DEALING WITH HETEROGENEITY: AN ANALYSIS OF SPANISH UNIVERSITIES

ABORDANDO LA HETEROGENEIDAD: UN ANÁLISIS DE LAS UNIVERSIDADES ESPAÑOLAS

ABSTRACT

Universities are highly dependent on regulatory frameworks, the geographical setting as well as on requirements for the creation of the different outputs they pursue. As a result, universities are heterogeneous organizations. This study analyses universities' heterogeneity in Spain. By using a dataset from the Spanish higher education system, we model the objective function of universities and investigate which factors help explain universities' performance, in terms of the three missions that they mostly perform (teaching, research and technology transfer). Also, a cluster analysis is performed to categorise Spanish universities. The findings contribute to better understand the different behaviours shown by universities. The findings underline the heterogeneity of Spanish universities: while some universities focus more on formation (teaching) goals, other universities excel at disseminating knowledge through different scientific outputs. The study concludes with a detailed inter- and intra- group analysis.

KEYWORDS: Higher education institutions; resources; objective function; cluster analysis

RESUMEN

Las universidades dependen en gran medida de los marcos regulatorios, la visión estratégica y del contexto geográfico. Consecuencia de esto, las universidades son claramente organizaciones heterogéneas. Este estudio analiza la heterogeneidad de las universidades en España. Utilizando datos del sistema universitario español se propone la formulación de la función objetivo de las universidades y se investiga qué factores ayudan a explicar el desempeño de las universidades en términos de las tres misiones que realizan principalmente (enseñanza, investigación y transferencia de tecnología). El estudio se acompaña de un análisis de clústeres en el que se caracterizan distintas tipologías de universidades. Los resultados obtenidos ayudan a comprender mejor los diferentes comportamientos mostrados por las universidades. En concreto, los resultados subrayan la heterogeneidad del sistema universitario español: mientras que algunas universidades se centran más en los objetivos de formación (enseñanza), otras universidades destacan por sus actividades de investigación y transferencia. El estudio concluye con un análisis detallado inter- e intra-grupo.

PALABRAS CLAVE: Instituciones de educación superior; recursos; función objetivo; análisis clúster

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INTRODUCTION

In recent decades, universities have faced many changes in both their internal and external environments, being constantly submitted to new challenges as society advances in science and technology (Abankina et al., 2016; Sánchez-Barrioluengo, 2014). Universities are required to simultaneously excel at three main domains—teaching, research and technology transfer—with the ultimate purpose of giving immediate responses to industry demands (Berbegal-Mirabent et al., 2013) providing the marketplace with new knowledge, experience and cutting-edge solutions, and therefore, contributing to the economic regeneration of the region (Shattock, 2009).

Moreover, universities operate in a highly competitive environment with a strong competition for attracting the best students, outstanding research staff and capture research funds (Olivares and Wetzel, 2014). In this sense, rankings have been widely considered as a valuable source of information to identify best performing institutions (Agasisti and Johnes, 2015). Given the high influence that these assessment tools can have, the pressure under which universities operate is remarkable, particularly if they want to scale positions and be placed among the top ones. Despite rankings have become a global phenomenon, there are however some concerns about how they are built and the partial view they offer, being a widespread consensus on that the information provided does not fully represent all the activities conducted at universities, not only because of the differences intra- and inter- institutions, but also because of the sensitivity to the methods applied to obtain the rankings (Agasisti and Bonomi, 2014).

Universities have responded differently to these requirements, often influenced by governments and funding agencies (Taylor and Miroiu, 2002). Previous evidence shows that this process has taken place at different rates and intensities (Shattock, 2009), and that universities' transformations are highly tied to a specific strategic vision, drawing different ways through which universities address their multiple objective function. Said differently, universities are heterogeneous and manage their resources differently. This approach assumes that

> BY USING A DATASET FROM THE SPANISH HIGHER EDUCATION SYSTEM, WE MODEL THE OBJECTIVE FUNCTION OF UNIVERSITIES AND INVESTIGATE WHICH FACTORS HELP EXPLAIN UNIVERSITIES' PERFORMANCE, IN TERMS OF THE THREE MISSIONS THAT THEY MOSTLY PERFORM (TEACHING, RESEARCH AND TECHNOLOGY TRANSFER)

different orientations might be adopted; consequently, universities might allocate their resources differently. As a result teaching, research and third mission activities are pursued at different intensities (Berbegal-Mirabent et al., 2013). This strategic orientation—commitment to the three missions—is not the only source of heterogeneity among higher education institutions (HEIs). Horizontal diversity is also due to differences in disciplinary subjects and types of research. On the other hand, there is also vertical diversity originated by distinct accreditation results, diverse positions in the existent rankings, and in the differential capabilities to compete for and obtain funding (Daraio et al., 2011). This high level of heterogeneity prevents making significant comparisons within universities (Agasisti and Bonomi, 2014; Agasisti and Wolszczak-Derlacz, 2015) and makes it harder to study HEIs performance.

At this point, the question of *how* the internal configuration of resources –i.e., technology, capital and other productive factors– influence the universities' capacity to achieve their different missions gains relevance. Given the resource constraints and universities' vulnerability with respect to uncertainty and environmental changes, a better understanding of the factors that explain their performance stands as a key issue for academics and policy makers (Agasisti et al., 2016; Agasisti and Johnes, 2015).

Following the recent calls of Daraio et al. (2015) and Sánchez-Barrioluengo (2014), in this study we examine how universities operate. More precisely, the objective of

this paper is two folded. First, we analyse the impact that universities' internal resources have on the achievement of universities' main objectives: teaching, research and third mission. To do this, we assess each university objective individually. We propose a conceptual framework highlighting a number of factors (human capital, specific infrastructures, financial resources and university's profile) that are suggested to shape universities' performance. Different regression models are run to verify the explanatory power of the previously identified factors. Second, by means of a cluster analysis, we classify universities in different groups based on the strategy they follow when prioritising the different missions. This analysis is complemented with the investigation of the role played by the critical antecedents –identified in the first stage– of each mission. The empirical application considers the Spanish public higher education system.

