Articulating the 'three- missions' in Spanish universities

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Abstract: The present paper elaborates a critical reflection on the 'one-size-fits-all' model which conceptualises universities as centres of excellence in education, research and third mission. It is argued that the shortcomings of this perspective are twofold: first, HEIs are treated as homogeneous institutions with equal capacity to perform and contribute to social engagement; and second, missions are undistinguishable from each other. Both features lead to mischaracterizations concerning the role of universities and their contribution to society. In the view proposed here missions are university strategies linked by complex relationship of compatibility, and the paper puts in perspective the persisting gap concerning the nature of and the relations across them.

1 Introduction

Over recent decades, Higher Education Institutions (HEIs) have undergone remarkable structural and functional changes (Wittrock, 1993; Youtie and Shapira, 2008) spurred by the ethos of broadening their remit. By and large this process has been based largely on the addition of a range of (non strictly) market-oriented and knowledge transfer activities, known as the university 'third mission', to the traditional areas of teaching and research. The addition of social and business engagement is seen as reflecting the changing nature of scientific knowledge and the natural tendency for academia to adapt in response to societal changes. In the context of a knowledge-based society, universities are expected to drive the development of regional innovation systems (OECD, 2007) and contribute to society by generating research and consultancy income, embedding knowledge in students and employees, upgrading regional business environments, and potentially improving the process of regional value capture (Benneworth and Hospers, 2007). Almost automatically, and perhaps uncritically, the scholarly discourse has focused on the establishment of efficiency criteria to meet these challenges while policy debates has centred on the "modernization" of HEIs (EC, 2006, 2011).

The present paper calls for a careful reflection on conceptual issues before embarking on modernization. A central issue is the persistence of the vision of universities as being, simultaneously, centres of excellence in education, research and third mission activities. In other words, the contribution of HEIs is conceptualized as flowing through three main channels coinciding with the missions of teaching and training, scientific research, and the promotion of university-society synergies. Building on this from a policy and managerial perspective, the theoretical concept of a 'one-size-fits-all' university model has emerged through which HEIs are seen as organizations with homogeneous and uniform capacities to perform and contribute to social engagement (Clark, 2001) through their three missions. Moreover, this model assumes that missions are carried out in an interconnected way and combine them to fulfil expectations, without taking into account the differences between higher education systems across different countries and even between institutions within the same educational system (Philpott et al.,

2011). In the view proposed here missions are university strategies that are linked by complex relationships of compatibility, and the paper puts in perspective the persisting gap concerning the nature of and the relations across them. We provide an initial critical reflection on whether the expectation that universities can engage in all three missions simultaneously is realistic (David and Metcalfe, 2007; Flanagan *et al.*, 2011).

To accomplish this goal, we first examine the changing role of the university through history. In the archetypical view, the integration of research and third mission relies implicitly on compatibility and even complementarity among missions (Geuna, 1999; Etzkowitz, 2004) and assumes implicitly that both drive the behaviour of universities in the same direction. Arguments in favour of the 're-missioning' are grounded in the belief that HEIs provide significant push to modern knowledge-based economies (Ormerod, 1996). However rather than testing this relation empirically, most studies focus on the relationship among specific activities (used as proxies) as part of an overarching university mission (Landry *et al.*, 2010; Palomares-Montero *et al.*, 2012; Bonaccorsi *et al*, 2014). The main limitation of this view is the lack of connection between the rationale of university strategies, and the materialization of practical activities (Molas-Gallart *et al.*, 2002). HEIs are complex organizations and performance indicators measure the multitude of different activities in which they engage. The problem is that the core of a university strategy may be reflected by one or more activities and these activities often contribute to an incoherent picture and add to the lack of consensus on the development and use of indicators (Bonaccorsi and Daraio, 2007).

The paper focuses on the connections across university missions through an empirical study of Spanish HEIs. The one-size-fits-all university model in this context goes beyond a theoretical landscape, being explicitly incorporated into the legislative framework that regulates Spanish public universities. This framework, which defines uniform policies and roles characterising the process of engagement, understands HEIs as isomorphic organizations without drawing attention to the individual capacities and unique operating context of particular universities. We

present then an empirical approach to the concept of mission by addressing the following questions:

- How do activities carried out by universities group together to represent a materialization of the university's strategies?
- Are university missions related? If so, what is their type of relationship?

The paper makes two contributions to the extant literature. First, it highlights the limitations of the one-size-fits-all model based on three channels of universities' contribution to society, and the contradictions between the theoretical arguments and the empirical evidence (Section 2). This gap is the starting point for our empirical analysis of the connection between the rationale of missions as university strategies, and the practical implementation of activities as the materialization of these strategies. In so doing we check the validity and importance of performance indicators as proxies for the Spanish context. The second contribution is the study of relations in order to assess whether university missions go hand in hand as part of the HEI's strategy to contribute to society. Section 3 presents the data and methodology used for the analysis in Section 4. Section 5 concludes and summarizes.

2   Universities and their missions: an overview

We define the 'one-size-fits-all' university model as the conceptual framework which captures uniform policies and management practice under which universities are conceived as homogeneous and isomorphic institutions (Philpott *et al.*, 2011) that combine teaching, research and third mission activities at once. On the basis of the implicit limitations of this university model and the assumption that missions can be considered HEI strategies, this section provides a review of the literature to highlight the controversy between this theoretical approach and empirical evidence of the history of the university re-missioning. The second part of the section discusses activities as materializations of these strategies and emphasizes the ever-growing spectrum of activities being developed by universities and lack of their systematic exploitation to measure performance.

2.1   Paradigm shift: The controversial re-missioning of universities

To draw on a biological concept, the modern university can be considered the result of a 'Red Queen Effect': they have constantly adapted, evolved and proliferated not merely to achieve competitive advantage, but also to survive. That is, their role of a social institution has evolved over time as a result of structural and functional transformations and changes in the environment (Youtie and Shapira, 2008; Wittrock, 1993).

Universities are purposeful actors that drive growth, produce valuable knowledge inputs to innovation and transfer this knowledge to society (Goddard *et al.*, 2012). They accomplish these expectations through carrying out the three missions of teaching -first mission-, research - second mission- and interaction with the socioeconomic environment (ISEE) –third mission-. Although these three university missions are a major issue in the higher education debate, the notion remains ambiguous and differs across universities, depending on the configuration of their activities, their territorial embedding, and the national institutional framework. Larédo (2007, p.13) argues that "universities do not structure themselves along the three missions, but articulate them differently depending on the functions they fulfil: 'mass tertiary education' (focus on the bachelor degree); 'professional specialized higher education and research' (focus on the professional master's and problem-solving research); and 'academic training and research' (focus on the PhD and the research articles)". This alternative mode of understanding university functions would structure their activities in a different way: missions do not exist in isolation, but rather universities' activities are constructed and adapted to respond to changes in the environment (Wittrock, 1993). Accordingly their positioning is the result of contingent historical factors[1].

Following the concept of 'three-university-missions', traditional teaching and research are part of a more complex nexus of (non-strictly-) market-oriented and knowledge transfer activities designed to increase the contribution to local socioeconomic development (Gunasekara, 2006;

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[1] This view emphasizes the changing nature of the mission. Scott (2006, p.3) says that "university missions are dynamic and fluid; they reflect the ever-changing philosophical ideals, educational policies, and cultures of particular societies or learned institutions".

OECD, 2007; Uyarra, 2010). That is, the current university model includes a simultaneous focus on HEIs as centres of excellence in education, research and ISEE. However, we argue that this theoretical approach has shortcomings. First, it assumes compatibility and even a complementarity between the tripartite university missions. Second it dilutes the variety of university capabilities to respond to societal needs. In other words, it assumes that the three missions go hand in hand, as part of a university strategy to contribute to a social knowledge economy. At the same time, it underplays changes to missions as part of the process of adapting to the environment because it takes no account of the trajectories and historical context of the university, which affects their performance. Recent work has criticized the homogeneous institutional model, by arguing that strategies that work for a particular institution in a particular region may not necessarily work for another institution and/or another region (Rodríguez-Pose, 2013), emphasising that there is no unique and best way for academic research to contribute to regional economic development (Hussler et al., 2010). These limitations of the policy framework of HEIs in Spain provide the base motivation for the present paper. The literature review goes on to identify contradictions between the theoretical arguments and the empirical evidence.

Although we do not provide an exhaustive review of changing university roles,[2] two main events (two academic revolutions)[3] mark in relation to the re-missioning of universities: the introduction of research as a core university mission (Geuna, 1999) and further changes towards renewed social commitment (Martin and Etzkowitz, 2000) through commercialization of research results (the 'entrepreneurial university') (Clark, 1998). In the context of the knowledge society, these changes in the scope and the style of universities' operations have been intimately connected with the evolution of knowledge. The latter should not be thought of as a set of codified notions, but rather as a kernel of tacit criteria underpinning the organization of activities for its replenishment and transmission. In search of a coherent framework for these

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[2] A detailed revision can be found, for example, in Geuna (1999).
[3] It is considered the 'first academic revolution' when primarily-teaching institutions took up research (Jencks and Riesman, 1968); according to Etzkowitz (2000) adoption of the third mission is the 'second academic revolution'.

changes, scholars put forth the notion of a shift from Mode 1 to Mode 2 of research (Gibbons *et al.*, 1994): in the former science spoke to society and influenced it through the effects of the knowledge and products that it generated; in Mode 2 science has instead been harnessed to the needs of society and is geared towards solving problems in a trans-disciplinary fashion to consolidate advantaged societies and social wellbeing (Power and Malmberg, 2008). The addition of scientific research and social engagement to the original mission of teaching is a tangible sign of the extent to which the interaction with society has shifted from being uni- (i.e. the university giving its intellectual products) to mainly bi-directional (Roper and Hirth, 2005).

Teaching and Research as core University Missions

While the medieval university focused on teaching and the transmission of knowledge to educate the elite, at the beginning of the nineteenth century the formation of Berlin's Humboldt University assigned importance to specialization, scientific research and the production of knowledge. The addition of academic research as a core university mission entailed acceptance of compatibility and even complementarity with traditional teaching (Geuna, 1999), implicitly assuming that they went hand in hand. However, several scholars argue that this relationship was not always clear-cut: some propose a positive relation between teaching and research (Colbeck, 1998; Walckiers, 2004; Bianchini *et al.*, 2013), others show a negative relationship (Barnett, 1992); some suggest a nonlinear relationship with the effect of research positive for teaching quality until a certain threshold after which higher levels of research can hinder the quality of teaching (García-Gallego *et al.*, 2012), and some deny the existence of any relation (Ramsden and Moses, 1992; Hattie and Marsh, 1996; Marsh and Hattie, 2002). Theoretical arguments reinforce the negative relation: according to Sample (1972) research is highly specialized whereas teaching has to be broad, and time spent on teaching is negatively correlated with time spent on research (Marsh, 1984). Thus, although the integration of teaching and research has been an essential feature of the university, there is surprisingly little rigorous evidence to support this view (Martin and Etzkowitz, 2000). The weak arguments in favour of a

positive relationship between teaching and research tend to signal that universities' have limited capacity to row in the same direction to fulfil both expectations.

