure among the variables and to not force any constraints on the relationship between variables given the relative new phenomena of entrepreneurial universities. Finally, with the aim of positioning each university along the spectrum of activities and to elaborate a taxonomy of the different models that universities adopt to foster innovation in their ecosystems, we employed a hierarchical cluster analysis using complete algorithm which assign the distance between clusters as the distant between two most distant cluster members (farthest neighbour). In this way, we ensure that close clusters do not merge together obtaining the maximum level of heterogeneity among the clusters (Yim and Ramdeen, 2015)

4.Results

The EFA confirmed the presence of six UTT activities, retrieved from the literature review: research commercialization, academic engagement, start-up assistance, entrepreneurship education for students and funding support. An additional activity was found with the EFA, entrepreneurial climate within university, and introduced as a new UTT activity (table 1).

Table 1. Results of the explorative factor analysis

Universities Technology Transfer activity	**Specific Universities Technology Transfer Activities and scale used**
Research Commercialization	- TTO activities (IPR, licensing) (Likert 1-4) - Research results economic valorization (Likert 1-4) - Improvement of the university ability to stipulate research contracts with industry (Likert 1-4) - Improvement of the university ability to stipulate research contracts with other public organizations (universities, research centres, science and technology parks) (Likert 1-4) - Research results IPR management (Likert 1-4) - Licensing management (Likert 1-4)
Academic Engagement	- Collaboration with ecosystem actors (research centres, government, Venture Capitalists/Investment funds, industry) (Binary 0,1) - Collaboration with industry on technology development lifecycle (Binary 0,1) - Lifelong education with graduate members, scientists and industry members (Likert 1-4) - International Networking with companies (Likert 1-4) - International Networking with universities (Likert 1-4)
Start-up Assistance	- Mentoring programs for startupper (Likert 1-4) - Business plan competitions (Likert 1-4) - Incubators programs (Likert 1-4) - Accelerators programs (Likert 1-4) - University spin-offs management/mentoring support (Likert 1-4) - University entrepreneurship courses (Binary 0,1) - University labs available for students (Binary 0,1) - University mentoring programs (Binary 0,1) - Space provision by University (Binary 0,1) - Competition with final prize powered by university (Binary 0,1)
Funding support	- Funding support for technology development, start-up and spin-offs (Likert 1-4) - Innovation stage funded by universities (Binary 0,1)
Entrepreneurship Education for Students	- Entrepreneurship education for students (Likert 1-4)
Entrepreneurial Climate within the university	- Entrepreneurship education for faculty members (Likert 1-4) - Assistance for finding investors (Likert 1-4) - Diffusion of an entrepreneurial culture (Likert 1-4) - training staff in commercialization of technologies (Likert 1-4)

The Hierarchical Cluster Analysis reveal three clusters. The dendrogram and box plots are provided in figure 1 and 2, respectively. We perform an ANOVA test to check whether the means of the three clusters were different and we found statistically relevance for all

of them and therefore a low probability of committing type I error (*table not provided here*). To characterize the clusters, we provide information regarding the average size and budget of the universities in the three clusters (table 2).

Table 2. Clusters' size in terms of average number of students or average number of academic staff, and average budget. Source: ETER, data of 2014

	CLUSTER 1 (3)	CLUSTER 2 (12)	CLUSTER 3 (4)
Average number of staff (academic and non-academics)	1924	6412	5198
Average number of students	24686	29381	24326
Average Budget (EURO)	148 M€	285 M€	228 M €

The first cluster contains three universities which show a focus on research commercialization (figure *2a*). but lag behind in other UTT activities. Moreover, this cluster has similar number of students with respect to the other cluster but has lower number of staff and a smaller budget.

The second cluster is the largest one, containing twelve universities. These universities devote considerable attention to entrepreneurship education: except for one outlier, we do not find variability (figure 2*e*). In addition, they engage systematically with the ecosystem (figure 2*b*) and invest in supporting the entrepreneurial climate of the university (figure *2f*). Overall, this cluster perform satisfactorily in all the activities, thus having a balanced approach.

The third cluster focus especially on start-up assistance. They perform other UTT activities similar to the cluster but with a lesser extent.

