University Research Centres: Organizational Structures and Performance

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Abstract: Currently, there are different types of University Research Centres (URCs) around the world. This research is focused on organizational structure and its influence on better research performance in URCs. In this case, URCs located in Aragon, Spain have been studied. A data set was extracted from their STI (Science, technology and innovation) indicators from 2000 to 2016. Using a self-built data base, constructed from reports, web pages and the university's data set, this information was analysed using a mixed-method approach, which involves data panel analysis and case studies, as a way of determining how these institutions are organized and how these influences on their performance. As a result, those URCs which showed a complex structure emerged has the best performers. This kind of structure similar to corporate governance at URCs promote better research performance within each URC.

Keywords: University research centres; organizational structure; STI performance; Spain

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Introduction

Currently, there is a wide range of scientific institutions. The proliferation of scientific institutions based on Science, technology and innovation (STI) has been promoted by local, regional and national public policy. In this way, a wide range of new institutions and structures have emerged giving shape and background to each innovation ecosystem: research centres, laboratories, hubs, technology parks, scientific parks, business incubators, etc. (Albahari, Pérez-Canto, Berge-Gil and Modrego, 2017). All of them, according to local policies are focused on economic development (Organisation for Economic Co-operation and Development [OECD], 1999). These sets of institutions are defined according to different National Innovation Systems (Nelson, 1993). One of the key issues in these systems has been the involvement of universities through their URCs. They are located in new buildings, constructed with government funding, in order to help promote their development (Toker and Gray, 2008). How they have been able to organize and how they have developed their capabilities and organize their resources has created a set of different institutions. URCs are well established in the USA, the first being created almost one-hundred years ago (Mowery and Ziedonis, 2002), while in the rest of the world they are relatively new. URCs are very important institutions in every NIS due to their double role of promoting economic development and technology transfer (Bozeman and Boardman, 2013). URCs have been analysed in depth with respect to their relationship with industry (Santoro and Chakrabarti, 2001; Boardman and Corley, 2008; Perkman and Walsh, 2007), their researchers and their relationship with academic activities (Bozeman and Boardman, 2013), human capital (Ponomariov and Boardman, 2010) and research collaboration (Corley, Boardman and Bozeman, 2006) to mention a few. Nevertheless, how organizational structure and research characteristics are influencing their results has seen less attention (Gray, Lindblad and Rudolph, 2001). Every URC has a system of internal management, a defined structure, various resources and interacts differently with society. The sum of these elements affects their scientific performance. In consequence, this research describes a set of elements involved in structure/design and researcher characteristics in URCs belonging to the University of Zaragoza. Those URCs are located in the Aragon Autonomous Community in Spain.

This paper is organized, in the following manner describes the organizational structure and researcher characteristics in the research institutions and defines research performance in the case of URCs, as literature review. Following section there is a short description of the Aragon region's innovation system. In the last part, the current study is explained as an introduction to the research design. The following sections describe the findings in order to promote discussion and the conclusion of the implications of the empirical findings.

Organizational structures and researchers at URCs

Research institutions show a set of conditions which promote scientific excellence. Excellence is based on doing the best you can in order to achieve the best possible performance. This is possible with the best institutions having the best people, doing the best that they can. This way of doing research has been widely analysed under the concept of Research Collaboration (RC). One of the main discoveries claims that RC impacts positively on scientific productivity (Corley, et al., 2006). Boardman and Bozeman (2006) developed a Contingency Model of Research Collaboration Effectiveness (CMRCE). This model is composed of three elements: attributes of collaborating individuals, attributes of institutions and attributes of collaboration and processes. Attributes of collaborating individuals and attributes of collaboration and processes are not analysed because the main goal of this research is to get a better mix of researchers and research institutions, while those aspects refer to the research collaboration activity that occurs inside a research institution. Nevertheless, this model is adopted because it describes the relationship between organization and researchers. This relationship is natural and symbiotic, nevertheless scarcely analysed in terms of defining the characteristics of the best research institutions and the characteristics of the best set of researchers. An adequate mix of them could promote better research performance.

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With respect to the attributes of institutions, the CMRCE definition is composed of resources, structure/design, organizational culture and role clarity. Given that this model, was defined in order to describe research collaboration effectiveness. From CMRCE we have adopted the analysis of structure/design as organizational structure. As Gray et al., 2001, claims the lack of studies on how organizational factors influence URCs is a missing link in the literature. According to the current literature review this gap remains open, hence this research proposes a way of closing this gap.

The main resource implicitly involved in this model is human capital: researchers. They at least describe features like: gender, age and level of education. These features have been considered as control variables within model testing aspects such as: relationship with academic activities (Bozeman and Boardman, 2013) and human capital (Toker and Gray, 2008; Ponomariov and Boardman, 2010).

Organizational structures in URCs

Currently, due to the diversity of research institutions it is possible to observe several levels of administration according to the organizational structures chosen by their leaders or by their owners. *Structure/design*, is a concept defined in terms of a loose and/or informal way of managing the institution as a condition of improving collaboration (Boardman and Bozeman, 2006). Different kinds of structures promote a kind of management which shows different levels of control, communication, participation, roles, incentives, duties, to mention but some of them. The structure or design within an institution describes the form of institutional organization, how it is linked to society, government and several intangible aspects as well as how it affects its environment. Hence, this apparent lack of control or rigid structure, is an illusion, because this organization is being controlled and managed in terms of resources and performance (Bok, 2003). Differences among URCs, after decades of policies promoting these kinds of institutions, come from: resource allocation, human capital availability, research activities, etc. URCs are more focused on research than on development. In consequence, the structure and design of URCs is determined by National Innovation Systems (NIS) (Nelson, 1993). According to the "triple helix", the relationship of university-industry and government promotes innovation inside each NIS (Etzkowitz and Leydesdorff, 2000). Universities are widely understood to be entities which develop and spread knowledge, as well as, currently, promoting and exploiting it. In this sense, URCs are institutions created by universities so that resources and research goals linked to industry and society can be managed separately from their normal academic activities. Simply, it is possible to describe these URCs as a branch of the university, controlled and structured by them. Many of the resources and the infrastructure come from the university which "own" them, but they grow over time thanks to public grants (local, regional or international) obtained by the researchers based in these institutions. Another emergent factor in this system is the formation of alliances. These alliances between universities and public and private institutions has changed the way that organizational structure in URCs is defined (Magro and Wilson, 2013).