Tripartite university missions

A set of exogenous events, including the emergence of new areas of knowledge such as biotechnology (Zucker *et al.*, 1998), and reductions in public funding (Rosenberg and Nelson, 1994), pushed universities to take on a new mission in order to increase their contribution to local socioeconomic development (Gunasekara, 2006; OECD, 2007; Uyarra, 2010) and find alternative sources of finance. This is known variously as third mission, third stream or social engagement, and emphasizes the social function of universities and their relationship with non-academic agents. The new third mission has been defined as 'the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments', i.e., the interactions between universities and their socioeconomic environment (Molas-Gallart *et al*. 2002, p.2). Without questioning the effect of this new role of HEIs on their traditional missions, just as teaching and research have become integrated, it seemed logical that the third mission should be similarly incorporated (Etzkowitz, 2004).

The adoption of a third mission inspired a literature on its relations with research activities. The complex relations between HEIs and external agents are especially relevant and some of the literature on university-firm relationships focuses on the tensions between the academic and business worlds. While universities conduct research as an end in itself and are characterized by open dissemination of knowledge and autonomy (Nelson, 2004), firms search for market application for their knowledge, and ultimately seek to protect their financial interests (Noble, 1977). Commercialization and exploitation of knowledge are far removed from the traditional university objectives and are believed to diminish the contribution to socioeconomic development (Florida and Cohen, 1999; Hughes and Kitson, 2012). The debate on the effect of ISEE in scientific production remains open. Some authors argue that engagement in university-industry relations produces high quality research output because these activities have positive

effects (Etzkowitz and Leydesdorff, 2000; Van Looy *et al.*, 2004; Thursby and Thursby, 2011). Others show that interactions with business can be detrimental to academic research (e.g. Slaughter and Rhoades, 1996; Nelson, 2001; Geuna and Nesta, 2006). These concerns revolve mainly around the problems of secrecy and skewing (Florida and Cohen, 1999). The secrecy problem refers to the extent to which an increasing degree of collaboration with industry is associated with restrictions on the disclosure of research findings and, more generally, on the dissemination of research results, which constitute a threat to the norms of open science. The skewing problem refers to the threat that a greater emphasis on collaboration with industry could be disruptive to a curiosity driven research agenda. For example, it might lead to a shift in the university's research agenda towards a profile characterized by short-term and target-driven research at the expense of curiosity driven, basic and long-term research. In addition, the existing literature shows that the effects of university-firm relationships and research change across the type of interaction mechanism. On the one hand, there is a positive relationship between industry funding and patents, and research performance, but a weak or (practically) no relationship with research quality (Gulbrandsen and Smeby, 2005; Azoulay *et al.*, 2009). On the other hand, Toole and Czarnitzki (2010) suggest that promoting spin-offs does not balance research with the more recent push to foster commercialization. Similarly, engaging in consulting activity has an overall negative impact on the average number of ISI-publications, although it depends on the scientific field and the intensity of this engagement (Rentocchini *et al.*, 2014). Perkmann *et al.* (2013) summarize that the impact of external collaborations on research and teaching is scarce so it cannot be assumed that engagement activities are always beneficial and should therefore be promoted. Complexity between academia and industry reflects the diversity of these micro-level studies where scientists are the unit of analysis. We introduce a novelty in the measure of the third mission because of our study is carried out at institutional level and different activities of university-industry relationship are simultaneously used to define the mission.

Finally, we need to reconsider the relationship between teaching and ISEE on which evidence is scarce. Some research includes all three missions, which provides a more complete picture. Ormerod (1996) argues, from a theoretical view point, that there is a strong complementarity among research, teaching and consultancy and the performance of all three activities can create a virtuous circle of social engagement, new research ideas and opportunities for developing new teaching programmes. However, Landry *et al.* (2010) finds a substitution effect between teaching and publication, complementarity between publication and ISEE, and absence of a relation between teaching and third mission activities.

Some work on the history of universities evidences that finding a balance between university missions is not done in a tension-free and synergetic manner by HEIs, and innovation policy studies tend to treat the key actors (universities) as relatively homogeneous (Flanagan *et al.,* 2011). At the same time, some studies point to the limitations in the institutional isomorphic perspective which understands universities as actors with equal capacities to perform and contribute to social engagement (Philpott *et al.*, 2011), and considers that missions are inseparable and carried out in an interconnected way. The remainder of the paper gauges whether the expectation that universities can fulfil all three missions simultaneously is realistic. That is, the value added of the work is the empirical validation of the three-university-missions model for Spanish universities by analysing whether these mission 'ride together' within the university strategy of being a social institution.

2.2   From theoretical strategies to practical activities

The previous section analysed the emergence of university missions and their adoption by universities as a strategy to contribute to social and economic development. That is to say, universities develop their strategic priorities of and seek the balance among teaching, research and ISEE to fulfil national, regional and local goals to create skilled human capital, produce knowledge and transfer know-how (Drucker and Goldstein, 2007). HEIs are key actors in economic development because "the aspects of the academic enterprise are perceived as being significant to the regeneration and transformation of the regions" (Arbo and Benneworth, 2007

p.18). University strategies and measurement of institutional objectives are achieved through specific practical activities (Godin, 2005). To meet the ever-growing expectations placed upon them, universities undertake several activities (that is, they are multi-activity organizations), which, in turn, have increased their complexity and required a redefinition of their role. There is an inherent difficulty in trying to achieve a consensus about the adequacy of these activities (Bonaccorsi and Daraio, 2007); some projects and 'grey literature' propose a set of indicators informed by theory to measure activities to proxy for university missions (Molas-Gallart *et al.*, 2002; E3m, 2011; Bonaccorsi, 2014). However, empirical studies do not treat university missions as a whole, but only test the relationship between some specific activities. This paper contributes to this literature by proposing the notion of missions as a construct. Using a philosophy of science approach, constructs are theoretical concepts that are not directly observable and require additional variables for their construction. In this perspective, missions are theoretical arguments that explain university goals and require indicators based on university performance.[4] Summing up, university missions are defined in HEIs as strategies that take place through the development of specific activities, and are evaluated using performance indicators. Connecting a theoretical university mission to the practical implementation of indicators to measure university performance is one of the objectives of the present work, which seeks to systematize them as empirical validation for the measurement of missions. This section provides a brief review of the performance indicators used in the literature to proxy for university missions and how they can be measured. We focus on activities and indicators rather than missions, because empirical studies that focus on missions are scarce.

One of the most important by-products of universities is human capital (Duch and García-Estévez, 2011) and graduates are one of the main mechanisms of knowledge spillovers from universities (Audretsch *et al.*, 2005). For this reason, numbers of enrolled students and graduates (in undergraduate courses) are often used as indicators of education production (Daraio *et al.*, 2011). At the same time, financial resources affect the activities of universities

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[4] This paper does not distinguish between input and output indicators. We consider all HEI activities as of the university performance.

(Landry *et al.*, 2010). According to Landry *et al.* (2010) funding comes from three sources: teaching revenue (part of internal university resources), university research, and industry. Time spent on teaching is a common measure of the first mission, but may not be the best one; the critical variables are the actual activities academics undertake to provide teaching outcomes (Marsh and Hattie, 2002). Intellectual capital (IC) is an important outcome of teaching activities and is the intellectual material that is formalized, captured and leveraged to produce a higher valued asset (Klein and Prusak, 1994). IC can be seen as a combination of intangible resources and activities (Secundo *et al.*, 2010). However, although IC is an important contribution of universities to society, its measurement through intangibles is not the focus of the present paper. We are interested in the activities of universities measured by tangible performance indicators.

Student education does not always end with an undergraduate degree. Some authors include both undergraduate and postgraduate students in estimates of teaching activities (Beasley, 1995). However, in the Spanish context, the postgraduate phase, which is characterized by masters and doctoral students and the production of theses, is related mainly to the second mission (Palomares-Montero *et al.*, 2012). This means that postgraduates can be used to measure teaching or research activities. The most widely used indicator of research performance is number of publications (Giese, 1990). Although publications in journals included in the ISI Web of Knowledge are a frequently used measure (Van Looy *et al.*, 2004; Lee and Bozeman, 2005; Breschi *et al.*, 2007), some consider that a broader range of publications and indicators is needed for the social science and humanities (Nederhof, 2006), for example, non-ISI publications.[5] As suggested above, research funding is important in second mission activities. Financial resources may be public and competitive and generally are measured in terms of number of research projects financed by competitive public grants or the income derived from them (Avital and Collopy, 2001; Bozeman and Gaughan, 2007).

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[5] The author also includes monographs as other type of necessary publications in social science and humanities (Nederhof, 2006).

Research projects in which non-academic agents, specifically firms, collaborate are a special case. Although they are publicly funded, conflicts of interest mark the university-enterprise relationship, as explained above. Molas-Gallart *et al.* (2002) consider non-academic research collaborations (such as those that include firms) as activities related to both the second and third missions. The situation is similar for university patents, which are studied extensively in the literature on patent applications (Meyer-Krahmer and Schmoch, 1998) and patents granted (Cesaroni and Piccaluga, 2005). Their dual nature is due to the fact that they are often treated as a natural research output (Etzkowitz, 1998), related to the university's second mission, but sometimes are considered a scientific finding to be commercially exploited (Meyer-Krahmer and Schmoch, 1998), related to the third mission. This phenomenon can be explained through the concept of 'dual knowledge', in which a single discovery can contribute to both scientific research and useful commercial applications (Murray and Stern, 2007). This is the view adopted in studies that use royalties to measure university-industry interaction (Thursby and Thursby, 2002; Azagra-Caro *et al.*, 2003). Although these measures to evaluate the impact of aspects of the technology transfer process are well-established in the literature, they are an incomplete representation of the wider process of knowledge exchange, which encompasses multiple mechanisms (D'Este and Patel, 2007; Aschhoff and Grimpe, 2014). Among these mechanisms include: consultancy activities (Link *et al.*, 2007); contracts and research and development (R&D) projects (Lee, 2000; Bozeman and Gaughan, 2007) and spin-offs according to the entrepreneurial university model (Link and Scott, 2005; Landry *et al.*, 2007). Income from these activities reverts to the universities as contract research revenue and is used to measure third mission (Molas-Gallart and Castro-Martínez, 2007). Certain activities related to teaching are also linked to the third mission if non-academic agents participate. This applies to training activities where under-graduate students work in companies (Molas-Gallart, 2002), which tend to be overlooked in analyses of third mission activity.