Regarding funding support, we found high variability and perform to a less extent with respect to other activities. Cluster 2 and Cluster 3 have similar value, while Cluster 1 fall behind.

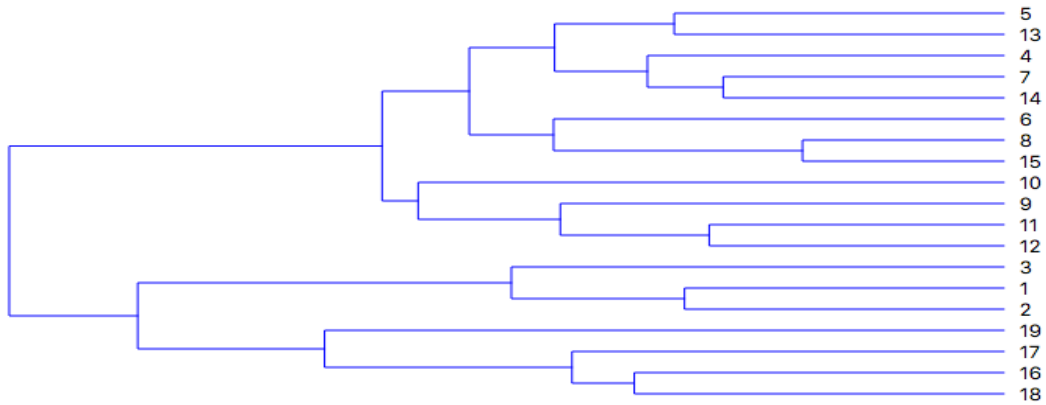
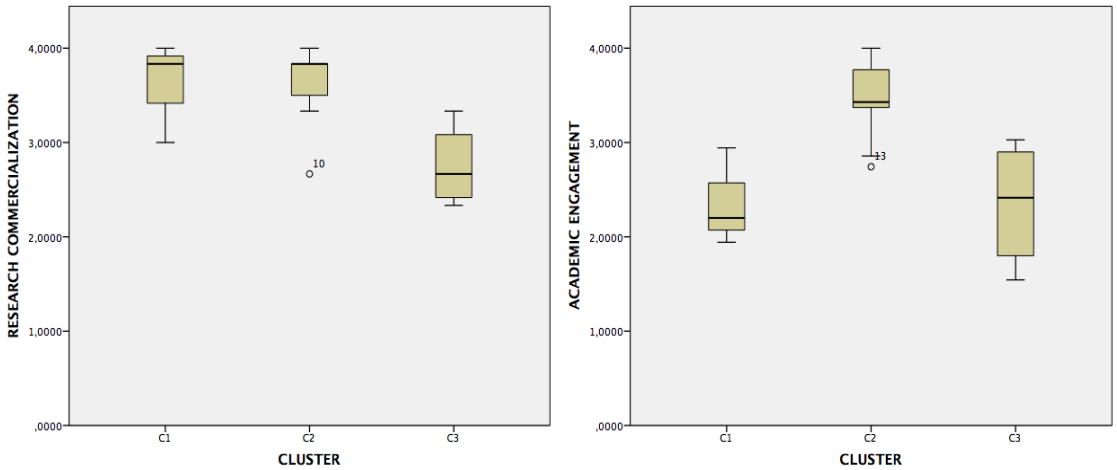
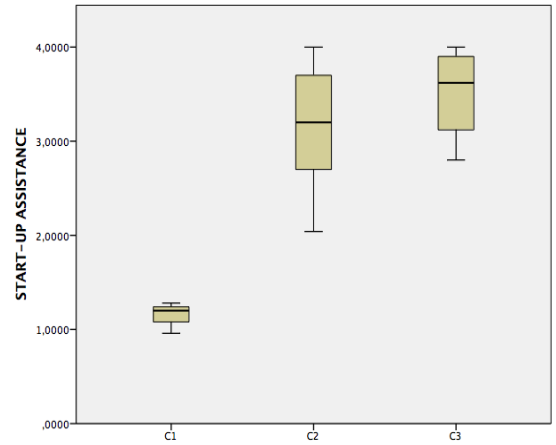


Figure 1. Dendrogram



(a)

(b)