S&T Human capital within URCs

S&T Human capital (Boardman and Bozeman, 2006) is a valid and interesting concept, which involves social capital, experience and how a researcher is able to enhance his/her capabilities in order to become a mature researcher. Nevertheless, the literature has not been able to determine a validated set of conditions that describes this complex concept. One of the main causes could be that this concept was coined under research collaboration studies, which promotes how research institutions and its researchers are able to create trust, networking and carry out successful projects. Hence, the concept in itself is collective, while in this research each institution is analysed through a set of people with some specific and measurable characteristics.

In this research, the concept is reduced to a set of individual characteristics like: gender, educational level and age. These characteristics describe the people inside each URC and how they influence results, according to the organizational structure in the URCs.

Science and Performance

Ben-Davis (1972; in Stigler, 1993) claims that universities compete by prestige. This prestige could be understandable as a set of conditions that allows an institution to be placed first in some international ranking or to be recognized by its peers as the best institution in some specific area, or as an institution as a whole. However, this concept is vague (Stigler, 1993) and also difficult to measure. Nevertheless, this goal seems to be in the line with the mission of many universities around the world. Stigler, claims that reputation more than prestige is a better indicator to measure performance in an intellectual competition among universities. He describes this competition based on ideas. These ideas are spread by papers, lessons, books, conferences, research groups, new school programs, etc. Currently, this prestige or reputation is measured by Higher Education International Rankings, the data base indexation of papers, international quality certification of higher education programs, etc. Thus, if it is necessary to see the current level of prestige of any given university, this information is easily obtainable by visiting the necessary web page. Nevertheless, this kind of information is not available for URCs as yet. In spite of this, prestige and reputation are also valid goals for every URC. Many of them are closely linked with local or regional development, and therefore linked to the improvement of the standard of living of local people. This seems to be normal due to the location and relationship with local industry and local firms, as part of its research activity or as a way to link its research discoveries with society in general (OECD, 1999). On the other hand, they are part of a university. URCs indicators or results are part of the university's indicators. URCs are financed by public funds, in the form of grants for specific research projects, and/or directly by the university itself. As mentioned Bozeman and Boardman (2013) describe a taxonomy for different kinds of URCs in the USA. This is a country that counts on more than one thousand of this kind of institution. It is possible to describe URCs as State, University among others. In the case of URCs, the relationship between universities and industry has encouraged an intricate, visible, influential and heterogeneous relationship between industry and university. (Lin and Bozeman 2006). In practice these institutions are producing research that is published in the relevant journals, obtaining grants and public funds, registering patents for their inventions as result of their research collaboration inside the URCs (Boardman and Bozeman, 2006). According to this discussion it is interesting to see how their performance has been.

The definition of a set of indicators for the STIs developed by universities is until now an unsolved issue, at least in Europe (EC, 2010). How scientific advances emerge from universities is also very controversial. The difficulties in measuring this activity stems from: the diversity of research missions, the scope of research, the hierarchy of publication outlets, the differences in publication and citation practices, to mention only a few (EC, 2010). To define indicators for a university's STI, requires the solving of problems such as how to measure the intangibility of scientific work, its scope, and the resources involved (Wildson, 2015). These aspects emerged from a couple of studies on scientific performance in the EU and the UK respectively, which has opened new doors and posed new questions. Meanwhile, the scientific community as a whole, not only the URCs, continues to carry out its job advancing in science and technological issues. In this context, URCs are also being analysed intensively with respect to their performance.

In this research, scientific performance is measured by three aspects: publications, projects and patents. These are taken as relevant outcomes of the work done by each URC. We have amassed a total of these indicators obtained on a yearly basis by each URC under study. All those outcomes correspond to a collective endeavour. Hence, these indicators follow the idea of scientific knowledge value (Bozeman and Rogers, 2002). The knowledge and technology transfer within each URC is a consequence of scientific leadership and knowledge sharing shown by each member of URC, in order to obtain grants or publish in the best journals and share knowledge based on interdisciplinary teams of researchers (König, Diehl, Tscherning and Helming, 2013). Most of the scientific performance indicators are based on individual production (De Rijcke, Wouters, Rushforth, Fransson and Hammarfelt, 2016). Nevertheless, research in most cases, is a collective activity. In this sense to consider the total done by year is the best way to see the results of the URC because it is the consequence of an internal and external synergy not only individual activity.