We are interested in the limitations of the one-size-fits-all model and its effect on university missions. A critical reading of the literature reviewed in this section highlights tensions in HEIs'

efforts to respond to all their missions simultaneously. Specifically this work investigates the following gaps: 1. How do activities carried out by universities group together to represent a materialization of the university's strategies? 2. Whether university missions are related to each other, and if so, what is the nature of this relationship? The next section provides an empirical analysis of these issues in the context of the Spanish university system.

3   Empirical analysis

3.1   *Spanish context*

According to Larédo (2007) the national institutional framework is particularly important for the evolution of the university. The present paper focuses on the Spanish context, which is a particular case of incorporation of missions into universities. Lack of recognition of the political and economic relevance of science and technology, and the absence of efficient patterns of action for the management of a science and innovation system, have for long characterized the Spanish Research System (Muñoz, 1998).

In countries such as Germany, France and the United States, research and ISEE became university missions at different moments in time. Scientific research and the production of knowledge were introduced at the beginning of the 19th century in Germany with the model proposed by Berlin's Humboldt University (Geuna, 1999). The Land-Grant University emerged in the US in the 1860s to provide low-cost higher education and to meet local technical needs, especially those relating to agriculture and the 'mechanical arts'. They had a specific orientation towards commercial application (Noble, 1977; Rosenberg and Nelson, 1994), ergo, these universities were created with a very explicit third mission (Martin, 2012). After that, the Grandes Écoles in France and the Fachhochschulen in Germany appeared, although they were less practically oriented than the US equivalent.

The introduction of the second and third missions in Spain was not gradual. The 1983 Reform of Higher Education promoted research in universities that rarely engaged in this activity, and provided incentives for conducting contract R&D with socioeconomic agents (Bricall, 2000). In

1986, the Science Law became the first science and technology policy implemented in Spain. It was intended to strengthen the national innovation system, stimulate research and, at the same time, promote the transfer of results to the productive sector (Castro-Martínez and Fernández de Lucio, 1991). Thus, Spain's science and technology policy was based on the injection of funds which had a significant impact on university outputs.[6] The abrupt appearance of research and ISEE as university missions implicitly assumed a positive relation between research and ISEE, and did not consider the effect of these new roles on traditional teaching activities.

Under this legislative landscape, Spain is a country with a unitary university structure (Schubert *et al.,* 2014), in which the one-size-fits-all model goes beyond a theoretical approach to framing the contribution of universities through three distinct channels. Rather, a homogeneous conception of HEIs is defined in the legal structure that regulates the functions, objectives and contributions of Spanish HEIs to society. Higher education laws describe the isomorphic skeleton of HEIs and have moved from emphasizing general roles of universities such as "scientific development, teaching and training and extension of culture" (BOE, 1983) to specify the functions that all Spanish public universities should fulfil: "*[to] enhance teaching and research excellence to promote cultural, economic and social development [...] and to disseminate, valorize and transfer knowledge to society ... [through] collaborations between society and universities in order to guide their activities to societal needs*" (BOE, 2001). In consequence, although universities depend on regional government, a model of homogeneity prevails within the Spanish Higher Education system at the national level; the three missions "live together" and form the backbone of universities' strategic plans.

3.2   Universities as the unit of analysis

This paper adopts a holistic approach and an institutional-level perspective to the analysis of universities. The contribution of universities to society is complex and not easily traceable because universities engage in a set of activities that cannot be studied in isolation. We

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[6] In three years (1986-1989) R&D expenditure in Spanish universities doubled (INE, 1986, 1989) (the majority of this increment came from funding derived from collaboration with firms) and output increased from over 4,000 publications and 44 granted patents to over 8,000 publications (ISI Web of Knowledge, 1986; 1989) and 282 patents (Azagra-Caro, 2004, p.154).

understand missions as strategies, embracing the different activities undertaken by universities. Some indicators (students and income) are readily available and published at the institutional level. A lower level of aggregation (e.g. departments) is useful to evaluate research (Larédo and Mustar, 2001), but is problematic if information on teaching is included (Daraio *et al.*, 2011) due to the difficulty of attributing indicators (e.g. students or funding). The value added of the present work is a focus on universities at the institutional level that allows us the analysis of the concept of mission as the university's strategy. This differs from previous studies of the factors affecting university performance that centre on factors other than the relationship between missions.

The Spanish higher education sector includes 73 universities (INE, 2008a) distributed across the Spanish territory - 48 public institutions and 25 private. Universities are some of the most important agents in the Spanish R&D system with 26.8% of total R&D expenditure, accounting for 47.1% of employment of full time researchers in 2008. However, most of this goes to public universities, which represent a quarter of total R&D expenditure and almost half of all researchers in Spain (Table 1).

[Insert Table 1 about here]

The importance of these public institutions in the Spanish research system puts them at the core of this analysis. Excluding the National Distance Education University,[7] our study population is composed of 47 Spanish public HEIs (4 polytechnics and 39 traditional universities).[8] The old Spanish universities emerged in the Middle Ages, specifically 1215 (University of Salamanca), although the growth of the Spanish Higher Education Sector accelerated in the last quarter of the 20th century coinciding with decentralization and acquisition of greater autonomy. The majority of the universities in the dataset (62%) were established before the 1983 Spanish Reform of the Higher Education Sector, and are spread throughout the territory. Since 1983, Spanish universities have been autonomous with administrative and financial management

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[7] The National Distance Education University is excluded because it is the only Spanish distance university and is the only university that continues to be administered by national government.
[8] Annex I provide a list of the Spanish public universities included in our dataset.

depending on regional government. Previously, HEIs were traditional and conservative, and focused on teaching activities.

3.3 Sources and variables

The main data sources for this study are: Ministry of Education (ME) data on students and researchers; National Statistics Institute (INE) statistics on higher education; Conference of Spanish Rectors (CRUE) biannual report *La Universidad Española en cifras* (Spanish universities in figures) for academic, productive and financial information; Spanish Patent and Trademark (OEPM) information on patents; and RedOTRI, the Spanish Network of University Knowledge Transfer Offices, for third mission indicators.[9]

Table 2 presents the indicators and their definitions. They are aimed at collecting a large part of the activities that universities develop to fulfil their missions; they are the embodiment of the strategies followed by HEIs as social institutions. Table 2 column 3 includes the sources of information. The data used are the cumulative values of the indicator measures for each university for 2007 and 2008. The construction of the theoretical model reflects differences in the performance indicators used to measure missions in the previous literature. We use three indicators for the first mission: enrolled students, number of graduates, and teaching revenues; five indicators for research activities: research projects (number and income) and papers published in scientific journals (Spanish, foreign and ISI journals); and seven indicators for the third mission: contract research income, R&D contracts and consultancies (number and revenues), royalties and spin-offs. In line with the literature, we include indicators for two missions combined. Postgraduate students (masters and PhDs) and numbers of theses - related to the first and the second missions, patents and projects in collaboration with firms - linked to the second and the third missions, and training of students – linked to the first and third missions.

[Insert Table 2 about here]

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[9] The survey produced by RedOTRI is linked to the Proton-Europe survey.

The typology of the region in which the university is located is expected to influence positively size and the indicators related to students (e.g., a university in a region with a higher population density will have more students). To avoid biased results and to control for university size, the indicators for students (enrolled and graduates) and teaching revenues are also divided by the number of researchers.[10]

3.4   *Analysis*

The analysis is in two steps. First, we run an Exploratory Factor Analysis (EFA) to cluster activities and test whether the treatment of missions as factors/constructs that distinguish among university missions is appropriate. While empirical studies of university missions use different proxies, we propose to systematize the measurement of missions using a set of indicators to define university performance that group them together. Second, we conduct a Confirmatory Factor Analysis (CFA) based on Structural Equation Modelling (SEM), to analyse the relationship among missions and the validity of the indicators proposed to measure them.

EFA identifies the minimum number of dimensions used to explain the maximum amount of information. EFA involves principal components analysis (Varimax rotation; Kaiser normalization). We chose two criteria to select the number of factors to extract: percentage of variance and the scree test. For the first, in social sciences it is not uncommon to consider a solution with 60% of the total variance as satisfactory (Hair *et al.*, 1998). The scree test criterion is used to identify the optimum number of factors that can be extracted before the amount of unique variance begins to dominate the common variance structure (Cattell, 1966).

CFA evaluates the measurement model in SEM. This analysis involves three steps: model specification, model estimation and model evaluation (Batista-Foguet and Coenders-Gallart, 2000). The path diagram (Wright, 1934) of the theoretical model for the CFA is depicted in Figure 2. The first step is model specification in line with the literature and takes account of the Bentler–Weeks method (Bentler and Weeks, 1980), where the parameters to be estimated are the (a) regression coefficients, and (b) the variances and the covariances of the independent

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[10] Researchers are individuals with a doctoral degree who work at a university.

variables in the model (Bentler, 2004). SEM differs from a traditional ordinary regression

because it allows for latent variables (missions in our case). The advantage of this methodology

is the possibility to measure abstract concepts (constructs or latent variables) and find relations.

The second step, model estimation, is based on the covariance matrix and an iterative procedure

that finds the values of the equation that minimize discrepancies between the data and the

theoretical model proposed in the first step (Lee, 2007). Following Olsson *et al.* (2000), we use

Generalized Least Squares (GLS) to solve the iterative procedure because the model has few

observations.[11] In addition, for the model estimation we use the marker variable method of

scaling, that means, fix to 1 the variances of the latent variables and give free the parameters to

be estimated (Little, 2013). This allows covariances between the latent variables to be

interpreted as correlations (Bentler, 2004) –allowing us to analyse the relationship between

university missions. The next step is model evaluation. The model test statistic has a chi-square

distribution if it is correctly specified, and can be used to test the null hypothesis that the

theoretical model fits the data. Since the chi-square coefficient has been found to be extremely

sensitive to sample size, a set of complementary indices is created (Batista-Foguet and

Coenders-Gallart, 2000). We use three incremental fit indices - NNFI, CFI and RMSEA[12]- to

evaluate the model because they are likely to reject correct models if the number of observations

is small (Hu and Bentler, 1999) as in our case. Finally, we check the reliability of the CFA

model by means of three coefficients to describe the overall consistency of the proposed

activities to explain the three university missions. Reliability traditionally is evaluated using

Cronbach's alpha coefficient. However this coefficient is a direct function of the number of

items explaining the construct. We therefore calculate two additional indices to check

reliability: composite reliability and average variance extracted (Hair *et al.*, 1998).