The remainder of the paper is organised as follows. In section 2 we present the conceptual framework used to assess university's performance. This leads to the definition of a number of hypotheses related to different organisational factors. Next, section 3 describes the data and method. A two stage analysis is conducted. First we assess each mission individually using regression techniques, and second, we run a non-hierarchical cluster analysis as the method to classify universities. The findings are discussed in section 5. Section 6 closes the article, highlighting the main concluding remarks and suggesting future research avenues.

CONCEPTUAL FRAMEWORK

During the last decades, an extensive body of literature has been developed trying to explain universities' performance (Fischer et al., 2015; García-Aracil and Palomares-Montero, 2010; Johnes and Ruggiero, 2017; Shin et al., 2011). Universities operate like any other organisation within the service sector, but with a main difference in their *raison d'être*, that consists in knowledge creation and diffusion. Therefore, in order to explain and evaluate their performance it is necessary to take into account tangibles (e.g. economic resources and facilities) and intangibles (e.g. experience, or specialisation of the human resources). Following Del-Palacio et al. (2011) we consider universities' internal services as inputs, measured as human capital, financial resources, and organisational assets –including infrastructures and the profile of the institution.

HUMAN CAPITAL

Human capital comprises individual's attributes as formal education, abilities and previous experience. This type of capital is considered unique since it cannot be taken away from the individual as tangible assets and financial capital can. Aryee et al. (2016) remark that the presence of high levels of human capital influence the quality of business behaviour. This is relevant in the case of universities as this type of business heavily relies on individual's knowledge and capacities (Huggins et al., 2012). The first dimension we consider refers to academic staff (Chinta et al., 2016). This dimension does not only capture the commitment of staff in the missions of the universities but also their capabilities and merits (e.g. PhD completed, awards). Academic staff constitutes a unique resource for universities, as faculty and researchers are the first frontline in command of the academic and research activities (Light and Calkins, 2015). In addition to the academic staff it is necessary to consider non-academic (or technical) staff, that is, the personnel responsible for providing administrative support for the proper performance of academic functions (e.g. records management, schedules, students' enrolment) as well as for performing the appropriate operations and maintenance of the facilities.

The second human capital component relates to the previous experience or background that both the faculty and the institution have in a specific field (Wolszczak-Derlacz, 2017). Through this component we aim at capturing the dynamic knowledge spillovers derived from past experience which may help create a more fertile setting for the development of new activities (van der Ploeg and Veugelers, 2008). One way to account for this experience is measuring how actively the university has been in producing the desired outputs—depending on the mission being measured—during the last years (Anderson et al., 2007). Those universities with seniority are more likely to have developed appropriate procedures and managerial capabilities that facilitate the production of the desired outputs today.

The third dimension considers the knowledge stock available at the university, which represents the ultimate consequence arising from any activity carried out at the university. This knowledge may be used or turned into another tangible or intangible output with a different use and nature (Anderson et al., 2007). Here, we assume that knowledge accumulation represents the basis for further developments within the university. Also, it might help reducing time spans necessary to develop new activities.

Given all these considerations, we hypothesise that:

H1: *There is a positive relation between human capital components (faculty, experience and capacity to accumulate knowledge) and the achievement of university's objectives.*

FINANCIAL RESOURCES

Many studies report a positive relationship between access to financial resources and university's knowledge transfer activities (Landry et al., 2007; Muscio, 2010). Financial resources comprise sources of fundraising for the day-to-day operations, such as external research funding coming from governmental agencies, commercial sponsorships, research grants, and revenues from tuition and fees (Kongar et al., 2010; Abramo et al., 2008). Yet, income from R&D activities may be considered a better proxy for university's financial resources as it represents the monetary income from the exploitation of research results, and this is closely related to the quality of the research performed by universities (Caldera and Debande, 2010). This income may be seen as that derived from specific fundraising universities-industry contracts, licensing agreements, or that coming from the commercialisation of specific research outcomes such as patents (Caldera and Debande, 2010). Given that financial resources are critical for developing HEIs' activities, we hypothesise:

H2: *There is a positive relationship between universities' financial resources and the achievement of universities' objectives.*

SPECIFIC INFRASTRUCTURES

Spaces and infrastructures that support university activities are also relevant. These include specific areas which are necessary to achieve university goals (Berbegal-Mirabent et al., 2015). According to Del-Palacio et al. (2011) these facilities include lecture rooms, laboratories and libraries. In terms of third mission activities, this space can also be represented by incubator facilities, that is, specific spaces that bring together entrepreneurs with a formal or an in-progress idea that is expected to evolve and become a real business (Grimaldi and Grandi, 2005; Wonglimpiyarat, 2016). In addition, over the last decades, universities have become increasingly entrepreneurial, generating value for society through the commercial exploitation of research outputs (Berbegal-Mirabent et al., 2015). In this particular, universities have created mechanisms to promote university-industry relationships. The establishment of technology transfer offices (TTOs) has hastened the interactions between academics and industry professionals, thus, bridging the gap between science and practice. These structures are responsible for the management of these interactions and have become key agents given their commitment with society (Aragonés-Beltrán, 2017). This way, our third hypothesis emerges:

H3: *The presence of specific infrastructures (i.e. technology transfer office) has a positive influence on the achievement of universities' objectives.*