Regional innovation ecosystem in the region of Aragon

In the particular case of the Spanish Innovation System, it is composed of firms, a governmental system of R&D, governmental bureaucracy, innovation supporting institutions and society (Cotec, 2007). A number of Technology and Scientific parks have emerged since the turn of the century and have promoted more intensive innovation and firm links to science, technology and industry (Albahari et al., 2017). On the other hand, (Buesa, Heijs, Martinez and Baumert, 2006) describes, as a critical part of system, the regional and productive environment, the university, the Civil Service and innovating firms. These authors claim that the regional and productive environment is the factor that has the greatest impact on the generation of technological knowledge, as evidenced by patents. They also describe a great diversity in patterns of innovation as a regional growth policy in each Autonomous Community (AC) in Spain. This issue is very important because each AC promotes and puts emphasis on different aspects within the regional system generating different performance and outcomes. Thus, the country does not show an equalitarian level of capabilities around science and technology. As a country, the government as developed the Spanish Strategy of Science, Technology and Innovation 2013-2020 (MINECON, 2012). This document gives the relevant issues in order to obtain social and economic benefits from firms based on locally created technology. This kind of policy is relevant in a country which only entered the technology era in the 1980s following the end of the Franco dictatorship (Buesa, 1988). Hence, this is an economy that has only recently looked to science, technology and innovation as a motor for economic growth. R+D+i institutions in some ACs are young in comparison to other countries in the European region, while in others like Catalonia or the Basque Country they date back to the beginning of the 20th Century. On the other hand, these institutions emerged from European policy promotion which gave the country financial resources in order to build a scientific infrastructure and improve its human capital (Magro et al., 2013).

Aragon is placed 11th in terms of inhabitants in Spain (1.3 million) and placed 4th in terms of size. Aragon produces 3.2% of Spain's GDP. In this context, the Aragon region does not show relevant innovation indicators in the country (See table 1). Nevertheless, it has developed its own innovation promotion policy and receives grants from the national government and the European Union (Law 9, 2003). This situation has promoted indicator increases and firm competitiveness over the last few decades. Furthermore, it is important to highlight that URCs in Aragon are relatively new and have emerged from EU research and innovation policies. This policy has not been analysed at this level before and it provides an interesting view point to observe how a group of university institutions has promoted research and university-industry productive alliances in a specific region in Spain, a country also relatively new in this arena. In spite of this situation as a country, Spain is in 10th place among global publication with 3.19% (2014). This is the most relevant indicator for Spain as a developed country in reference to this topic. In this context Aragon accounts for 5.4% of this total (See table 2). Other indicators like doctoral dissertations and patents are less important. Aragon is behind other ACs such as Madrid, Catalonian, the Valencian Community, the Basque Country, Andalucia and Galicia (ICONO, 2016). In terms of research project grants, one of the most relevant is the recent Horizon 2020 Program from the EU. In 2015, Spain received 178 million Euros in grants (8th place in the EU region) of which Aragon only received 2.3%. This would indicate that Aragon needs to increase its public policies and financial resources in order to improve its performance In this context it is also important to know the influence of organizational structure on this performance.

Table 1. Key indicators of Science and Innovation in Aragon versus Spain. Data from ICONO (2016)

Year	R&D Expenses (Euros)		R&D expenses as GDP (%)		Expenses per inhabitant (Euros)		Full time employees in R+D		Full time researchers	
	Aragon	Spain	Aragon	Spain	Aragon	Spain	Aragon	Spain	Aragon	Spain
2005	221,261	8,441,118	0.79	1.12	175	234	5,285	174,773	3,550	109,720
2006	263,428	9,467,323	0.87	1.20	205	266	5,886	188,978	3,924	115,798
2007	296,894	10,423,729	0.90	1.27	227	295	6,522	201,108	4,549	122,624
2008	352,376	11,265,434	1.03	1.35	264	320	6,912	215,676	4,743	130,986
2009	370,945	11,156,600	1.12	1.39	276	315	7,106	220,777	4,884	133,803
2010	374,240	11,077,035	1.13	1.39	279	313	7,102	222,022	4,853	134,653
2011	322,113	10,656,871	0.95	1.33	240	304	6,534	215,079	4,462	130,235
2012	312,795	10,053,758	0.93	1.30	233	286	6,133	208,831	4,094	126,778
2013	298,081	9,724,812	0.90	1.24	223	279	5,534	203,302	3,699	123,225
2014	300,795	9,617,972	0.91	1.23	226	276	5,402	200,233	3,671	122,235

Table 2. STI Productivity in Aragon versus Spain. Data from ICONO (2016)

	Papers (2014)		Doctoral dissertations (2014)				Patents (2015)			
		%	Public University	%	Private University	%	Application	%	Concession	%
Spain	77,013		10,724		592		2,855		2,426	
Aragon	4,191	5.4	326	3	1	0.1	153	5.4	112	4.6

One of the most influential institutions in this performance is University of Zaragoza (UniZar). It was established in 1542 by Emperor Charles V. This institution has had a strong link with science from its origins with scientists such as: Miguel de Servet and Santiago Ramón y Cajal. Nevertheless, the in 20th Century when technology emerged as a motor of economic growth among developed countries, this university maintained its focus on science and research scarcely linked to industry and technology. This University recovered its autonomous status in 1985, after a long period of dictatorship in Spain. In this period, university-industry was not a public policy in the country. Hence, the main institutions linked with this activity in Aragon emerged after this time. This is the most important university in the region where 50% of the population lives in Zaragoza. The UniZar has three regional branches in Teruel, Huesca y Jaca. Currently, UniZar is a complex institution that has around 32,000 students from bachelor to doctoral. The university possesses 11 University Research Centres (See table 3) which emerged from the 1980s onwards through its own endeavours (Own) or via alliances with public and private institutions (Mixed).