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[11] Olsson et al. (2000) argues that although maximum likelihood (ML) is a more robust iterative
procedure, in the case of similar results for ML and GLS, more precision in the estimation of parameters
can be achieved by using GLS if the number of observation analysed is small (Olsson *et al.*, 2000).
[12] Non-Normed Fit Index (NNFI), Comparative Fit Index (CFI), and Root Mean Square Error of
Approximation (RMSEA). For more information see Batista-Foguet and Coenders-Gallart (2000).

Both methodologies carry the advantage of not needing *ex ante* assumptions. We need only to be careful about the scale of measurement of the variables. EFA is not too restrictive with respect to variable assumptions (Hair *et al.*, 1998), but the results can be affected by different units of measurement (Salvador-Figueras and Gargallo-Valero, 2006). On the other hand, CFA requires normal and independent variables (Ullman, 2000). Due to differences in the nature of our variables (Table 2) and to avoid problems in our results we used normalized variables.[13]

4   Results and Discussion

Table 2 presents descriptive statistics for the measurements in the two-years 2007 and 2008 and reflects the Spanish public Higher Education Sector as a whole. Spanish public universities, on average, have 38 enrolled students and 5.3 graduates per researcher. The revenue from teaching activities is €17,400. Postgraduate students number 4,000 on average - 60% doctoral students and 40% masters. The average number of theses in Spanish universities is 146. Research funding comes from the National Plan and universities account for 69 research projects and €20 million on average. If firms participate in the research, university research income reduces to a quarter of that amount. In terms of publications, over half of them are published in foreign and ISI journals and the remainder in Spanish journals. Spanish universities have less than 20 patent applications and less than 10 patents granted per year. Revenue from commercialization activities (royalties) is just over €85,000 per university. Contract research income is €11 million and R&D contracts €18 million on average (total contracts). In 2007 and 2008 Spanish universities created 220 new spin-offs.

In addition to the family portrait, the figures show the heterogeneity among Spanish public universities based on their performance. For undergraduates, the differences among universities are smaller, with Castile-La-Mancha, Carlos III, Balearic Islands and Vigo presenting higher values for teaching indicators. Traditional universities such us Granada and Barcelona record intensive knowledge production (publications), while polytechnic universities are more likely to

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[13] We also applied data imputation techniques to replace missing values (Expectation Maximization algorithm –EM-) in order to take account of the information from all universities.

develop Intellectual Property Rights (IPR). Polytechnic universities belong to the group of new, modern universities that contribute to economic development and are better suited to engagement in the region than traditional universities (OECD, 2007). The universities in Madrid (Technical University of Madrid, Complutense of Madrid and Autonomous of Madrid) show important performance for knowledge transfer via contracts. Although from a policy point of view the homogeneous vision dominates the Higher Education System, and universities should be active actors in teaching, research and third mission, the results presented here indicate differences in the scope of universities' capabilities to contribute to society: while some universities present high levels of knowledge production and transfer, others are more effective at developing human capital through teaching activities. Future studies should incorporate a regional as well as a disciplinary component to understand differences in terms of university performance and social contribution according to geographic location and internal composition.

As already indicated, we ran an EFA to analyse the grouping of performance indicators. Data reduction using factor analysis identifies three groups covering the 22 indicators. Since we know that the activities of universities are partly represented, the EFA explains 63.7% of total variability. The three components identified correspond to the university missions of teaching (third component), research (second component) and third mission (first component). Figure 1 shows the factor loadings in the rotated matrix according to the positioning of the indicators for each of the three factors. This result helps to answer the first research question and supports the idea that missions can be understood as constructs and that tangible university activities measured by performance indicators are an adequate materialization to systematize their strategies.

[Insert Figure 1 about here]

We next perform a CFA to analyse the relationship among missions. This information will be an indication of the university's capacity to carry out all three missions within a HEI strategy. On the one hand, due to the advantage of this methodology of including no-well-positioned

indicators as part of two missions, we can see to what extent the university activities are aimed at the main objectives in their strategies (e.g. in relation to the knowledge content of these activities); as well as how to interpret performance indicators according to their positioning. On the other hand, results indicate what activities are better at capturing the strategy of the university in relation to a specific mission; that is what indicators better explain their variability. This result will be useful for future analysis when researchers need to choose indicators as proxy for missions.

The model and the parameter estimates are depicted in Figure 2. We focus first on evaluating the model. Goodness of fit is determined mainly by the chi-square statistic, and a non-significant result implies adequacy of the final model[14] (Batista-Foguet and Coenders-Gallart, 2000). The three incremental fit indices - NNFI, CFI and RMSEA- confirm the model's goodness of fit: the values of the first two indices are above 0.95, and the last is below 0.05. These results confirm the importance of the performance indicators for measuring university strategies. Figure 2 also shows the factor loadings (standardized solution) from the CFA. Their significance indicates the validity of the performance indicators for explaining each construct/mission (Hair *et al.*, 1998). In addition, all standardized parameters are above the threshold, 0.4 (Ford *et al.*, 1986), except for patent applications in the second mission.

Understanding universities' missions as their main contributions to society, three main objectives are derived. Teaching is aimed at the creation of human capital in the form of higher skilled labour (OECD, 2008). The second and the third missions include a specific knowledge component. The purpose of research is the production of knowledge and, because a huge part of this knowledge is tacit, embodied in individuals, rather than being easily codified and transferred (Arbo and Benneworth, 2007), third mission goal is mainly knowledge transfer. These strategies are in accordance with the view, by local and regional authorities, of universities as providers of knowledge and skills (Goddard and Chatterton, 1999) to stimulate

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[14] The results of the maximum likelihood model are similar to the estimated parameters. However, p-value for goodness of fit is significant ($\chi^2=505.95$; *d.f.=200; p=0.00. NNFI=0.996; CFI=0.997; RMSEA=0.182*). The similarity among these results confirms the suitability of the method used here (Olsson *et al.*, 2000).

technical innovation and promote higher productivity and positive externalities in the form of knowledge spillovers to the private sector (Anselin *et al.*, 1997).

Human capital produced by HEIs is well-captured by the numbers of under-graduates, which together with teaching revenues represent the teaching construct. In this case, the number of enrolled students per researcher explains the highest percentage (99.7%) of variability in the first mission (graduates and teaching revenues explain 92% and 40% respectively). However, the case of postgraduate students (masters and PhD) and numbers of theses is different. Although apparently it is a stage in student education, these indicators are related more to the second mission in the case of the Spanish public universities (they are only significant as a measure of research). The explanation for this is that, in Spain before 2007, post-graduate programmes were considered part of the learning process required to acquire the skills necessary to become researcher (BOE, 2001), and did not have a professional component. Although 2007 is included in our analysis, HEIs required time to adapt their plans and programmes to the new European requirements related to the Bologna process. Future analyses can include more detailed information related to attempts to tailor the Spanish Higher Education Sector to the European Space for Higher Education (BOE, 2007) because master degree is now considered a final education stage (rather than a step in the PhD process) and there is a distinction between professional and scientific programmes. A scientific master equips the student with skills to train future researchers; a professional master provides the student with specialist skills that respond to non-academic demand. These policy changes are an attempt to improve the relationship between universities and firms, by complementing taught generic skills with industry experience (Salter and Martin, 2001). As students are the principal mechanisms facilitating knowledge spillovers and the principal connection between firms and universities, we test training of students as a measure of both the first and third missions. Students who work in firms during their study period will contribute to improving their training (Molas-Gallart, 2002) while also providing benefits for the company by embodying the skills suitable for a particular activity. This means that, depending on the objectives of the university missions,

training students should be a performance indicator to measure both teaching and the relations between universities and external actors as part of the third mission. However, in the Spanish context, this indicator is not significant for either mission.

The results above are the symptom of a trade-off between autonomy to choose a strategy which becomes the focus of HEIs' activities, and acting as suppliers of specialized services (Geuna, 1999). The difficulties to bring near the scientific and business worlds have been increasing with the ever-growing activities that HEIs are expected to play. On the one hand, the promotion of researchers within the scientific community depends on their ability to carry out fundamental research (Nedeva and Boden, 2006); on the other hand, the proliferation of activities related to knowledge exchange, consumption and exploitation require financial engagement in third mission activities. Some authors tighten these differences by means of the 'dual knowledge' that is endogenous to some activities developed by HEIs (Murray and Stern, 2007). For example patent applications that, according to our results, refer to both the second and third missions (although the scores lie more on the side of the latter since, in the second mission, the parameter value is lower than the recommended minimum). The knowledge behind the invention incorporates a part to be published in the scientific literature and other part to obtain IPR. However, granted patents are only significantly related to the third mission, which categorizes them as a scientific finding to be commercially exploited in line with Meyer-Krahmer and Schmoch (1998), but in contrast to Etzkowitz (1998). Patents granted also show a negative sign, but not significant, in relation to the second mission, meaning that they are not related to the indicators measuring research. Again, this process jeopardizes the science base, the dissemination of knowledge and the autonomy of these institutions (Nelson, 2004) and their ability to contribute to socioeconomic development (Florida and Cohen, 1999). The negative relationship between patents granted and the other indicators of research is a symptom of the 'secrecy problem' proposed by these authors, which refers to restrictions on the publication of research findings. Publications allow researchers to demonstrate the results of their research, and secrecy contradicts the norms of open science and dissemination of scientific knowledge by

universities and threatens the advancement of science (Tartari *et al*., 2012). However, patents constitute an IPR that reduces scientific openness and limits the diversity of experimentation in basic research (Murray *et al.,* 2009). The secrecy problem is accompanied by a skewing problem, which refers to the alleged shift in research efforts from basic to applied research. Our results also reflect this problem in the case of competitive projects. While research project income may explain the second mission, collaborative projects with firms show a negative and significant relationship with research and a positive and significant relationship with ISEE. This can be interpreted as while the strategy hidden in research activities developed by universities is an end in itself leading to create more basic projects, firms are more worried about its application and their financial rewards developing a more applied research (Noble, 1977). For an entrepreneurial university (Etzkowitz, 2000) technology transfer activities are core, but tend to tilt researchers' incentives towards the demands of the private sector such that firms influence the pursuit of science to suit their own ends. If the strategies of HEIs at the institutional level are more focused on applied than basic research, then researchers lose the autonomy to establish their own research agendas to meet universities expectations (Tartari *et al.*, 2012) and may put at risk the contribution to the socioeconomic development of society.