UNIVERSITY PROFILE

One of the key aspects that students, researchers and companies look at when deciding where to study, where to work or with whom to collaborate with, is the reputation of the institution (Ho and Peng, 2016). Universities are likely to desire a good positioning in these rankings, as it signals universities' capacity to educate and to create cutting-edge research (Hazelkorn, 2009). A closer look at how these rankings are built reveals that publication counts and number of citations are recurrent indicators, having a relevant weight in these evaluation schemes. This means that if we use how well universities are positioned in rankings to explain research outputs, these two measures will be highly correlated. For the purpose of this study we use an alternative approach to account for the reputation of the university. Specifically, we focus on the teaching mission and compare the offer with the demand. More precisely, we look at the percentage of new entries in first option with respect to the total number of new entries (adequacy ratio)

and the demand compared to the total number of places offered (preference ratio). We argue that those students that are able to enrol in the university and the academic program they wanted to will be more committed with their studies and consequently, the dropout rate will be lower. Accordingly, we hypothesise that:

> **H4:** *There is a positive relationship between how demanded is the university (i.e. adequacy ratio and preference ratio) and its performance in teaching activities.*

Expertise understood as seniority is another key factor. Experiences implies dynamics of people working together and the establishment of group structures (Wolszczak-Derlacz, 2017), which are found to ease the work done by university workers. These structures might relate to either administrative process (i.e. regulatory framework for the three missions) or performance (i.e. working groups, TTOs and grant system among others). Based on these arguments, the following hypothesis is derived:

> **H5:** *There is a positive relation between seniority (i.e. age of the university and of the TTO) and the achievement of universities' objectives.*

Lastly, we control for the university's academic diversification and the orientation of the research engaged (McMillan and Chan, 2006). Previous research indicates that universities either with medical schools or more oriented towards engineering studies are more likely to engage in third mission activities than those with a greater orientation in social sciences or humanities (Carlsson and Fridh, 2002). In terms of publications, a similar behaviour is observed as in some knowledge fields it is easier for academics to develop their research activities and publish in scientific journals (engineering and medical sciences) than in other fields (arts and humanities) (McKelvey and Holmén, 2009). On the contrary, the recent work of Chinta et al. (2016) point out that the fact of offering different studies and diversifying the fields in which the university develops its activity, enriches, complements and can improve universities' results. Thus, based on these latter arguments we hypothesise that:

> **H6:** *There is a positive relation between academic diversification and the achievement of universities' objectives.*

DATA AND METHOD

DATA

The data used in this study come from two sources, the IUNE Observatory and from the Ministry of Education, Culture and Sport. IUNE (http://www.iune.es/) is an observatory, supported by public funding, that has the objective of offering updated and reliable information of the research activity conducted in the Spanish higher education system. On the other hand, we also rely on data from the Ministry of Education, Culture and Sport, that on a recurrent basis publishes statistics and reports about Spanish universities.

The database comprises information for the total number of public universities in Spain offering on-site education (47) for the academic year 2014/15. As 2014/15 outputs require resources from the previous years, the explanatory variables are introduced as lagged terms.

MODEL SPECIFICATION

At this point it is important to define the different university objectives. From a university's perspective, the key element of the teaching mission (*T*) encompasses graduating students. Traditionally, the number of graduates has been used to measure teaching outcomes (Daraio et al., 2011; Johnes, 2006). However, in absolute terms universities with hard-science schools produce fewer graduates than universities with faculties in humanities and social sciences (Agasisti and Gralka, 2019). Thus, using the number of graduates to measure teaching would yield biased results as this variable does not consider the capacity of any given university to graduate students. Alternatively, we measure the teaching mission as the number of graduates during the academic year 2014/15 relative to the total number of students enrolled in the same academic year. This ratio is calculated at the university level, and due to lack of complete information it only includes students and graduates in undergraduate programmes. By construction this variable avoids scale size effects, and represents the net flow of students, as it considers the inflow of student in the university, that is, the total number of enrolments and a term that reflects the number of students that successfully finished their studies.

Concerning the research mission (*R*), previous works measure this activity as publications in peer-reviewed journals, books and book chapters, and conference proceedings, or even take into consideration research funding, usually measured by the number of research projects funded by competitive public grants or the resulting income (Bozeman and Gaughan, 2007; Palomares-Montero and García-Aracil, 2011). Following Daraio et al. (2011) and Breschi et al. (2007), in this study we proxy research outcomes by the number of scientific papers per faculty published during 2014 in journals included in the Web of Knowledge (WoS). On the one hand, the inclusion of papers published in journals indexed in this database allows reflecting both the quantity and quality of the research carried out (Merigó and Yang, 2017). On the other hand, this indicator is a good proxy given that publication counts is the factor with the highest weight in the researchers' evaluation processes for internal promotion purposes in Spain.

Lastly, the third mission (*TM*) is measured by the income from R&D contracts in 2014 standardised by the total number of academic staff working at the university. The reason for choosing this measure is that R&D contracts are more important than patents and licensing in explaining the outcomes resulting from this mission (Sánchez-Barrioluengo, 2014). In fact, D'Este and Patel (2007) proved that R&D contracts are the most frequent type of interaction between universities and firms compared to the other two.

The achievement of the aforementioned missions implies the access and intensive use of general and specific resources. The relation between university's missions and the different resources analysed is portrayed in Table 1.

Concerning the set of explanatory variables, descriptive statistics are presented in Table 2. Different variables are used to measure human capital, according to the mission under analysis. As previously mentioned in the conceptual framework, the teaching mission can be affected by the lecturers' dedication in terms of students per class, that is, the average number of students per faculty member. Similar to Abbott and Doucouliagos (2003) and Taylor and Harris (2004), this variable is measured as the average number of enrolments in undergraduate degrees

Table 1. Variable definition proposed to assess.

Factor		Teaching Graduates / Students	Research Papers / Academic staff	Third stream R&D income / Academic staff
Human capital	Faculty	Students / Academic staff Full time academic staff / Academic staff	PhD Faculty / Academic staff Research periods / Academic staff	PhD Faculty / Academic staff Support staff / Academic staff Total income (last 3 years) /
	Experience	-	Publications (last 3 years) / Academic staff	Academic staff Research projects (last 3 years) / Academic staff
	Knowledge accumulation	-	Research projects (last 3 years) / Academic staff	Patents granted (last 3 years) / Academic staff
Financial resources		Expenditures per student	Current expenditures per academic staff	R&D income (last 3 years) / Academic staff
Specific infrastructures		-	-	Age of the Technology Transfer Office
University profile		Adequacy ratio Preference ratio	- Educational diversity University age	-

Table 2. Descriptive statistics for the selected variables.