Table 3. University Research Centres (URCs) belonging to the UniZar* (Data 2016)

Name	Acronym	Establishment	Research groups	Researchers	Classification	http://www.icma.unizar-csic.es/ICMAportal/
Instituto de Ciencia de Materiales de Aragón / Aragon Materials Science Institute (ICMA)	ICMA	1985	25	174	Mixed	http://www.icma.unizar-csic.es/ICMAportal/
Laboratorio de Investigación en Fluidodinámica y Tecnologías de la Combustión / The Laboratory of Research in Fluid Dynamics and Combustion Technologies	LIFTEC	2000	4	14	Mixed	http://www.liftec.unizar-csic.es/es/
Instituto de Investigación en Ingeniería de Aragón / Aragon Institute of Engineering Research	I3A	2002	35	560	Own	http://www.i3a.unizar.es/es
Instituto de Biocomputación y Física de Sistemas Complejos / The Institute for Biocomputation and Physics of Complex Systems	BIFI	2002	4	153	Own	http://www.bifi.es/es/
Instituto de Nanociencia de Aragón / The Institute of Nanoscience of Aragon	INA	2003	11	140	Own	http://ina.unizar.es/es/
Instituto de Investigación Sanitaria de Aragón / Aragon Health Research Institute	IIS	2004	61	553	Mixed	http://www.iisaragon.es
Instituto Universitario de Matemáticas y Aplicaciones / The Institute of Mathematics and Applications	IUMA	2007	10	96	Own	https://iuma.unizar.es
Instituto Universitario de Ciencias Ambientales / Environmental Sciences Institute	IUCA	2008	19	228	Own	http://iuca.unizar.es
Instituto Mixto Circe / Research Centre for Energy Resources and Consumption	CIRCE	2009	7	102	Mixed	http://www.fcirce.es
Instituto de Síntesis Química y Catálisis Homogénea / Institute of Chemical Synthesis and Homogeneous Catalysis	ISQCH	2011	14	149	Mixed	http://www.isqch.unizar-csic.es/ISQCHportal/
Instituto Agroalimentario de Aragón / Agro-Food Institute of Aragon	IA2	2014	30	306	Mixed	https://ia2.unizar.es

Source: www.unizar.es (7th March, 2017) and each web page by URC.

'* Active in March 2017. According to UniZar Report 2015, LIFTEC is also considered a research centre.

Method

In the following sections of this paper, we will report the findings from an inquiry that has attempted to link organizational structure and performance at URCs in the Aragon region. Eleven URCs from University of Zaragoza were studied using a mixed-methods approach including quantitative panel data multivariate analyses along with a multiple case study methodology. The overriding objective of this study was to identify how organizational structure promotes different levels of performance amongst URCs. In order to meet this objective, we attempted to answer the following research questions:

1. What kind of structure does each URC show?
a. Which classification emerges from this analysis?
2. How are research characteristics influencing URC performance?
3. According to the URCs classification (point 1), are there any differences in performance amongst them?
4. Which group achieves the best performance?

As discussed in Section 3, throughout the study, the term URC performance will be used to refer to the results obtained by each URC on a yearly basis with respect to publications, projects and patents.

Research design
A mixed-methods approach was used to address our research questions. A data panel analysis was used to address research question 2 (Baltagi, 2005), while a multiple-case study design with pattern matching was used to address research questions 3 and 4 (Yin, 1994). URC was the unit of analysis for the research questions. Simple descriptive analyses were used to address question 1, based on available data from each URC web page (See table 3).

Case selection
In order to be able to understand the effects of organizational structure in each URC, all of the URCs belonging to University of Zaragoza were analysed. The cases were selected because they were different in their scientific focus and resources but relatively similar in organizational context. The University of Zaragoza was chosen because it is the largest and most influential university in the region. Hence, through observing the URCs belonging to UniZar we were able to describe the situation in the Aragon region. This region only has one private university which is less than 20 years old, so its influence on research, development and innovation within the region is still relatively small.

Other measures and analytical tools
A variety of analytical tools were used to interpret case relationships, including descriptive statistical analysis, graphics, etc. but these are not presented in this paper.

Results

Overview: Organizational structure in URCs
Appendix 1, shows a description of the structure in each URC under analysis. They were classified as own/mixed. Own corresponds to those URCs created and managed by UniZar, while mixed refers to those which are managed by an external actor in the Spanish Innovation System and UniZar. According to this analysis, the presence of Corporate governance has been highlighted (OECD, 1998) in these institutions. This is demonstrated by different levels of management, in most cases a Directory, composed of representatives from UniZar or an external institution. The more complex structures show more than four levels of management.

A summary is observed in table 4. According to this description, in both classifications there are complex or simple structures. A complex organizational structure is composed of a URC Governing board, Director, Management commission or management team, research council and research divisions. Some of them have an external commission also. They describe 4 or 5 levels of management. In describing the organizational structure in these institutions, it is necessary to show how they define the course of their URCs, define the director, sub-directors or deputy director, scientific director, new researchers and also supervise the strategic plan, the budget, the annual report, and propose external commissions. These duties are defined by each URC according to their goals and vision, and especially by its condition as mixed or own. A URC Governing board is composed of representatives of UniZar and representatives of an external partner (in the case of Mixed URC). They elect a URC Director every four years. Own URC base their functions on democracy and participation, while Mixed base their functions on mutual control and coordination.

Table 4. Summary of the classification of URCs under analysis

Classification	Simple	Complex	Total Cases
Own	IUMA	I3A, BIFI, INA, IUCA	
Cases	**1**	**4**	**5**
Mixed	LIFTEC, CIRCE, ISQCH	ICMA, IIS, IA2	
Cases	**3**	**3**	**6**
Total cases	**4**	**7**	**11**

URCs which have a simple organizational structure have two levels: Management team and research divisions. There is no set trend in this group, they can be mixed or own and in one case (CIRCE) the first level is composed of an URC Governing board. In this case, it has not been possible to discover, according to the web page information available, if the board members have similar duties to those in the URCs with a complex organizational structure. In spite of this, its URC Governing board is similar to others.