[Insert Figure 2 about here]

Publications and IPR are part of the codified knowledge created at universities that is formalized and easily exchanged and communicated. In fact, publications in foreign and ISI journals have the highest explanatory power for research (89.7% and 87.1% respectively) since open channels are the most important mechanisms of knowledge transmission (Cohen *et al.*, 2002). However, some knowledge is tacit and embedded in individuals' know-how and practice. In other words there is a huge part of knowledge that is not formalised and is accumulated through personal experience, learning-by-doing, social relations and so on. For the transfer of tacit knowledge, face-to-face relationships and communities of practice based on trust matter (Arbo and Benneworth, 2007). It has been reported that contract research and consultancy are the most frequent interactions between universities and firms (D'Este and Patel, 2007) with patenting and

licensing of relatively lower importance (Cohen *et al.*, 2002). This argument is in line with our results showing that contract research income is more important than patents in Spanish HEIs' to explain the third mission. In this case, the variability explained by the former is 99.1%, while patents granted is 92%. In addition, in total contract research income, R&D contracts are more important (87.4% of variability) than consultancy activities (64.4%). This is a somewhat surprising result for the Spanish case that can be interpreted as a direct consequence of modernization of the Science and Technology Law in the 1980s. One of the policy objectives of this process was generation of mechanisms to increase the links between public research and industry. These mechanisms include financial incentives for university staff via research contracts with firms and the University Reform Law allowed the use of contract income to a total maximum of double the cost of employees (Muñoz, 1998).

The last result provided by CFA is the relationship between university missions which entail the most striking finding of the study. The correlation among the latent variables highlights the relations among the various missions. All the coefficients are significant. There is a positive correlation between the second and third missions, but a negative one between these two missions and the first mission. That is, research and ISEE ride together and both missions go in the same direction as university strategies guaranteeing the contribution of HEIs in terms of knowledge production and transfer. However, simultaneously, both present a negative relationship with teaching.

Finally, we check the reliability of the CFA model. As mentioned previously, Cronbach's alpha is the coefficient traditionally used to check reliability, but it is a direct function of the number of items explaining the construct. This means that the first mission may have a low value because it includes only three items compared to the eight and nine for the other missions.[15] We therefore calculated two additional indices to check reliability: composite reliability and average variance extracted (Hair *et al*., 1998). The results are presented in Table 3. The composite

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[15] We included only the indicators with significant results. The second mission includes neither applied patents nor collaborative projects in the calculation of reliability indices, because both are more suited to measuring the third mission.

reliability values and Cronbach's alpha coefficients are mostly highly satisfactory, above 0.7 except for the first mission reliability values; average variance extracted index also exceeds the minimum standard of 0.5 (Hair *et al.*, 1998). These results confirm the reliability of the model.

[Insert Table 3 about here]

5   Concluding remarks

The evolution of universities reflects long-term economic and cultural developments as well as the transformation of their attendant society. Modern universities contribute by generating research and consultancy income, embedding knowledge in students and employees, upgrading regional business environments, and potentially improving the process of regional value capture (Benneworth and Hospers, 2007) as the result of carrying out their three missions. The traditional missions of teaching and research are now seen as part of a broader and more complex nexus of (non strictly) market-oriented and knowledge transfer activities. Against the backdrop of mounting social and economic challenges due to globalization, the foretold changes have fuelled, perhaps uncritically, the expectations that universities can become hubs of strategic knowledge for the development of regional innovation systems.

However, the one-size-fits-all model of universities as centres of excellence in education, research and third mission (that is, interaction with local socioeconomic actors) raises concerns over potentially unrealistic expectations related to the capacity of universities to fulfil all these roles simultaneously and is perceived to be out of sync with current societal needs and therefore in urgent need of reform (EC, 2006; Philpott *et al.*, 2011). The present study of Spanish public universities highlights two main shortcomings of this model: first, that it assumes homogeneity among institutions, that is, equal capacity to perform and contribute to social engagement; and second, that it considers that the strategies of universities (their missions) ride together in a tension-free and in a synergetic manner. The unitary structure of the Spanish higher education policy system (Schubert *et al.*, 2014) is described by a national regulation framework which

articulates the contribution of HEIs through their three-university-missions of teaching, research and ISEE.

In contrast to the isomorphic landscape, our results suggest that the Spanish Higher Education System is composed of a set of heterogeneous universities. Their performance shows differences in the scope of their capabilities and how they seek to contribute to society. While some universities present high levels of knowledge production and knowledge transfer, others are more effective at producing qualified human capital through teaching activities. While universities develop their strategies according to policy pressures, in reality they face several difficulties to find the balance among their missions. Preliminary evidence shows that while research and the third mission ride together, teaching is negative related to both of them. The recent addition of a third mission led to a reorganization of university portfolios and this study offers evidence that the universities' missions are still negotiating their position within universities' strategies. This means that policy should take account diversity of universities and reinforce their specific capacities to contribute to the social knowledge economy. On their part, universities should make greater efforts to improve and achieve their social contribution and decrease the tensions with external actors. These results suggest the need to focus on individual missions to achieve quality and excellence, which is the model proposed by both academics and policy makers who believe that universities should develop a specialist focus on one university mission (Geuna, 1999; EC, 2005). Rethinking whether all HEIs should develop simultaneously all three missions may be vital to ensure their contribution to the socio-economic development of regions.

Empirical studies require proxies to measure university missions based on the different activities in which universities engage. This diversity means lack of homogeneity in their use. Although more than one indicator can be used to explain the same concept, its contribution to the variability of the mission is not always the same. Thus, number of enrolled students per researcher and international (ISI and non-ISI) publications are the best indicators to measure the first and second missions respectively. In the case of the third mission, in contrast to our

expectations, contract research income is the most important indicator explaining its variability. This means that the Spanish model of the university-ISEE relationship rests on contracts (mostly R&D contracts), which contrasts with the American model which is based on patents (AUTM, 2010). Contracts were initially introduced as a policy of rapprochement between academia and the private sector; however, the reform did not take account of the absorptive capacity of Spanish firms to guarantee successful links. Contracts have become a trade-off between the researchers' contribution to society and their self-interest and personal enrichment. Although US experience shows that too much emphasis from HEIs on acquiring and exploiting IPR can hamper knowledge-sharing and collaborative research with the business sector (David and Metcalfe, 2007), the Spanish evaluation system continues to attach great importance to these activities. Evaluation processes mainly focused in these mechanisms may obscure not only the presence of other types of university-industry interactions that are less visible, but are equally or even more important (D'Este and Patel, 2007) but also neglect interconnections and complementarities that may exist between different types of relations (Uyarra, 2010). While it is true that finding a balance between the objectives of the academic and business worlds is not easy, it is necessary. In fact, collaboration between firms and universities benefits both: the probability of innovative outcomes for firms is improved, and HEIs seem to have a more significant impact than any other type of collaborative partner (Howells *et al.*, 2012). The equilibrium should involve developing an understanding of industry practice and providing an education that equips students with more generic and long-lasting skills (Salter and Martin, 2001); open dissemination of scientific knowledge for the advancement of science and tighter restrictions on the publication (Tartari *et al.*, 2012); and autonomy to establish researchers agendas and application and firms' financial rewards (Noble, 1977).

This study has some limitations. Although the indicators are built on data from secondary sources, their origin is universities. This is a limitation because the data provided by HEIs might be skewed to reflect their interests and demonstrate achievement of their objectives. There are also some limitations related to the methodology. First, a larger number of cases enable a better

structural equation modelling (Williams *et al.*, 2004) and due to the reduced number of observations available, the interpretation of results should be cautious. The present study does not use a sample, but rather the whole population of Spanish public universities, which avoids biased results. This study treats universities equally, regardless of the weight of scientific fields within their structure and organization. Future research could take account of these aspects in order to understand whether discipline differences affect the relationships among university missions. In addition, the integration of a functional and temporal dimension would enable a test on the complementarity among missions and their effect on the externalities produced in the region and the consolidation of the results presented here.

In conclusion, although there is a tendency in innovation policy studies to treat key actors (such us universities) as relatively homogeneous, our results suggest lack of compatibility between university missions, and that HEIs are not able to fulfil all society's expectations simultaneously. At the core of this wave of revisionism is the recognition of the shortcomings of the one-size-fits-all model and a call for a better understanding of how different modes of funding and alternative governance models can meet strategic priorities. These different models of a modern university, based on strategic choices regarding which forms of linkages to emphasize, are possible to achieve their modernization if they want to play their part in Europe's drive for more growth. Differentiation strategies will require a focus on individual strengths to adapt to change and recognition of local/regional environmental needs.

Acknowledgements

References

Anselin, L.; Varga, A. and Acs, Z. (1997). "Local Geographic Spillovers between University Research and High Technology Innovations" Journal of Urban Economics, 42(3), pp. 422-448.

Arbo, P. and P. Benneworth (2007). "Understanding the regional contribution of higher education institutions: A literature review." OECD Education Working Paper, No. 9.

Aschhoff, B. and Grimpe, C. (2014). "Contemporaneous peer effects, career age and the industry involvement of academics in biotechnology." *Research Policy*, 43, 367-381.

Audretsch, D.; Lehmann, E. and Warning, S. (2005). "University spillovers and new firm location ". *Research Policy*, 34, 1113-1122.

AUTM (2010). *AUTM Licensing Activity Survey: FY2010*. In: http://www.autm.net/AM/Template.cfm?Section=FY_2010_Licensing_Survey&Template=/CM/ContentDisplay.cfm&ContentID=6874

Avital, M. and Collopy, F. (2001). "Assessing research performance: implications for selection and motivation". *Sprouts: Working Papers on Information Systems,* 1(14). In: http://sprouts.aisnet.org/1-14

Azagra-Caro, J. M. (2004). *La contribución de las universidades a la innovación: efectos del fomento de la interacción universidad-empresa y las patentes universitarias*. Universitat de Valencia.

Azagra-Caro, J. M.; Fernández de Lucio, I. and Gutiérrez-Gracia, A. (2003). "University patents: output and input indicators...of what?". *Research Evaluation*, 12(1), 5-16.

Azoulay, P.; Ding, W. and Stuart, T. (2009). "The Impact Of Academic Patenting On The Rate, Quality And Direction Of (public) Research Output". *Journal of Industrial Economics* 57(4), 637-676.

Barnett, B. (1992). "Teaching and research are inescapably incompatible". *Chronicle of Higher Education*, 38, A40.

Batista-Foguet, J. M. and Coenders-Gallart, G. (2000). *Modelos de Ecuaciones Estructurales*. La Muralla S.A. Madrid.

Beasley, J. E. (1995). "Determining teaching and research efficiencies". *Journal of the Operational Research Society*, 46, 441-452.

Benneworth, P. & Hospers, G. (2007). "The new economic geography of old industrial regions: universities as global- local pipelines" Environment and Planning C: Government & Policy, 25(5), pp. 779-802.

Bentler, P. M. (2004). *EQS 6 Structural Equations Program Manual*. Encino, CA: Multivariate Software, Inc.

Bentler, P. M. and Weeks, D. G. (1980). "Linear Structural Equations with latent variables" Psychometrica, 45, pp. 289-308.