Variable	Mean	Std. Dev.	Min	Std. Dev.
Dependent variables				
Graduates / Students	0.1446	0.0343	0.0854	0.3050
Papers / Academic staff	1.1080	0.5917	0.4865	3.8072
Income R&D contracts / Academic staff	5.3001	4.1038	1.1176	20.0548
Explanatory variables				
Human capital components				
1. Faculty				
Students / Academic staff	14.1638	3.0824	9.9000	28.1000
Full time academic staff (%)	0.6586	0.1258	0.2763	0.8738
PhD Faculty (%)	69.0818	8.5171	48.7000	85.8000
Research periods / Academic staff	1.8149	0.4263	1.0000	2.8000
Support staff / Academic staff	0.6874	0.1100	0.5038	1.0647
2. Experience				
Papers last 3 years / Academic staff	2.2201	0.8953	0.9680	5.3991
R&D incomeb last 3 years / Academic staff	13.6938	9.9581	1.8428	59.4206
3. Knowledge accumulation				
Research projects last 3 years / Academic staff	0.1081	0.0441	0.0302	0.2982
Patents granted last 3 years / Academic staff	2.3344	1.2588	0.6496	5.4389
Financial resources				
Expenditure per studenta	6,521.5740	1,262.8160	3053.0000	9,312.0000
Current expenditures per academic staffa	27,000.0000	16,300.0000	65,00.0000	7,6000.0000
Specific infrastructure				
TTO age (years)	23.8936	4.4293	13.0000	36.0000
University profile				
Adequacy ratio	71.7302	14.7834	15.2600	96.8400
Preference ratio	158.9434	65.7741	63.8100	367.5000
Education diversity (Herfindahl index)	3.6287	0.9130	1.0900	4.7900
University age (years)	139.4255	220.3767	17.0000	797.0000

For some variables, the number of observations varies due to the presence of some missing values.
[a] Expressed in thousands of euro
[b] As already discussed, note that this variable can also be considered as a financial resource.

during the academic year 2013/14 per faculty in the same period. Aiming at exploring differences in graduation rates (student success or failure) do to faculty member time and tenure status (Jacoby, 2006; Kezar and Sam, 2010), an additional variable is introduced expressed as the proportion of full-time faculty relative to total faculty members.

Similar to Martín (2006), the human capital factor for the research mission is measured as the proportion of faculty with a PhD degree. Through this variable we aim at incorporating a quality criterion (holding a PhD) linked to a greater academic productivity in terms of publication counts. Besides, we also account for the external validation of the research conducted by faculty members. In particular, we proxy it through the number of research periods awarded by the Spanish National Agency of Quality Assessment and Accreditation in the last three years per total faculty (Palomares-Montero and García-Aracil, 2011). Previous experience—the second dimension of human capital—is proxied by the number of publications in the last three years relative to the total faculty working at the university. This variable controls for size differences in terms of faculty, while it indirectly incorporates the presence of organisational designs related to research groups, which gradually can establish synergies, exploit externalities and create cooperative patterns among the group members. Lastly, knowledge stock is measured through the number of research projects participated by academics during the past three years. These projects, either with a national or an international scope, have a competitive basis and entail some funding for the development of the research activities detailed in the project.

The establishment of university-industry R&D partnerships requires some guidance and help—due to the administrative work related to securing intellectual property rights and confidentiality—but also qualified researchers and preferable, with a background in such partnerships. Thus, the first two variables refer to the proportion of faculty holding a PhD degree and the ratio of non-academic staff relative to academic staff. Experience is captured through the income obtained from R&D contracts (last 3 years) with respect to total academic staff. Accumulated knowledge is represented by previous experience in research projects (3 years) relative two total academic staff. Moreover, some studies indicate that university patenting stimulates future third stream activities (Sánchez-Barrioluengo, 2014). Accordingly, we also include a variable with the number of patents awarded by the Spanish Office of Patents and Trade Marks (OEPM) in the last three years per academic staff.

As for the access to financial resources, we use expenditures per student for the teaching mission and the current expenditures per academic staff to explain research activities (Daraio et al., 2011). In the case of third mission activities, we use the same variable used to represent previous experience, that is, income from R&D contracts from the last three years. Financial resources emerging from R&D may be understood as those derived from specific fundraising activities (such as public or private contracts). These revenues are typically reinvested and used to finance new third mission activities (Caldera and Debande, 2010).

According to our conceptual framework, infrastructures are expected to facilitate the effective achievement of university's activities. Concerning the presence of specific infrastructures that accelerate new R&D contracts, we included TTOs (Aragonés-Beltrán et al., 2017). Given that all Spanish universities have a TTO, we account for these infrastructures by considering their age since foundation (Caldera and Debande, 2010).

The last factor in our model considers the profile of the university. For the teaching mission two ratios are included: the adequacy ratio (percentage rate of new entries by pre-enrolment in first option with respect to the total number of new entries by pre-enrolment) and the preference ratio (the number of students pre-enrolled in first option compared to the total number of places offered). Lastly, we also control by university age and academic diversity. Spanish universities offer different degrees which can be catalogued in five groups: humanities studies, social sciences, experimental sciences, medical sciences and engineering studies. As stated in section 2, the distribution of academic degrees is heterogeneous among universities and this diversification may have an influence on the different university missions. To account for this diversity, and following McMillan and Chan (2006) we use the Herfindahl index (HHI) calculated as $HHI=\sum_{j=1}^{J} s_j^2$, where s is the proportion of academic degrees offered by each university in the *jth* disciplinary category. The academic degrees considered for universities

are those offered during the academic year 2014/15. To facilitate the interpretation of the results for this variable, we use the inverse value of this factor.