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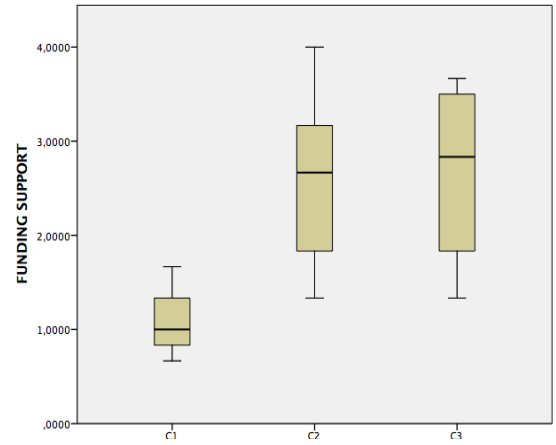

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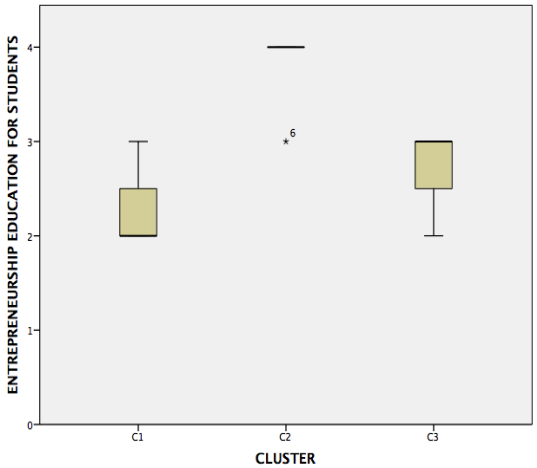
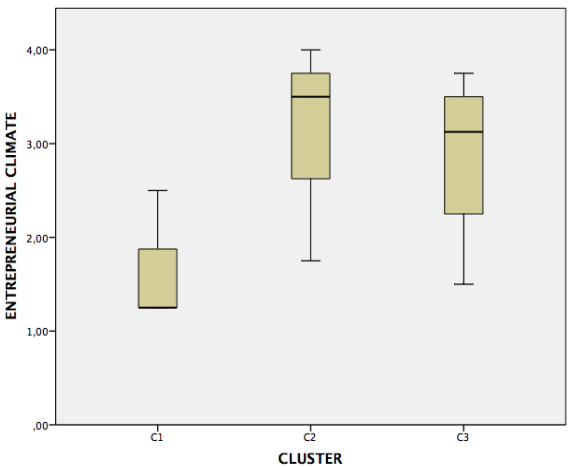


(e)



(f)

Figure 2. Box plots

5.Conclusion

This paper contributes to literature on university technology transfer in two ways. First, we review and provide a set of university technology transfer activities. Secondly, we highlight different models of universities technology transfer. We acknowledge that despite all universities have embraced the entrepreneurial paradigm, they differ in their approach, adopting different models and therefore performing differently the UTT activities.

In particular, we found a cluster focussing on research commercialization, another having a more balanced approach and third one focus on support to start-ups but being closer to the second cluster regarding other activities. The cluster with larger number of universities (cluster 2) has a more balanced approach performing satisfactorily all the UTT activities. This may confirm that in order to pursue the third mission of economic development, a balance approach is suitable. However, further research should check if this balanced approach is more effective to contribute to economic development.

This paper has important managerial implications. Universities managers, in particular, can compare the execution of their activities with the one identified in our literature review and investigated in the questionnaire, that reveal 6 main UTT activities. In addition, they may position in one of the identified cluster and plan to move to a more balanced approach.

Limitations and further research

This paper has some limitations. Firstly, we have a limited sample to consider in the analysis. Future research will either expand this sample or complement with qualitative analysis. In this vein, future research should use both quantitative and qualitative studies. Further research should explain the motives that lead universities to embrace a specific model. These are likely to be affected by the social, technological/industry, organizational and policy/institutional context (Autio et al., 2014; Geuna and Muscio, 2009). Further research should also explore more in detail the university and individual research characteristics that result in different UTT models. Finally, we do not analyze whether the existence of different models may depend on different timing of adoption of the entrepreneurial paradigm (Cesaroni and Piccaluga, 2016). It could be the case that the transition to a more balanced approach (cluster 2) may require time and deliberate allocation of resources (Cesaroni and Piccaluga, 2016)

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