Bianchini, S.; Lissoni, F. and Pezzoni, M. (2013). "Instructor characteristics and students' evaluation of teaching effectiveness: evidence from an Italian engineering school." *European Journal of Engineering Education*, 38 (1), 38-57.

BOE (1983). Ley Orgánica 11/1983, de 25 de Agosto, de Reforma Universitaria. Jefatura del Estado. Boletín Oficial del Estado, núm. 209, de 1 de Septiembre de 1983, pág. 24034-24042

BOE (2001). Ley Orgánica 6/2001, de 21 de diciembre, de Universidades. Jefatura del Estado español. Boletín Oficial del Estado, número 307, de 24 de diciembre de 2001, páginas 49400-49425.

BOE (2007). Real Decreto 1393/2007, de 29 de octubre, por el que se establece la ordenación de las enseñanzas universitarias oficiales. Jefatura del Estado español. Boletín Oficial del Estado, número 260, de 30 de octubre de 2007, páginas 44037-44048.

Bonaccorsi, A. and Daraio, C. (2007). *Universities as strategic knowledge creators: some preliminary evidence*. In: Bonaccorsi, A. and Daraio, C. (Eds). Universities and Strategic Knowledge Creation. Edward Elgar.

Bonaccorsi, A. (2014). *Knowledge, Diversity And Performance In European Higher Education. A Changing Landscape*. Edward Elgar Publishing.

Bozeman, B. and Gaughan, M. (2007). "Impacts of grants and contracts on academic researchers' interactions with industry". *Research Policy* 36, 694–707.

Breschi, S.;F. Lissoni and Montobbio, F. (2007). "The scientific productivity of academic inventors: New evidence from Italian data". *Economics of Innovation and new Technology*, 16(2), 101–118.

Bricall, J. M. (2000). *Universidad 2 Mil*. CRUE: Conferencia de Rectores de las Universidades Españolas.Madrid.

Castro-Martínez, E. and Fernández de Lucio, I. (1991). *Innovación productiva y diferentes modelos de transferencia tecnológica*. In: Nuevas tecnologías y desafío socioeconómico. Estudis i simposis. Institut Català d'Estudis Mediterranis.

Cattell, R. B. (1966). "The scree test for the number of factors". *Multivariate behavioral research*, 1, 245-276.

Cesaroni, F. and Piccaluga, A. (2005). "Universities and Intellectual Property Rights in Southern European Countries". *Technology Analysis & Strategic Management*, 17(4), 497-518.

Clark, B. (1998). *Creating Entrepreneurial Universities: Organizational Paths of Transformation*. Pergamon.Guildford, UK.

Clark, B. (2001). "The entrepreneurial university: new foundations for collegiality, autonomy, and achievement." *Journal of the programme on institutional management in higher education*, 13 (2), 17-23.

Cohen, W. M.; Nelson, R. R. and Walsh, J.P. (2002). "Link and impacts: the influence of public research on industrial R&D". *Management Science,* 48(1), 1-23.

Colbeck, C. L. (1998). "Merging in a Seamless blend: how faculty integrate teaching and research?". *The Journal of Higher education*, 69(6), 647-671.

CRUE (2008). *La Universidad Española en cifras*. Madrid. CRUE.

D'Este, P. and Patel, P. (2007). "University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?". *Research Policy*, 36, 1295-1313.

Daraio, C.; Bonaccorsi, A.; Geuna, A.; Lepori, B.; Bach, L.; Bogetoft, P.; Cardoso, M.; Castro-Martinez, E.; Crespi, G.; Fernández de Lucio, I.; Fried, H.; Garcia-Aracil, A.; Inzelt, A.; Jongbloed, B.; Kempkes, G.; Llerena, P.; Matt, M.; Olivares, M.; Pohl, C.; Raty, T.; Rosa, M. J.; Sarrico, C. S.; Simar, L.; Slipersaeter, S. Teixeira, P. N. and Eeckaut, P. V. (2011). "The European university landscape: A micro characterization based on evidence from the Aquameth project". *Research Policy*, 40(1), 148-164.

David, P. A. and Metcalfe, S. (2007). *Universities and Public Research Organisations in the ERA. Fulfilling universities' critical societal roles in the advancement of knowledge and the support of sustained innovation-driven economic growth in Europe*. (Third draft of the report). "Knowledge for Growth" Expert Group. European Comission.

Drucker, J. and H. Goldstein (2007). "Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches." International Regional Science Review 30(1): 20-46.

Duch, N. and García-Estévez, J. (2011). "Do universities affect firms' location decisions? Evidence from Spain". *Instituto de Economía de Barcelona Working Paper*. In: http://www.ieb.ub.edu/aplicacio/fitxers/2011/4/Doc2011-7.pdf

E3m (2011). *Green Paper. Fostering and Measuring ´Third Mission´ in Higher Education Institutions*. Final Report of the project "European indicators and ranking methodology for university third mission". In: http://www.e3mproject.eu/docs/Green%20paper-p.pdf

Etzkowitz, H. (1998). *Making of an Entrepreneurial University: The Traffic among MIT, Industry and the Military, 1860-1960*. In: Science, Technology and the Military 12. Mendelsohn, E.; Smith, M. R. and Weingart, S. P. (eds). Kluwer Academic Publishers.

Etzkowitz, H. (2000). "The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm". *Research Policy*, 29(2), 313–330.

Etzkowitz, H. (2004). "The evolution of the entrepreneurial university". *International Journal of Technology and Globalisation*, 1(1), 64-77.

Etzkowitz, H. and Leydesdorff, L. (2000). "The dynamics of innovation: from National Systems and ''Mode 2'' to a Triple Helix of university–industry–government relations". *Research Policy*, 29, 109-123.

European Commission (2005). *European universities: enhancing Europe's research base.* Final report by the forum on University-based research. Luxembourg.

European Commission (2006). *Delivering on the modernisation agenda for universities: Education, Research and Innovation.* Brussels.

European Commission (2011). *Supporting growth and jobs – an agenda for the modernisation of Europe's higher education systems*. Brussels.

Flanagan, K.; Uyarra, E. and Laranja, M. (2011). "Reconceptualising the 'policy mix' for innovation". *Research Policy,* 40, 702-713.

Florida, R. L. and Cohen, W. M. (1999). *Engine or Infraestructure? The University Role in Economic Development*. In: Branscomb, L. M.; Kodama, F. and Florida, R. L. (Eds). Industrializing knowledge.. MIT Press.

Ford, J. C.; McCallum, R. C. and Tait, M. (1986). "The application of exploratory factor analysis in applyied psychology: a critical review and analysis.". *Personnel Psychology*, 39, 291-314.

García-Gallego, A.; Georgantzís, N., Martín-Montaner, J. and Pérez-Amaral, T. (2012). "(How) Do research and administrative duties affect university professors' teaching?". *Documentos de Trabajo del Instituto Complutense de Análisis Económico*. Universidad Complutense de Madrid. In: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2133898

Geuna, A. (1999). *The Economics of Knowledge Production. Funding and the structure of university research*. Edward Elgar.Cheltenham (UK).

Geuna, A. and Nesta, L. (2006). "University patenting and its effects on academic research: the emerging European evidence". *Research Policy*, 35, 843-863.

Gibbons, M.; Limoges, C.; Nowotny, H.; Schwartzman, S.; Scott, P. and Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Scienceand Research in Contemporary Societies*. London: Sage.

Giese, E. (1990). "Ranking of universities in the FRG". *Scientometrics*, 19(5-6), 363-375.

Goddard, J.B. and Chatterton, P. (1999) "Regional Development Agencies and the knowledge economy: harnessing the potential of universities". *Environment and Planning C : Government and Policy*. 17(6), pp. 685-699.

Goddard, J.; Robertson, D., and Vallance, D. (2012). "Universities, Technology and Innovation Centres and regional development: the case of the North-East of England". Cambridge Journal of Economics.

Godin, B. (2005). *Measurement and statistics on science and technology*. Routledge.Abingdon (UK).

Gulbrandsen, M. and Smeby, J. C. (2005), "Industry Funding and University Professors' Research Performance". *Research Policy* 34(6), 932-950.

Gunasekara, C. (2006). "The generative and developmental roles of universities in regional innovation systems", *Science and Public Policy*, 33(2), 137-150.

Hair, J.; Anderson, R.; Tatham, R. and Black, W. (1998). *Multivariate data analysis (5ª Edition)*. Prentice Hall.New Jersey.

Hattie, J. and Marsh, H. W. (1996). "The relationship between research and teaching: a meta-analysis". *Review of Educational Research,* 66(4), 507-542.

Howells, J.; Ramlogan, R. and Cheng, S.L. (2012). "Innovation aand university collaboration: paradox and complexity within the knowledge economy". *Cambridge Journal of Economics*, 36, 703-721.

Hu, L. and Bentler, P. M. (1999). "Cutoff criteria for fit indices in covariance structure analysis. Conventional criteria versus new alternatives". *Structural equation modeling*, 6, 1-55.

Hughes, A. and Kitson, M. (2012). "Pathways to impact and the strategic role of universities: new evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development". *Cambridge Journal of Economics*, 36, 723-750.

Hussler, C.; Piccard, F. and Tang, M.F. (2010). "Taking the ivory from the tower to coat the economic world: regional strategies to make science useful." *Technovation*, 30, 508-518.

INE (1986). Estadística sobre actividades de I+D.

INE (1989). Estadística sobre indicadores de I+D.

INE (2007). Estadística de la enseñanza universitaria en España. INE. In: www.ine.es

INE (2008a). Estadística de la enseñanza universitaria en España. INE. In: www.ine.es

INE (2008b). Estadística sobre actividades de I+D. INE. In: www.ine.es

ISI Web of Knowledge (1986). Web of Science. December 2011,available at: http://www.accesowok.fecyt.es/

ISI Web of Knowledge (1989). Web of Science. December 2011, available at: http://www.accesowok.fecyt.es/

Jencks, C. and Riesman, D. (1968). *The Academic Revolution*. Doubleday, New York.

Klein, D.A. and Prusak, L. (1994) "Characterising Intellectual Capital". LLP working paper, Ernst & Young, Center for Business Innovation, New York, NY.

Landry, R.; Amara, N. and Ouimet, M. (2007). "Patenting and spin-off creation by Canadian researchers in engineering and life sciences". *Journal of Technology Transfer*, 32, 217-249.

Landry, R.; Saïhi, M.; Amara, N. and Ouimet, M. (2010). "Evidence on how academics manage their portafolio of knowledge transfer activities". *Research Policy*, 39(10), 1387-1403.

Larédo, P. (2007). "Revisting the Third Mission of Universities: Toward a renewed Categorization of University Activities?". *Higher Education Policy*, 20(4), 441-456.