In summary, these findings indicate a trend of complex organizational structures. This finding suggests an analysis of each group according to its organizational structure (Simple/Complex). In the following analysis, the relationship between URC resources and research and technological performance is shown using the OS (Simple/Complex) as a dummy variable as a way of analysing its influence on performance.

Scientific performance and URCs: data panel analysis

The empirical approach proposes to test the relationship between URC's scientific and technological performance (publications, projects and patents) and the resources involved. Resource and capabilities approach (Barney, 1991) allows for the definition of the main resource needed in order to achieve a distinctive competitive advantage. This means, each URC has infrastructure and financial support in order to achieve its research goals. Nevertheless, these resources are generic in nature, such as: offices, buildings, laboratories. The latter could be special or specific, even unique, but nevertheless they represent tangibles that need a researcher or specialist in order to get the best out of this specific asset. In this way, the main resource in each URC is the research personnel. They are working together, coordinating, obtaining grants, giving orientation to its researches, proposing new topics, mixing ideas, materials, sharing knowledge and networking. In summary, they allow each URC to obtain its performance. In this research, the research personnel are described according to three main characteristics: age, gender and educational level. These aspects are similar to those used by Dietz and Bozeman (2005), in order to determine the influence of experience on technical human capital improvement. In other researches these aspects are treated as control variables (Lin and Bozeman, 2006). However, in this research the research unit is each URC. Hence, the conditions of their members as a whole are relevant and in this case, cannot be a control aspect. The control variable is the resources that the University of Zaragoza gives to each institution yearly. This financial support is described as the amount of money that the university pays, in the form of a salary, to the researchers in each URC. Some researchers belong to the University of Zaragoza. The university divides its academic activity into docent and researchers. UniZar controls the scholars in this condition and calculates the amount involved according to this dual work and scholar category in each case.

We have a time series (from 2000 to 2016[1]) for each variable and URC under analysis (11 cases). The time series depends on the establishment date of each URC. Hence, there are differences in terms of the data available for each URC, as well as non-observable individual effects. This situation, suggests the use of econometric technics such as data panel analysis (Arellano-González and Bover, 1990). This is a mix of cross-sectional analysis and time series, which means considering specific units under analysis and allowing for the gathering of information for the observation over time, controlling non-observable individual heterogeneity. In this research, each URC is heterogeneous to the research activity carried out according to its endeavour, the resources involved, the date of establishment or the kind of organizational structure. According to this situation, the quantitative methodology of analysis proposed possesses a set of positive aspects such as: the reduction of collinearity among variables, obtaining more freedom grades and more efficiency, better testing of the dynamic-fit, the identification and measuring effect that time series effect or a cross-sectional test does not detect, to mention some of them (Baltagi, 2005).

The time period 2000 to 2016 has been chosen so as to obtain the widest picture possible of the activities carried out by each URC during this period. Nevertheless, the data available from each UCR's yearly report, is not coincident with the establishment year. In this sense, we have an unbalanced panel data, composed of 119 observations, 11 cases and the time-series 2000-2016.

Thus, to determine a possible relationship between the research and the technological performance of a URC and the resources involved, the following set of regressions have been tested, considering research and technology performance by a URC as 3 different dependent variables:

X_1 = Publications (PUBL)

X_2 = LN_Projects (LN_PROJ)

X_3 = Patents (PAT)

Hence, it is possible to define the following set of regressions:

$$X_{1t}= \alpha_1 OS_{1t} +\alpha_2 GEN_{1t}+\alpha_3 AGE_{1t}+\alpha_4 EDU\_L_{1t}+ \beta_1 + \varepsilon_{1t} \quad (1)$$

$$X_{2t}= \alpha_1 OS_{2t} +\alpha_2 GEN_{2t}+\alpha_3 AGE_{2t}+\alpha_4 EDU\_L_{2t}+\beta_2 + \varepsilon_{2t} \quad (2)$$

$$X_{3t}= \alpha_1 OS_{3t} + \alpha_2 GEN_{3t}+\alpha_3 AGE_{3t}+\alpha_4 EDU\_L_{3t}+\beta_3 +\varepsilon_{3t} \quad (3)$$

The dependent variable (Xit) is an approximation of the outcomes of each URC i in the time t, in this case it is composed of three elements analysed separately, as a way to observe the differences among them: Publications, projects and patents. The terms bi and eit represents the individual effect and idiosyncratic error respectively. The financial support that the University of Zaragoza gives annually to each URC has been defined as a control variable: Unizar_FS. The data used in this calculus was obtained from each URC annual report during the period under analysis which were available on their web pages and in the SEGEDA[2] data base. The datasets generated during and/or analysed during the current study are not publicly available. They are open to administrative and scholars at UniZar members. In this case was available to this research, but are available from person outside UniZar on reasonable request.

Once the data base was completed, it was possible to adjust the variables X_2(Projects) and LN_UZ_FS. Both are defined in thousands of euros. As a way to be more comparable in each regression with others variables, both were recalculated using a Natural logarithm. In table 5 there is a description of each variable defined.

[1] From establishment date or agreement date by each URC.
[2] https://segeda.unizar.es/pentaho/Home. SEGEDA: Service Management Data of University Zaragoza (Servicio de Gestión de Datos de la UniZar) / Data extracted from January to May 2017.