The model specification used to corroborate our hypotheses has the following form:

[1]

$$f(\text{T,R,TM})_i = \alpha_0 + \beta_1 \text{HumanCapital}_i + \beta_2 \text{Financial Resources}_i + \beta_3 \text{Infrastructures}_i + \beta_4 \text{Seniority}_i + \beta_5 \text{Academic Spread}_i + \varepsilon_i$$

Equation (1) implies that the objective function of the *ith* university comprises teaching (*T*), research (*R*), and third mission activities (*TM*). For all the missions, the linear regression is the econometric technique chosen.

CLUSTER ANALYSIS

Cluster analysis is a technique that allows identifying groups of observations with different behavioural paths, given the presence of specific variables that are expected to influence the sampled units (Everitt, 1980). For this study, four variables are chosen. Specifically, we select the three dependent variables used in the previous analysis (i.e., flow of graduates relative to total students, publications per academic staff, and R&D contracts' income per academic staff) as well as the variable capturing academic diversity as a way to control for heterogeneity.

A non-hierarchical cluster analysis (K-means) is run. An efficient optimisation of the within-cluster homogeneity and between-cluster heterogeneity implies that the number of clusters has to be specified prior the estimation. To corroborate the number of clusters and the validity of our analysis we first computed the Calinski and Harabasz (1974) statistic. This index is obtained as $CH(k)=\frac{B(k)/k\text{-}1}{W(k)/n\text{-}k}$, where $B(k)$ and $W(k)$ are the between and within-cluster sums of squares, with k clusters and a sample size of n observations. Since the between-cluster difference should be high, and the within-cluster difference should be low, a largest $CH(k)$ value indicates the best clustering. We compute this index after a non-hierarchical cluster analysis, in order to compare the resulting $CH(k)$ values to alternative number of clusters.

RESULTS

FIRST STAGE ANALYSIS: INDIVIDUAL ANALYSIS OF UNIVERSITY'S MISSIONS

Before to comment the results it is important to note that we tested whether disturbances emerging from the different model specifications are normally distributed. The normal probability plots of the residuals obtained for the different regressions support the normality assumption of disturbance terms. The Shapiro-Wilk test was also performed and further corroborated the normality of the residuals. Table 3 shows the results of the regression models.

Concerning the *teaching* mission, our results reveal that from the different variables used to proxy human capital, the only one that helps explain the flow of students is the proportion of full time academic staff, which seems to have a positive influence. This finding supports the current normative framework which asks for, at least, 60% of the academic staff being full time employed. The rationale behind this requirement is that full-time academic staff is expected to be more available for students and respond to their demands. This does not mean that part-time are not necessary, on the contrary, they can complement full time academic staff bringing their expertise from the industry world. However, theoretical fundamentals are typically taught by staff with an academic orientation, who are expected to be at the front end of science. Results also signal that students' flow increases with the adequacy rate. This means that if students are admitted in their first option, the likelihood of finishing within the expected time is higher. In other words, it seems that when students enrol in the academic degree they applied for, they are more committed with their studies. Future studies should further investigate this effect and examine the role of motivational factors to explain this result. Lastly, education diversity is also found to be significant. This result is consistent with our initial intuition that some disciplines such as medicine or engineering are typically more complex, and therefore, students might require some extra years to finish their studies —institutions with a lower academic diversity are those offering studies in such disciplines— therefore, we can conclude that broadening the academic portfolio increases the flow of graduates relative to total students.

As for the *research* mission, results do support our argument that both experience and knowledge

Table 3. Regression results: Determinants of each university's mission.

Variables	Teaching Graduates / Students	Research Papers / Academic staff	Third stream R&D income / Academic staff
Human capital components			
1. Faculty			
Students / Academic staff	0.0007 (0.0013)		
Full time academic staff (%)	0.0806 * (0.0445)		
PhD Faculty (%)			-0.1648 *** (0.0597)
Research periods / Academic staff		0.0256 (0.1042)	
Support staff / Academic staff		0.2098 (0.2664)	-10.5447 *** (3.8293)
2. Experience			
Papers last 3 years / Academic staff		0.2478 *** (0.0598)	
R&D incomeb last 3 years / Academic staff			0.2558 *** (0.0803)
3. Knowledge accumulation			
Research projects last 3 years / Academic staff		6.7967 *** (1.9262)	31.8485 *** (11.2315)
Patents granted last 3 years / Academic staff			0.8532 * (0.4747)
Financial resources			
Expenditure per studenta	0.0030 (0.0059)		
Current expenditures per academic staffa		0.0201 ** (0.0082)	
Specific infrastructure			
TTO age (years)			-1.1627 (1.9214)
University profile			
Adequacy ratio	0.0005 ** (0.0002)		
Preference ratio	0.0001 (0.0001)		
Education diversity (Herfindahl index)	0.0072 * (0.0040)	0.0910 ** (0.0392)	1.1666 (0.8866)
University age (years)	-0.0005 (0.0032)	-0.0272 (0.0224)	0.0726 (0.2907)
Intercept	-0.0113 (0.0421)	-0.9579 (0.3280)	14.2301 ** (7.0136)
F – test	5.22 ***	57.51 ***	7.22 ***
R squared	0.2656	0.9216	0.6053
RMSE	0.0319	0.1800	2.9261
Observations	47	47	44

Robust standard errors adjusted by heteroskedasticity are presented in brackets. For some variables, the number of observations varies due to the presence of some missing values. *, **, *** indicate significance at the 10%, 5%, and 1%, respectively.

accumulation positively influence research results, yet, the first dimension of human capital —faculty— does not seem to have an impact. Another key finding is that financial resources do have a positive and a significant effect on research outputs, validating our hypothesis. These results imply that both experience and funding are relevant for generating new publications. This argument particularly holds true for universities with a broad academic diversity.