Larédo, P. and Mustar, P. (2001). *Research and innovation Policies in the New Global Economy: An International Comparative Analysis*. Edwar Elgar.Cheltenham.

Lee, S. and Bozeman, B. (2005). "The Impact of Research Collaboration on Scientific Productivity". *Social Studies of Science*, 35, 673-702.

Lee, Y. S. (2000). "The Sustainability of University-Industry Research Collaboration: An Empirical Assessment". *The Journal of Technology Transfer*, 25, 111-133.

Lee, S. (2007). Structural Equation Modeling. A bayesian approach. John Wiley & Sons, Ltd

Little, T. (2013). Longitudinal Equation Modelling. Guilford Press.

Link, A. N. and Scott, J. T. (2005). "Opening the ivory tower's door: An analysis of the determinants of the formation of U.S. university spin-off companies". *Research Policy*, 34, 1106–1112.

Link, A. N.; Siegel, D. S. and Bozeman, B. (2007). "An empirical analysis of the propensity of academics to engage in informal university technology transfer". *Industrial and Corporate Change*, 16(4), 641-655.

Marsh, H. W. (1984). "Students' evaluations of university teaching: Dimensionality, reliability, validity, potential baises, and utility". *Journal of Educational Psychology*, 6(5), 707-754.

Marsh, H. W. and Hattie, J. (2002). "The relation between Research Productivity and Teaching Effectiveness: Complementary, Antagonistic or Independent Constructs?". *The Journal of Higher education*, 73(5), 603-641.

Martin, B. R. (2012). "Are universities and university research under threat? Towards an evolutionary model of university speciation". *Cambridge Journal of Economics*, 36, 1-23.

Martin, B. & Etzkowitz, H. (2000). "The origin and evolution of the university species", *VEST*, 13(3-4), 7-32.

MEC (2008) Estadística de la Educación. Enseñanzas Universitarias. Curso 2007-08. MEC. Mayo 2011. In: http://www.educacion.gob.es/educacion/universidades/estadisticas-informes/estadisticas/alumnado/2007-2008.html

Meyer-Krahmer, F. and Schmoch, U. (1998). "Science-based technologies: university-industry interactions in four fields". *Research Policy*, 27, 835-851.

Molas-Gallart, J. and Castro-Martínez, E. (2007). "Ambiguity and conflict in the development of "Third Mission" indicators". *Research Evaluation*, 16(4), 321-330.

Molas-Gallart, J., Salter, A., Pastel, P., Scott, A. and Duran, X. (2002). *Measuring Third Stream Activities. Final Report to the Russell Group of Universities*. Science and Technology Policy Research (SPRU), University of Sussex. Brighton (UK).

Murray, F. and Stern, S. (2007). "Do formal intellectual property rights hinder the free flow of scientific knowledge? An empirical test of the anti-commons hypothesis". *Journal of Economic Behavior & Organization*, 63, 648-687.

Murray, F.; Aghion, P., Dewatripont, M.; Kolev, J. and Stern, S. (2009). "Of mice and academics: examining the effect of openness on innovation". *NBER Working Paper No. 14819*. In: http://www.nber.org/papers/w14819

Muñoz, E. (1998). "The Spanish system of research. Research and innovation in Spain". *Instituto de Estudios Sociales Avanzados (CSIC). Working Paper 15*. In: http://digital.csic.es/bitstream/10261/2027/1/dt-9815.pdf

Nederhof, A. J. (2006). "Bibliometric monitoring of research performance in the Social Sciences and the Humanities: A review". *Scientometrics*, 66(1), 81-100.

Nedeva, M. and Boden, R. (2006). "Changing Science: The Advent of Neo-liberalism". Prometheus 24(3), 269-281.

Nelson, R.R., (2001). "Observations on the post Bayh-Dole rise of patenting universities". *Journal of Technology Transfer,* 26, 13-19.

Nelson, R.R. (2004). "The market economy, and the scientific commons". *Research Policy*, 33, 455-471.

Noble, D. (1977). *America by Design: Science, Technology and the Rise of Corporate Capitalism*. Oxford University Press.New York.

OECD (2007). *Higher Education and Regions. Globally Competitive, Locally Engaged*. OECD.Paris.

OECD (2008). *Tertiary Education for the Knowledge Society. Vol 1*. Special features: Governance, Funding, Quality. OECD.

OEPM (2011). Solicitudes de Patentes nacionales presentadas o participadas por Universidades. OEPM. Mayo 2011.

Olsson, U. H.; Foss, T.; Troye, S.V.; Howell, R.D. (2000). "The Performance of ML, GLS, and WLS Estimation in Structural Equation Modeling Under Conditions of Misspecification and Nonnormality". *Structural equation modeling*, 7(4), 557-595.

Ormerod, R. J. (1996). "Combining management, consultancy and research". *Omega: International Journal of Management Scie*, 24(1), 1-12.

Palomares-Montero, D.; García-Aracil, A. and Castro-Martínez. E. (2012). "Misiones actuales de las universidades públicas: una perspectiva sociológica". *ARBOR Ciencia, Pensamiento y Cultura*, 188(753), 171-192.

Perkmann, M.; Tartari, V.; McKelvey, M.; Autio, E.; Broström, A.; D'Este, P.; Fini, R.; Geuna, A.; Grimaldi, R.; Hughes, A.; Krabel, S.; Kitson, M.; Llerena, P.; Lissoni, F.; Salter, A. and Sobrero, M. (2013). "Academic engagement and commercialisation: A review of the literature on university–industry relations." *Research Policy*, 42, 423-442.

Philpott, K.; Dooley, L.; O'Reilly, C. and Lupton, G. (2011). "The entrepreneurial university: Examining the underlying academic tensions." *Technovation*, 31 161-170.

Power, D. and Malmberg, A. (2008). "The contribution of universities to innovation and economic development: in what sense a regional problem?". *Cambridge Journal of Regions, Economy and Society*, 1, 233-245.

Ramsden, P. and Moses, I. (1992). "Association between research and teaching in Australian higher education". *Higher Education* 23, 273-295.

RedOTRI (2007). Informe Encuesta RedOtri.

RedOTRI (2008). Informe Encuesta RedOtri.

Rentocchini, F.; D'Este, P.; Manjarrés-Henriquez, L. and Grimaldi, R. (2014). "The relationship between academic consulting and research performance: evidence from five Spanish universities". *International Journal of Industrial Organization.*

Rodríguez-Pose, A. (2013). "Do Institutions Matter for Regional Development?". *Regional Studies* 47(7), 1034-1047.

Roper, C. and Hirth, M.A. (2005). "A history of change in the third mission of higher education: The evolution of one-way service to interactive engagement". *Journal of Higher Education Outreach and Engagement*, 10(3), 3-21.

Rosenberg, N. and Nelson, R. (1994). "American universities and technical advance in industry". *Research Policy*, 23, 323-348.

Salter, A. J. and Martin, B. R. (2001). "The economic benefits of publicly funded basic research: a critical review". *Research Policy* 30, 509-532.

Salvador-Figueras, M. and Gargallo-Valero, P. (2006) Análisis Factorial [online]. In: http://ciberconta.unizar.es/LECCION/factorial/FACTORIALEC.pdf

Sample, S. B. (1972). "Inherent conflict between research and education". *Educational record*, 53, 17-22.

Scott, J. C. (2006). "The Mission of the University: Medieval to Postmodern Transformations". *The Journal of Higher Education*, 77(1), 1-39.

Secundo, G.; Margherita, A.; Elia, G. and Passiante, G. (2010) "Intangible assets in higher education and research: mission, performance or both?". *Journal of Intellectual Capital* 11 (2), pp. 140-157

Schubert, T.; Bonaccorsi, A.; Brandt, T.; De Filippo, D.;Lepori, B.; Niederl, A.; Schmoch, U. and Slipersæter, S. (2014). "Is there a European university model? New evidence on national path dependence and structural convergence". In: Bonaccorsi, A. (Ed.)

Knowledge, Diversity and Performance in European Higher Education. A changing landscape. Edward Elgar Publishing.

Slaughter, S. and Rhoades, G., (1996). "The emergence of a competitiveness research and development policy coalition and the commercialization of academic science and technology". *Science Technology & Human Values*, 21, 303-339.

Tartari, V.; Salter, A. J. and D'Este, P. (2012). "Crossing the Rubicon: exploring the factors that shape academics' perceptions of the barriers to working with industry". *Cambridge Journal of Economics*, 36, 655-677.

Thursby, G. and Thursby, M. (2002). "Who is selling the ivory tower? Sources of growth in university licensing". *Management Science* 48, 90-104.

Thursby, J. G. and Thursby, M. C. (2011). "Faculty participation in licensing: Implications for research". *Research Policy* 40, 20-29.

Toole, A. A. and Czarnitzki, D. (2010). "Commercializing Science: Is There a University "Brain Drain" from Academic Entrepreneurship?". *Management Science,* 56(9), 1599-1614.

Ullman, J. D. (2000). *Structural Equation Modelling*. In: Fidell, T. Y. (Ed). Using Multivariate Statistics (4th edition). Allyn & Bacon.

Uyarra, E. (2010). "Conceptualizing the Regional Roles of Universities, Implications and Contradictions". *European Planning Studies,* 18(8), 1227-1246.

Van Looy, B.; Ranga, M.; Callaert, J.; Debackere, K. and Zimmermann, E. (2004). "Combining entrepreneurial and scientific performance in academia: towards a compounded and reciprocal Matthew-effect?". *Research Policy*, 33(3), 425-441.

Walckiers, A. (2004). Multi-dimensional screening and University output, part 2: Should Universities produce both research and teaching? *Mimeo.*

Williams, L. J.; Gavin, M. B. and Hartman, N.S. (2004). *Structural equations modeling methods in strategy research: applications and issues*. In: Ketchen, D. and Bergh, D. (Eds). Research Methodology in Strategy and Management. Emerald Group Publishing Limited.

Wittrock, B. (1993). *The modern university: the three transformations.*In: Wittrock, B. and Rothblatt, S. (Eds). The European and American University since 1800. Historical and sociological essays. Cambridge University Press.

Wright, S. (1934). "The method of path coefficients". *Annals of Mathematical Statistics* 5 (3): 161–215

Youtie, J. and Shapira, P. (2008). "Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development". *Research Policy*, 37(8), 1188-1204.

Zucker, L.G.; Darby, M.R. and Brewer, M.B. (1998). "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises". *The American Economic Review*, 88(1), 290-306.