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Table 5. Variables description

	Tag	Description
Dependent variables		
X_1: Publications	PUBL	Total number of publications per URC per year
X_2: Projects	LN_PROJ	Natural log of the total amount of grants or funds obtained by each URC per year
X_3: Patents	PAT	Total number of patents (applications and concessions) per URC per year
Independent variables		
Organizational Structure	OS	Dummy variable which describes Complex organizational structure (1) or simple (0)
GENDER (GEN)		
Male	GEN_M	Total number of men within the total number of researchers per URC per year
Female	GEN_F	Total number of women within the total number of researchers per URC per year
AGE (AGE)		
Less than 30 years old	AGE_L_30	Total number of researchers less than 30 years old within the total number of researchers per URC per year
More than 30 years old	AGE_M_30	Total number of researchers more than 30 years old within the total number of researchers per URC per year
EDUCATIONAL LEVEL (EDU_L)		
Hold PhD	PHD	Total number of researchers holding a PhD within the total number of researchers per URC per year
Non-hold PhD	NON_PHD	Total number of researchers not holding a PhD within the total number of researchers per URC per year
Control Variable		
University of Zaragoza financial support	LN_UZ_FS	Natural log of the total amount of financial support given by the University of Zaragoza to each URC per year
Others		
Projects	PROJ	Total amount of grants or funds obtained by each URC per year

We proceeded to calculate the descriptive statistics for each variable under analysis (see table 6). Once this was done, a sequence of econometric models formulated successively was calculated, according to the Hausman test which defines whether a panel is random or fixed. The results from this procedure are shown in Annex 2, according to the models proposed in this research.

Table 6. Variable descriptive statistics.

Variable	Sub-category	N	Mean	Std. Dev.	Min	Max
Dependent						
PUBL		119	146,983	118,29	1	445
LN_PROJ		119	14,157	1,355	7,472	16,563
PAT		119	2,270	7,315	0	45
Independent						
OS		119	0,655	0,477	0	1
GEN	GEN_M	119	94,420	82,375	0	400
	GEN_F	119	56,344	56,129	0	277
AGE	AGE_L_30	119	26,319	23,126	0	100
	AGE_M_30	119	124,445	114,273	1	494
EDU_L	PHD	119	97,613	88,018	1	326
	NON_PHD	119	53,151	54,921	0	244
Control						
LN_UZ_FS		118	14,331	1,123	11,448	16,917
Other						
PROJECT	PROJ	119	2,789,982	3,295,445	1,759	1,56e7

As a way of solving the second research question - Which variables influence URC performance? and the sub-question - What are the net or multivariate effects of significant performance variables within URCs?. The panel data analysis, is summarised in table 7, Model 1 involves the basic model without a control variable, considering OS, GENDER: GEN_M, AGE: AGE_L_30, EDU_L: PHD. Model 1A uses the same variables plus a control variable: LN_UZ_FS, Model 1B is composed of OS, GENDER: GEN_F, AGE: AGE_M_30, EDU_L:NON-PHD and Model 1C uses the same variables as Model 1B but with a control variable. Each model is calculated using a part of the variable, for example: GEN_M or GEN_F, not both, because of collinearity. The same situation occurs for AGE and EDU_L. For the same reason, we test Model 1 with a part of each variable, while Model 1B is composed of the other part. It is not necessary to process all possible combinations among variables.

Table 7. Summary Data panel results

		X_1: PUBL				X_2: LN_PROJ				X_3:PAT		
			Control		Control		Control		Control	Control		Control
		Model 1	**Model 1A**	**Model 1B**	**Model 1C**	**Model 1**	**Model 1A**	**Model 1B**	**Model 1C**	**Model 1**	**Model 1B**	**Model 1C**
Wald Chi2		239,69***	255,93***	288,54***	251,91***	30,67***	166,42***	44,72***	162,67**	90,93***	134,56***	144,26***
R^2	Overall	0,8683	0,872	0,873	0,874	0,4088	0,561	0,263	0,561	0,668	0,694	0,709
OS		3,61***	3,96***	4,23***	4,44***	2,10**	2,09**	2,90***	1,98**	1,04	-1,33	-1,80*
GENDER	GEN_M	1,86**	1,88**			1,09	1,65*			5,41***		
	GEN_F			-1,27	-1,38			-1,50	-1,48		-6,87***	-6,69***
AGE	AGE_L_30	-0,68	-0,75			-0,54	-1,27			-4,37***		
	AGE_M_30			7,24***	7,42***			3,04***	1,84**		10,66***	9,65***
EDU_L	PHD	2,20**	2,32**			-0,12	-1,15			-2,84***		
	NON_PHD			0,57	-0,63			0,66	0,9		2,72***	2,78***
LN_UZ_FS			-1,62		-1,52		7,13***		6,98***			1,68*
_Cons		0,14	1,61	0,45	1,59	42,96***	3,79***	50,09***	3,90***	-1,29	-1,67*	-1,90*

* <0,10; ** <0,05; *** <0,01

In the case of Publications (PUBL:X_1), all models are significant with a R2 overall over 85%, this shows a high explanation capacity over 10%, the critical figure in this calculus (Falk and Miller, 1992). According to the Hausman test all models are random, this means that there is not a systematic pattern in time in each URC. OS, GEN_M and EDU_L:PHD, in model 1 and 1A, AGE_M_30 in model 1B and 1C, are significant variables. In summary, male researchers, more than 30 years old and holding a PhD are influencing Research performance in terms of Publications.

On the other hand, Projects are influenced by OS and the control variable is significant. In this case, the models are significant in all cases. R^2 overall is significant in levels from 26% to 56% which is considered adequate for this kind of analysis. GEN_M is significant in Model 1A and AGE_M_30 in models 1B and 1C. In this case, the control variable has a positive and high rate of influence on getting projects. The constants in all models are significant. In summary, men over 30 years old in those URCs with complex OS do have influence in terms of obtaining grants for projects by a URC.