In the case of the *third mission*, we observe a negative effect of the first dimension of the human capital factor. The rationale behind this result might be twofold. A plausible interpretation is that the activity conducted by non-academic staff seems not to alleviate the workload of academic staff, suggesting misalignments in the capacity planning of the workforce or alternatively, that contracts with firms are easily reached if lead by academic staff. Future research should examine this effect in more detail and investigate the specific tasks conducted by non-academic staff and their impact on research activities. The proportion of academics holding a PhD also impacts negatively. Future works should elaborate on this issue and investigate the profile of the researchers involved in third mission activities, as our results seems to indicate that faculty engaged in R&D contracts are in a weaker contractual position. In this sense, it is of paramount importance the existence of favourable policies that encourage engagement in third mission activities. Unfortunately, due to data limitations we were not able to conduct this type of analysis. On the contrary, knowledge stock and experience do positively shape third mission results (similar results as in the research model). A logical interpretation is that these two dimensions help creating a more fertile setting for the development of new activities. Both projects and patents might bring contacts with companies, which might later materialise in new university-industry R&D partnerships. Previous experience in R&D contracts also has a positive effect. As noted earlier, this variable also accounts for the financial resources available for the establishment of new third mission activities. Thus, income from R&D contracts can drive future knowledge transfer activities as the incentives linked to potential extraordinary revenues could represent an important motivation for both the institutions and their faculties. Our results are, however, not in accordance with hypotheses 3, 4 and 5, as neither specific infrastructures nor the profile of the university helps maximising third mission outcomes. Nevertheless, it is worth stating that when relaxing the robust condition in the regression analysis, the academic diversity variable became significant (p-value=0.082).

SECOND STAGE ANALYSIS: CLUSTERING UNIVERSITIES

From our data, the number of clusters that maximises the *CH(k)* index is 6 (*pseudo-F* value=87.97). Therefore, the final non-hierarchical cluster asks for a six-ways division. A

Table 4. Results of the discriminant analysis.

True Groups	Classification						Observations
	1	2	3	4	5	6	
Group 1	10 (100.00%)	10 (100.00%)	10 (100.00%)	10 (100.00%)	10 (100.00%)	10 (100.00%)	10
Group 2	0 (0.00%)	11 (91.67%)	0 (0.00%)	0 (0.00%)	1 (8.33%)	0 (0.00%)	12
Group 3	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
Group 4	0 (0.00%)	0 (0.00%)	0 (0.00%)	6 (100.00%)	0 (0.00%)	0 (0.00%)	6
Group 5	0 (0.00%)	3 (37.50%)	0 (0.00%)	0 (0.00%)	5 (62.50%)	0 (0.00%)	8
Group 6	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	8 (100.00%)	8
TOTAL	**10 (21.28%)**	**14 (29.79%)**	**3 (6.38%)**	**6 (12.77%)**	**6 (12.77%)**	**8 (17.02%)**	**47**

Tabla 5. Descriptive statistics for the selected variables.

Groups	1		2		3		4		5		6	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Dependent variables												
Graduates / Students	0.132	0.028	0.149	0.012	0.151	0.015	0.136	0.029	0.155	0.067	0.147	0.029
Papers published / Academic staff	0.932	0.301	0.995	0.207	1.355	0.442	1.278	0.522	0.758	0.201	1.628	1.122
Income R&D contracts / Academic staff	4.083	0.533	2.676	0.273	16.908	2.727	9.900	1.569	1.734	0.279	6.521	0.434
Education diversity	3.979	0.995	3.774	0.512	3.900	0.547	2.338	1.261	3.579	0.716	3.889	0.556
Significant explanatory variables												
Adequacy ratio	63.566	23.170	75.893	11.031	74.603	20.885	76.593	9.860	68.890	10.456	73.806	9.406
Full time academic staff (%)	0.646	0.092	0.675	0.113	0.688	0.133	0.599	0.180	0.696	0.140	0.646	0.139
Papers (3 years) / Academic staff	1.926	0.557	2.065	0.415	2.701	0.785	2.541	0.960	1.705	0.493	2.914	1.521
Research projects (3 years) / Academic staff	0.093	0.029	0.102	0.020	0.139	0.029	0.141	0.025	0.074	0.030	0.134	0.075
Patents granted (3 years) / Academic staff	2.500	1.396	1.693	0.986	2.515	1.228	3.669	1.568	2.301	0.891	2.056	1.011
R&D income (3 years) / Academic staff	11.341	3.624	7.943	3.344	25.148	6.414	28.238	16.306	6.492	1.646	17.258	6.072
University age	156.700	272.584	115.083	188.463	35.000	9.849	128.000	214.304	103.375	165.475	238.125	297.895
Support staff / Academic staff	0.702	0.098	0.681	0.092	0.747	0.111	0.705	0.097	0.650	0.058	0.681	0.190
PhD Faculty (%)	70.160	10.237	67.820	6.997	61.300	11.059	68.817	3.381	71.975	10.158	69.600	8.495
Volume (size)												
Papers (3 years)	2,613.60	1225.56	3,409.75	2957.62	2,453.00	345.72	5699.00	4240.01	2,135.50	2,335.11	5148.13	3,708.48
Research projects (3 years)	125.70	56.52	164.42	140.18	127.67	10.60	301.00	144.53	90.00	100.50	222.50	113.96
Patents (3 years)	34.50	25.98	21.08	11.43	24.67	14.64	74.17	40.40	23.88	19.19	40.13	33.40
Income from R&D contracts (3 years)	15,744.90	8,520.49	14,799.67	17,090.53	23,419.33	5,810.20	60,587.50	46,044.77	6,398.00	3,330.45	33,818.88	24,152.60
Graduate students	2422.20	1,012.56	3,149.17	2,548.03	1,750.00	488.40	3,301.83	1,986.56	2278.38	1,567.88	3,732.75	1,653.85
Students	17,929.60	6,437.32	20,995.58	16,248.03	11,489.00	2,452.20	24,103.67	11,259.26	15,475.00	11,329.73	26,029.25	13,116.66
Support staff (FTE)	939.31	303.66	1,093.04	953.84	691.83	69.21	1,508.35	652.44	729.18	596.27	1,210.08	684.49
Academic staff (FTE)	1,363.13	451.47	1,636.38	1,346.10	938.70	158.10	2,081.73	731.17	1,114.45	864.69	1,836.01	977.54

discriminant analysis was also run to further validate our cluster analysis. Results presented in Table 4 indicate that our approach is appropriate.