ANNEX I: List of Spanish Public Universities (year of birth)

University of Salamanca (1215)
University of Valladolid (1346)
University of Barcelona (1430)
University of Zaragoza (1474)
University of Santiago de Compostela (1495)
University of Valencia –General Studies (1499)
University of Sevilla (1505)
Complutense University of Madrid (1508)
University of Granada (1531)
University of Oviedo (1604)
University of La Laguna (1701)
University of Murcia (1915)
University of the Basque Country (1968)
Autonomous University of Barcelona (1968)
Autonomous University of Madrid (1968)
Technical University of Catalonia (1971)
Technical University of Madrid (1971)
Polytechnic University of Valencia (1971)
University of Córdoba (1972)
University of Málaga (1972)
University of Cantabria (1972)
University of Extremadura (1973)
University of Alcalá (1977)
University of the Balearic Islands (1978)

Universitat d'Alacant (1979)
University de Cádiz (1979)
University of Las Palmas de Gran Canaria(1979)
University of León (1979)
University of Castile-La-Mancha (1982)
Public University of Navarra (1987)
University of A Coruña (1989)
University of Vigo (1989)
Carlos III University of Madrid (1989)
Pompeu Fabra University (1990)
University Jaume I of Castellón (1991)
University of Girona (1992)
University of Lleida (1992)
Rovira i Virgili University (1992)
University of La Rioja (1992)
University of Huelva (1993)
University of Jaén (1993)
University of Almeria (1993)
University of Burgos (1994)
Pablo de Olavide University (1997)
Miguel Hernández University of Elche (1997)
Rey Juan Carlos University (1997)
Technical University of Cartagena (1998)

Table 1.- R&D indicators in Higher Education sector in 2008

	Higher Education	
	Total Universities	**Public Universities**
R&D Expenditures	26.8%	24.7%
R&D Staff (FTE)	36.6%	33.5%
Researchers (FTE)	47.1%	43.1%

Note: FTE = Full time equivalent

Source: Survey of R&D activities (INE, 2008b)

**Table 2.- Definition of the variables and descriptive statistics**

VARIABLE	DEFINITION	Source	Mean	Deviation	Min.	Max.	N
Enrolled students	Number of enrolled students in pre-graduated courses divided by number of doctors	MEC[a]	38	10.3	21.3	92.0	47
Graduates	Number of graduated students in pre-graduated courses divided by number of doctors	INE[b]	5.3	1.0	3.5	7.1	47
Teaching revenues	Revenues (thousands of Euros) from teaching activities divided by number of doctors	CRUE[c]	17.4	3.4	11.9	28.2	47
Training students	Number of students carrying out practices at enterprises during their pre-graduated studies	CRUE	1,822	1,874	196	11,065	47
Master students	Number of master students	INE	1,472	1,293	5	6,165	47
PhD students	Number of PhD students	INE	2,540	2,821	342	17,805	47
Theses	Number of doctoral theses that was reading	INE	146.5	124.8	19	536	47
Research project income	Revenues (thousands of Euros) from research activities (projects. subventions. …) from public administrations fundamentally	CRUE	20,251	15,727	1,761	66,967	47
Research projects	Granted research projects	CRUE	69	46.3	11	227	47
Spanish publications	Number of publications in Spanish journals	CRUE	384	355.7	8	1,590	47
Foreign publications	Number of publications in foreign journals	CRUE	887.9	592.6	50	2,861	47
ISI publications	Number of publications that were published in journals included in Journal Citation Report (JCR)	CRUE	854.5	573.4	17	2,425	47
Applied patents	Number of applied patents	OEPM[d]	19.5	17.2	2	80	47
Granted patents	Number of granted patents by Spanish Patent and Trademark	RedOTRI[e]	9.4	10.3	0	44	47
Collaboration with firms	Revenues (thousands of Euros) from research projects where firms participate	RedOTRI	5,052	7,425	0	47,598	47
Contract research income	Revenues (thousands of Euros) from contracts research	CRUE	11,110	15,693	639	90,274	47
R&D contracts	Number of R&D contracts	RedOTRI	415.4	486	7	2,851	47
Revenues R&D contract	Revenues (thousands of Euros) from R&D contracts	RedOTRI	18,384	24,149	435	159,672	47
Consultancy	Number of consulting activities	RedOTRI	343.2	491.1	0	2,484	47
Revenues consultancy	Revenues (thousands of Euros) from consulting activities	RedOTRI	2,139	4,661	0	30.758	47
Royalties	Patents revenues	RedOTRI	85.2	151.5	0	871	47
Spin-off	Number of new spin-off	RedOTRI	5	6.5	0	31	47

Table 3.- Reliability coefficients

	First mission	Second mission	Third mission
Cronbach's alpha	0.595	0.899	0.924
Composite reliability	0.909	0.956	0.968
Average Variance Extracted	0.774	0.738	0.771

Figure 1.- Results of the Exploratory Factor Analysis
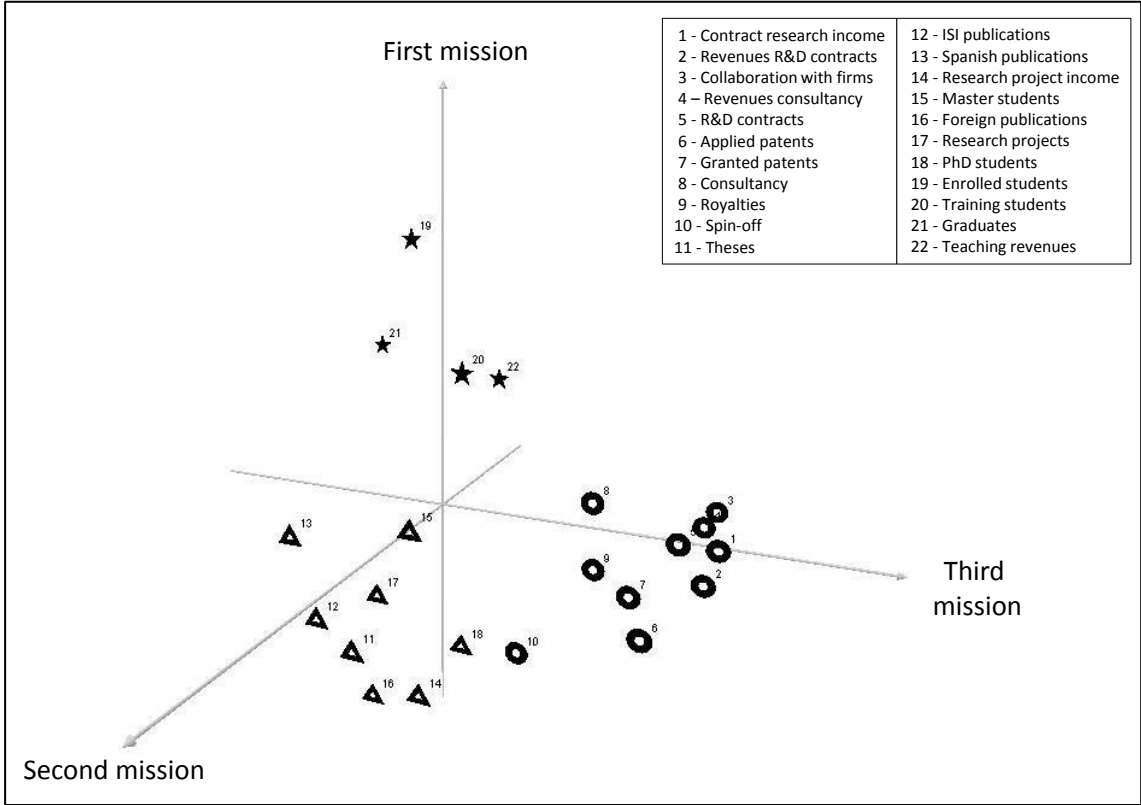
Method: Principal Components Analysis. Rotation: Varimax with Kaiser Normalization

Figure 2.- Structural Equations Modelling for the Confirmatory Factor Analysis

$\chi^2=200.76$; d.f.$=200$; p$=0.47$. NNFI$=0.962$; CFI$=0.967$; RMSEA$=0.009$
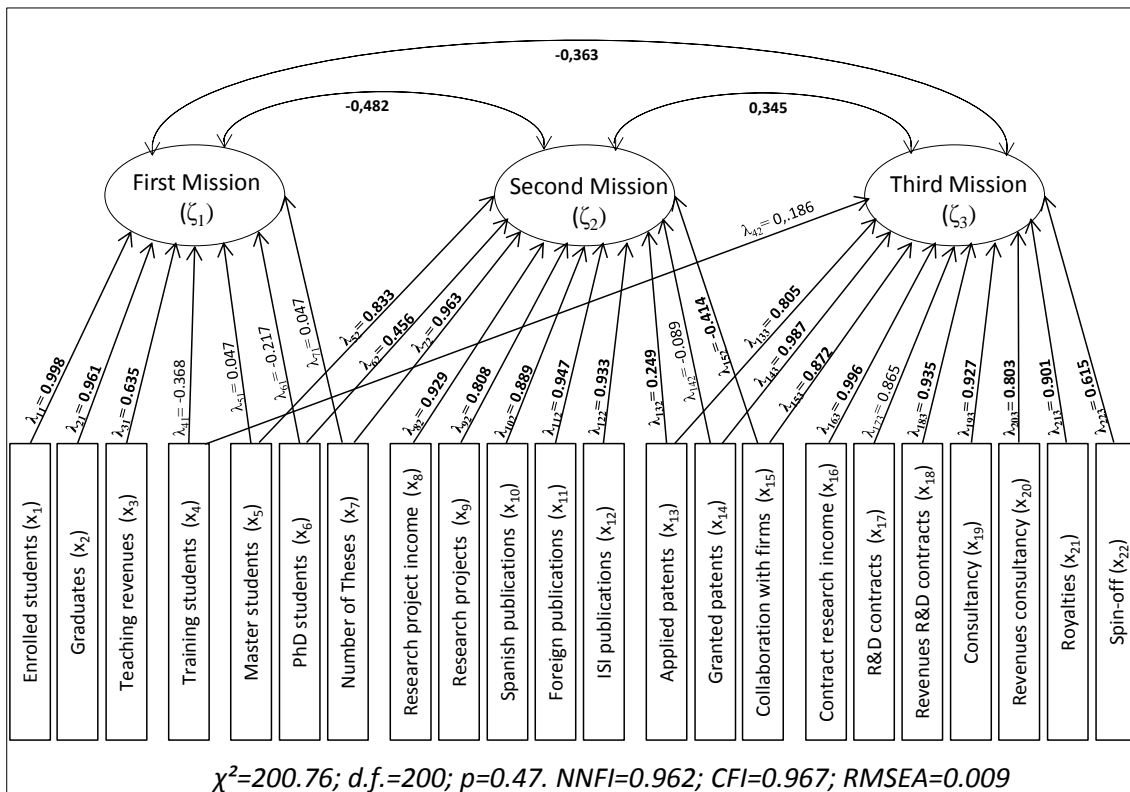
Note: Significant results in bold.