Lastly, patent models as a part of the technological performance of each URC show significant models with a high capacity for explanation (R^2 from 67% to 71%). In this tested case model OS was not significant or it was low and negative as in the case Model 1C. It was not possible to calculate Model 1A because the Hausman test was not viable. The Models in this case are interesting because they show an influence by the variable as a whole. For example, Gender is significant, both male and female, but males have a positive influence. In terms of Age, researchers over 30 years old have a positive influence. Meanwhile, according to the level of education, those without a PhD have positive influence on patent development. The control variable does have influence in Model 1C and the constant is less significant and negative. In summary, male researchers over 30 years old and not holding a PhD and UniZar financial support promotes patents in URCs.

In conclusion, Complex OS shown in a group of URCs influences both publications and projects. The resources involved in publications are male researchers, over 30 years old and holding a PhD, while projects are also influenced by men over 30 years old, but they do not require a specific level of education. At the same time, the resources involved are influenced by male researchers over 30 years old without a PhD as well as UniZar financial support. These results are very consequent with the institutionalized scientific performance, publications and projects. Complex OS in these institutions promotes a standard performance, while technological performance, such as patents, requires a strong relationship with industry. Some of the URCs under analysis have been able to achieve this kind of linkages over a long period of time and through personal relationships between researchers and company managers, but these are not very well institutionalized. Each technology-transfer model represents an activity that is not very well defined in some URCs, also they have not been defined as the main activity because the URC promotes research more than patent development. This is a distinctive characteristic of the Spanish Innovation System, because technology transfer is done by: technological parks, while science and research is done by URCs. Therefore, to be able to generate patents in an institution with little focus on patenting is a value added that URCs are giving to the Spanish Innovation System. In this system, universities have been able to give maturity and competitiveness to the relationship university-industry (Buesa, 2012).

Scientific performance and URCs: Best performance

In the following analysis performance will be measured. This will effectively allow us to know if organizational structure promotes better or lesser performance in these institutions. This analysis solves question 3 and 4.

We have calculated the mean of each group showed in Table 4: Group 1: URCs Complex and Own, Group 2: Complex and Mixed, Group 3: Simple and Mixed. The 4th group Simple and Own is composed of just one URC and was considered inadequate for analysis in isolation from all the other URCs. According to results described in Table 8, it is possible to conclude that there is not one group that is the best in all the performance indicators, instead there is a group of URCs which show a kind of structure which promotes some of the performance indicators (publications, projects and patents. Publications are promoted by Group 2, URCs which show a Complex OS and are composed of the University and a public partner or private institution (Mixed). They on average produced 257.4 publications (mean) during the period under analysis (2000 to 20016). With respect to Projects and Patents, they are promoted by Group 1 (Complex and Own URCs). In both cases, having a Complex Organizational structure leads to greater influence on URCs performance. It is important to note a better performance in Group 1, because it is a set of URCs which have worked without formal alliances within their organizational structure, although some of them have been able to develop linkages with industry and other research institutions.

Table 8. Mean of Scientific performance by URC according to grouping

			PUBL	**PROY**	**PAT**
		n	Mean	Mean	Mean
Group 1	Own_Complex	52	156.19	**4,012,296**	**4.88**
	Other	67	139.84	1,841,321	0.42
		119			
Group 2	Mixed_Complex	26	**257.42**	**2,253,678**	**0.58**
	Other	93	116.10	2,939,917	2.87
		119			
Group 3	Mixed_Simple	31	21.90	**806,883**	**0.55**
	Other	88	191.05	3,488,574	3.01
		119			

In summary, from the results we have found that URCs with a complex style of organizational structure have influence on their scientific performance. On observing the URCs with a complex structure plus whether they are also own or mixed, it is apparent that the complex and own URCs perform better in projects and patents, while complex and mixed show a greater influence on publications. In terms of research characteristics which allow each URC to achieve their results, the resources involved in publications are male researchers over 30 years old and holding a PhD, while projects are also influenced by males over 30 years old, but a specific level of education is not necessary. Patents are influenced by male researchers over 30 years old without a PhD and with UniZar financial support.

Discussion and Conclusion

An adequate mix of researcher characteristics promotes better research performance in URCs with complex organizational structures. According to the results this better research performance, comes from age, gender and educational level. Age is composed of researchers less than 30 years old and more than 30 years old. This division is culturally mentioned as the limit between young and senior researchers. This aspect is very important in a researcher's life. Normally, a scientific career is long with several marked steps. One of these being the attainment of a PhD. Nevertheless, this process faces a vital step: finding an academic position. To become an academic and practice research and teaching activities is a difficult barrier to cross for many young people interested in developing research activity. This dependence on public resources and university rules limits the involvement of the young (Huisman, De Weert and Bartelse, 2002). Hence, the results of this research are in line with the real situation in Europe. The greater influence of researchers, over 30 years old, on publications, projects and patents and therefore research performance in URCs is a consequence of a university trend to have academics within this age group. In spite of this situation it is also important to mention that a research career is normally long, so experience and networks are part of the human capital that make a long career possible (Corley et al., 2006).

Educational level, as a variable is composed of researchers with or without a PhD. This indicator has been built as a way to show that an important number of people doing research and pushing publications, patents and projects have not, necessarily, been trained to a PhD level. In this research, this status is irrelevant in obtaining grants and projects. This could be due to a project being obtained by a set of people with different skills and experiences. Hence, a project in itself requires people with different levels of education. Nevertheless, publications are promoted by researchers holding a PhD. This a natural consequence of their training as people that spread their knowledge by publishing their discoveries and the results of their research. On the other hand, non-holding PhD researchers show a positive influence on the promotion of patents, while those holding a PhD demonstrate a more negative influence. This is due to the relationship with industry and scarce experience, in most cases, of people holding recently obtained PhDs (Dietz et al., 2005). The building of these linkages is more difficult and artificial for PhD holders than for people who do not attain this kind of educational level. Meanwhile the theoretical models studied at PhD level tend to be unclear to people without this level of education. This causes communication difficulties between people from industry and researchers (NASEM, 2017).