Table 5 presents the average values for the different variables of interest by groups. Universities in cluster 1 have a diversified strategy. They seem to prioritise all the missions at the same intensity, however, score the lowest outputs in all the dimensions. Taking into account the region where they are settled in, it seems that they are trying to cover regional needs. This intuition is further confirmed by the diversity of the academic offer. However, this broad strategy does not seem to help them in achieving outstanding results.

Universities in clusters 2 and 5 behave similarly, performing pretty well in the teaching mission. Universities comprised in these groups have chosen a strategy where students are placed at the centre, being clearly oriented towards academic goals. A more detailed analysis reveals that universities in cluster 2 are large, and concentrate a high number of students enrolled in their preferred studies. The weakest point is in third mission outputs. This low performance is also observed in universities in cluster 5, yet the main difference relies in that universities in this later cluster are somewhat less efficient as it can be deduced when looking at both the relative and the total number of research and third mission outputs despite having highly qualified academic staff. We therefore conclude that their extremely biased academic orientation might lead to an inefficient allocation of resources for the simultaneous development of third mission activities.

An opposite performance is that shown by universities in cluster 3, being these institutions the most efficient ones on average. Although we are not explicitly testing efficiency models, considering the number of academic staff, universities from this group are doing a good job in terms of the use of their resources, as key indicators (e.g. total number of research projects, publications, patents and income from R&D contracts) when standardised by total academic staff are higher compared to those from universities in other clusters. Nevertheless, when considering only volume, the average number of outputs is low, due to the small size that characterise universities in cluster 3. These findings suggest that their success may rely on a reduced but highly skilled workforce that enables these institutions to take full advantage of their knowledge stock and experience through an efficient use of resources.

The common feature that characterises universities in cluster 4 is specialisation. Three out of the four technical universities located in Spain belong to this group. The other three included in this group have a strong focus on health and medical sciences. As suggested by previous works (McKelvey and Holmén, 2009) universities with such a profile tend to outperform in terms of research and third mission activities, while the flow of graduates relative to total number of students is low. These universities are pledging their resources and commitment to the creation of knowledge with potential commercial applications and its subsequent valorisation in the marketplace. Note, however, that because these universities are also considerably big (in terms of total number of students and staff), when standardising research and third mission results by total academic staff, their performance is similar to that of universities in cluster 3. Another distinctive feature of cluster 3 is that despite the average adequacy ratio is high, the graduation rate is low. This result is not surprising. Students willing to enrol in such disciplines do not do so as a second or third option, but as first choice. Nevertheless, such studies are typically more difficult and usually imply completing the degree with an extra academic year.

Lastly, universities in cluster 6 seem to excel in the research mission. As found in the regression stage analysis, this performance is explained by a solid experience and accumulated knowledge in research projects and publishing. In terms of income from R&D projects they are ranked third, meaning that the research experience is somewhat transferred to the marketplace. Yet, the historical record of patents is considerably low. Another common characteristic is its size (large) and a diversified academic offer.

DISCUSSION AND IMPLICATIONS

Universities are organisations with a clear long-term strategic planning, and their contributions to society typically become observable a couple of years after their implementation. Universities' missions and structures are nowadays in the spotlight, being redefined in an attempt

to fulfil both social and labour market demands and, at the same time, perform more efficiently by making the most of their scarce resources.

Aiming at targeting potential strategies and factors that lead to an improved use of resources and capabilities of universities when addressing their objective function, in the first part of this study we have analysed the impact that universities' internal resources have on the achievement of teaching, research and third mission activities. There is a wide array of outputs that can be used to measure universities' performance. Nevertheless, and given the scope of this empirical analysis, we have assessed each university objective individually. Consistent with the literature, the selected output variables refer to critical objectives that universities try to achieve: the number of graduates in relation to the number of enrolments (as a proxy for teaching activities), average number of papers published in scientific journals indexed at WoS database per academic staff (for basic research), and the average income from R&D contracts per academic staff (to proxy third stream activities).

Based on the findings, we can conclude that human capital factors (H1) are particularly relevant specifically when they are measured in terms of experience and knowledge accumulation. Both dimensions represent the experience or background that a HEI has in a specific field. In terms of policy making this implies that human capital is critical for universities when it comes to achieve their objectives. Therefore, appropriate policies should be designed in order to retain researchers with projection and experience. However, it is important to note that, in Spain, to carve out an academic career is a long-term race. Due to the economic downturn in 2008, young researchers find it difficult to secure their job position once they have obtained their PhD. With the current scheme, universities invest—in terms of money, time and resources—in training assistant researchers (those pursuing a PhD). However, assistant researchers mostly go to the job market once they finish their formation and they often find a position in another (public or private) university. This is an example of brain drain problems in public universities. If expertise and knowledge accumulation are catalysts for the achievement of HEIs' outputs, universities should redesign their internal policies and promotion schemes in order to ensure that knowledge stock will be sustained over time.

> THE FINDINGS UNDERLINE THE HETEROGENEITY OF SPANISH UNIVERSITIES: WHILE SOME UNIVERSITIES FOCUS MORE ON FORMATION (TEACHING) GOALS, OTHER UNIVERSITIES EXCEL AT DISSEMINATING KNOWLEDGE THROUGH DIFFERENT SCIENTIFIC OUTPUTS

Hypothesis two (H2) was partially confirmed. Our findings support that third-mission activities offer an economic platform to develop new university-industry partnerships. We can interpret this result as evidence that good teaching records are reliant on other factors. In this case, it would be interesting for future studies to examine the role played by motivations.

Results do not support that experienced TTOs help achieve third mission objectives (H3). TTOs are expected to bridge the gap between universities and companies, however, based on our results, it seems that there is still a long way to go, at least in Spain, before academics could really benefit from the advantages of having an experienced office performing this tasks. A different interpretation might be that perhaps the issue is not that much on how old—expertise—the TTO is, but on the people working in it and the know-how and capabilities they can bring to help researchers better commercialise their research results. Another plausible interpretation is that only a small proportion of researchers are aware of the existence of a TTO at their university and the services provided. Besides, TTO awareness is greater among academic workers who possess experience as entrepreneurs, have conducted research in engineering, medicine, or life sciences, have closed research and consulting contracts with industry partners, and/or have occupied postdoctoral positions.

Lastly, the profile of the university seems to have a different influence depending on the mission under analysis. The flow of graduates per total students is higher when students have the chance to study what they applied for. However, this implies that universities with a high proportion of students that did not choose that

university should develop some additional strategies (i.e. international mobility offer, extra-curricular activities) that motivate students to be part of the university community and therefore, more easily engage and commit with their studies. In terms of the academic diversity our results confirm the recent works of Moed et al. (2011), Curi et al. (2015), and Foltz et al. (2012), who posit that when specialisation is too strong, it is more difficult to develop new capabilities and research at the interface of different fields, and that the efficient exploitation of resources diminishes. As for the effect of the age of the university, we can conclude that this hypothesis is rejected. It is, however, remarkable the negative effect when assessing research outputs, which seems to signal that in order to improve the outcome it is not only necessary investing in the promotion and specialisation of the workforce, but also in attracting new talent that can energise and bring new ideas. To this end, it is of paramount importance to make universities more attractive (Di Paolo and Mañé, 2016). A system of grants, awards and public recognitions or an economic policy that facilitates the dissemination of the results are some initiatives in which universities might engage in order to capture new and qualified researchers.

Table 6 summarises the main results in relation to the different models and hypotheses tested.

The results of the cluster analysis underline the heterogeneity of Spanish universities. While some universities seem to focus on supporting regional goals (cluster 1), other universities excel either at teaching activities (clusters 2 and 5) or at disseminating knowledge through publications (cluster 6). This latter path suggests that although they have the means to transform this knowledge into marketable results, they are probably lacking institutional support. These universities could implement specific policies and programmes in order to create an enabling knowledge transfer culture that allow exploiting all the knowledge stock they already have. On the other hand, universities in cluster 4 are already taking advantage of the natural spillovers that arise from the adoption of an entrepreneurial culture. Consequently, they base their strategy on their capacity to transform their different resources, accumulated knowledge and make use of their previous experience to get involved in more profitable university-industry R&D partnerships. Lastly, universities in group 3 are those that, despite not having

Tabla 6. Validation of hypotheses.

Hypothesis	Factor	Teaching	University Objectives Research	Third Stream
H1	Faculty	Partially accepted (b>0)	Rejected (b=0)	Rejected (b<0)
	Experience	-	Accepted (b>0)	Accepted (b>0)
	Knowledge accumulation	-	Accepted (b>0)	Accepted (b>0)
H2	Financial resources	Rejected (b>0)	Accepted (b>0)	Accepted (b>0)
H3	Specific infrastructures	-	-	Rejected (b=0)
H4		Partially accepted (b>0)	-	-
H5	University's profile	Rejected (b=0)	Rejected (b=0)	Rejected (b=0)
H6		Accepted (b>0)	Accepted (b>0)	Rejected (b<0)

the best environmental conditions and resources, are doing an efficient use of resources, in terms of teaching, research and third mission objectives.

CONCLUDING REMARKS

In a knowledge-driven society where different stakeholders demand more transparency in the autonomous governance of public institutions, universities are trying to find an appropriate balance between their three core missions, assuming new roles and responsibilities that could potentially lead to the modernisation of their governance structures and operations. In this context, the study of the ways through which universities align their resources in relation to the achievement of their multiple objectives has become a critical research issue.

In this study we have brought further insights on this specific topic linked to the management of universities. Despite many theoretical developments can be found pointing out the factors and mechanisms that help explain universities' performance, little empirical evidence is provided in the literature addressing the issue of heterogeneity among HEIs, and thus, comparing universities with appropriate peers. In order to bridge this theory and research gap, we first embarked on the analysis of the different roles played by universities and their underlying objectives. Second, we have identified different performance pathways. To do this, we have considered the Spanish public university sector. These universities are characterised by a high degree of heterogeneity which can be explained by economic and geographic differences, by changes in the environment that condition their behaviour, and by their dissimilar speed of adaptation to these environmental changes.

Following the works of Hazelkorn (2005) and Temple (2009), our results give empirical evidence about the existence of specialised institutions concentrated on specific competences, and that this characteristic helps explaining their teaching, research and knowledge transfer performance. Thus, the observed differences in the paths followed by universities to address their objective function suggest that universities use various strategies to engage regional needs.

Although we believe this work to provide useful insights to the analysis of universities, there are some limitations that open up new research lines. First, the empirical application considers a specific country (Spain). Future studies might consider expanding the geographical scope. Second, due to data availability, only public universities are examined. In this sense, comparison of public and private universities might undoubtedly bring new perspectives and determine whether the presence of shareholder-driven objectives and a different financial structure condition universities' performance. Third, although it was possible to create reliable variables to assess universities' performance, further studies might consider the inclusion of other variables.

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