Gender in science is a widely analysed issue, especially with respect to woman in science, at least from the 1970s in the USA (Gaughan, 2005). With respect to the results obtained in each proposed model they are related to educational level, with males showing little influence on projects, some influence on publication, and a marked influence on patenting. This is due to the scarce number of women holding PhDs, there is a 0.934*** (Pearson correlation) in the data base. However, the number of women is not particularly small, on average 34% of URCs members are women (Dev Std 13%). They add diversity and a different point of view to research results. Nevertheless, if they are not holding a PhD with respect to this research they are not influencing publication and patenting. There is something to analyse within regional public policies on this issue, because at national level (Spain) women make up 39% of all researchers (ICONO, 2016).

With respect to the control variable, financial support from UniZar to each URC under analysis, this has a marked influence on projects. This kind of variable has not been analysed before in this kind of study. In this case, it was considered relevant due to the fact that financial support given to URCs by a public university is very important with financial support for these institutions from national and regional government being very limited. This puts a lot of pressure on URCs which must survive using their own financial resources. All institutions require working capital in order to cover all their expenses. Hence, every URC has a set of internal policies which allows it to obtain these financial resources from researchers who have been able to obtain grants and external financial support for their projects. Obtaining financial support for projects is a critical activity for URCs and Universities. In the case that a researcher or research team obtains a grant for a project, a part of this is given to the university as an overhead. This situation produces a virtuous circle between the university and its researchers. This is the case of UniZar which invests these resources in research and not in other activities. This means that the level of commitment from the university to research activity within URCs allows both institutions to improve their indicators and compete in the global scientific context. With respect to publications, as seen in the results of this research, there is a lack of financial support from UniZar. Publishing is an activity done by all scholars within a university and URCs. This double status of publications, from a critical point of view, could be seen as a result of the university more than the URC. Nevertheless, this result shows that the university has more publications and that the URCs represent only a part of it. Publication is an important activity within every URC because it allows the researchers to spread their discoveries and share their knowledge. Thus, this is also a relevant indicator of URC activity (Dietz et al, 2005). In the case of patenting, results show a link between patenting and university financial support. This is similar to projects. Patenting increases university income, which in turn increases university resources for URCs. The symbiotic relationship between the university and the URCs and how they manage their financial resources shows their dependence on public funds as well as requiring increased financial support and involvement in R+D+i from private institutions (foundations and companies).

In conclusion, this set of simple characteristics that describe researchers (age, gender and educational level), influence research results in URCs. Hence, the distribution and the management of the characteristics of the researchers can improve URCs performance. Therefore, this kind of analysis is the seed for the creation of a standard report and its revelations about the research institutions from a global, national and regional point of view. Despite the discussion on indicators still being open, this research proposes a simple set of indicators which allow for the observation of research performance in URCs, institutions where research is done by people coming together and mixing a set of resources and capabilities within their field of research based on social networks and scientific knowledge (Bozeman et al., 2002). This research is in line with those which have analysed organizational and institutional conditions that promote research activity. Hunter, Jansen Perry and Currall (2011) described the positive relationship between an organizational climate characterised by support for commercialization and invention disclosures and patents. With respect to the creativity in scientific research, this is promoted by organizational structures which give researchers access to a variety of complementary technical skills, stable research sponsorship, timely access to extramural skills and resources as well as facilitating leadership (Heinze et al.,2009). In consequence, a researcher needs the kind of structure and processes which help him/her to be excellent. Therefore, this research is also adding elements in research management and research policy.

Research performance is strongly linked to the URCs organizational structure. This kind of structure coincides with a loose management style with regards to the organization of their resources and internal capabilities, as a way of promoting research collaboration (Boardman et al., 2006) within each URC. On the other hand, a complex organizational structure promotes better performance. This result is aligned with authors who describe *university corporatisation* (Parker, 2011). In his paper Parker, describes how university governance is promoting similarities with large companies (corporations). According to this approach, this set of UCRs, as part of a public university are doing this through their organizational structures based on a Directory and a set of internal rules, controls and reports. This is due to the legacy of EU public policies in Aragon, as well as local conditions that promote a scientific culture that emerged from the first URCs in the region (I3A, BIFI and INA) owned by UniZar. Currently, all financial resources obtained from local or international sources, are required to be open to the scrutiny of the local community. This trend promoted by Governance of science (De Rijcke et al., 2016) as well as the pressure of competition among universities trying to increase their international ranking requires attention and the disclosure of the scientific activity within the universities. In relation to this issue it is interesting to observe the set of reports done by URCs under analysis. Their organizational structures and level of commitment within the region and society compel them to do it. Also, these research institutions have been able to go beyond themselves by patenting and, in some cases, promoting spin-offs. This situation shows the possibility of establishing a strong relationship between academia and industry in institutions which were not originally created with this goal in mind. Spain has Technology parks, Technology Centres and Innovation Technology Support Centres as its main institutions focussed on patenting and technology transfer. Hence, URCs are able to give some support to the Innovation ecosystem in this topic which is a highly valuable aspect to the people in charge of URCs in Aragon.

This research is an example of the recent history in regional STI development. Knowing, in detail, these kinds of results in URCs management, allows for better decision making and the development of adequate public policies, especially in those countries and regions which have recently established these kinds of institutions. All those public policies promoting STI require the practice of good governance in order to adequately use public resources (Prewitt, 1993) as the demand for them intensifies.

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