Exploring the Impact of University-Firm Collaboration on Regional Development

The Spanish Case

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Abstract

University-firm collaboration (UFC) is expected to have a positive impact on firms and universities, as well as on the regions where such interactions take place. In the case of firms, this collaboration is meant to enhance the innovation of products and practices at corporate level, leading to a better economic performance, which might boost the positive effects of industry on regions too. In the case of universities, this collaboration can enable knowledge dissemination and technology transfer. These partnerships support universities' competitiveness in terms of internationalisation and impact on industry and society. Universities can address their 'third mission' through collaboration with industry, responding to both societal needs and market demands. In this sense, UFC could be considered a tool for regional development. The empirical studies on the relationship between the practice of UFC, as a specific case of R&D partnership, and development of regions, are limited, especially in quantitative terms. This paper is aimed at exploring the impact of university-firm collaboration on the economic growth and societal development of regions, making use of data from Spanish firms and regions. Preliminary findings from show that there is a moderate positive relationship between the emergence of university-firm collaborations and most regional development indicators. UFC strengthens knowledge management and innovation capacity at industry, indirectly generating a positive effect on regions' economy and human capital. The collaboration can also tackle societal needs, directly generating positive effects on citizens' life. Further research is required to study the nature and drivers of the observed moderate positive relationship between UFC and regional development.

Keywords: University-Firm Collaboration (UFC); Regional Development; Societal Impact; Economic Growth; Economic Geography; Universities' Third Mission.

JEL: I23; O20; O30; R10; R58.

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1. Introduction

Economic growth and societal development in regions have been strongly linked to regional knowledge (Etzkowitz & Klofsten, 2005), for which universities result to be key actors (Charles, 2006). Universities (including higher education and research institutions) have increasingly been recognised as relevant stakeholders for regional development, giving rise to a *'third mission'* beyond research and education in which universities must engage regionally (Laredo, 2007) to promote innovation and development at the surrounding society. This new task is normally related to proactively bringing the knowledge maintained and created at universities to its application in industry and society. To this end, universities engage in collaboration for innovation with governments and industry (Etzkowitz, 2003), conducting activities in favour of technology transfer and knowledge dissemination. Therefore, university-firm collaboration (hereafter referred as UFC) stands as a tool of regional engagement for universities. At the same time, firms seek to participate in UFC expecting positive effects on the innovation of products and processes at the corporate level, which in turn would lead to a higher economic performance (Hewitt-Dundas *et al.*, 2017). However, firms may also engage in such collaboration for contributing to specific societal demands, as part of their corporate social responsibility. Additionally, contributions of UFC to the enhancement of productivity and innovation at the firm level can also impact economic growth and regional innovation through the generation of knowledge spillovers (Grossman & Helpman, 1991).

This paper is aimed at tackling the next research questions:

1. *How do universities and firms enhance their impact on regional development through UFC?* This question is approached through the theorisation of university-firm collaboration and its impacts on regions at section 2.
2. *What are the direct and indirect relationships between UFC and the economic growth and/or societal development at regions?* This question is approached through a descriptive statistical analysis of the relationship between university-firm collaboration and regional development indicators at sections 3 and 4.

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Preliminary results show a positive relationship between the emergence of collaboration between universities and firms and the selected indicators of economic growth and societal development at regions. This positive relationship could be explained by a positive effect of UFC on regional development, which can be theorised in terms of the direct and indirect positive impacts that this collaboration has on regional development. However, this paper remains explorative and generically descriptive, and further empirical research will be required in order to test the causality in the relationship between UFC and regional development. This paper is structured as follows: Next section provides a conceptualisation of UFC and its direct and indirect impacts on regions (2). Afterwards, this paper's research design (data, variables and methodology) is presented (3), followed by the preliminary results on the descriptive statistical analysis of the relationship between UFC and regional development (4). Finally, these results are discussed, and conclusions are presented (5).

2. Conceptual framework

This section provides some relevant insights from the literature on UFC and its impacts on regional development, mainly based on the innovation and regional studies research streams, focusing specifically on relevant contributions from the Economic Geography knowledge body and its connections to this paper's topic. At the end, a graphical conceptualisation of the relationship between UFC and regional development is presented.

2.1. University-firm collaboration (UFC)

Universities are increasingly responding to more internal and external demands. For instance, internationalisation is relevant to universities competitiveness, while still trying to engage regionally. The *'think globally, act locally'* (Devine-Wright, 2013) notion advocates for a place-attached UFC, in which internationally competitive research teams and activities work on and identify with regional or local issues (Manrique & Nguyen, 2017). Accordingly, UFC can support international competitiveness in human capital while taking care of regional matters. Some universities engage in regional growth partnerships that can influence regional policy (Hudson, 2006); such partnerships can work on issues

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such as sustainability, productivity and innovation, which are of the interest of firms that also get involved in such collaborations.

University-firm collaboration give firms access to fundamental knowledge and the possibility of conducting high quality research, essential for innovation. Both universities and firms have realised the importance of collaborating between them, especially for innovation purposes. On one side, the agenda of higher education and research institutions have evolved along the past decade and a '*third mission*' -apart from research and education- (Göransson & Brundenius, 2011) has risen in terms of the interaction between universities and its external environment (industries, regions). Universities certainly have a relevant role in the innovation (Charles, 2006) and development of regions (Etzkowitz & Klofsten, 2005), and UFC is one of the most important and visited practices for enhancing this role (Perkmann & Walsh, 2007; Perkmann *et al.*, 2013). On the other side, firms are recognising the importance of learning and innovating in times in which knowledge plays a fundamental role in economy (Fitjar & Rodríguez-Pose, 2013). Innovation seems to be one of the requirements for firms in a global and competitive market, and UFC is a useful practice to achieve innovation and its positive effect on corporate economic performance (Hewitt-Dundas *et al.*, 2017).

This paper argues that despite the main direct effects of UFC take place primarily at firms and universities themselves, such benefits can also generate positive indirect impacts on economic growth and regional knowledge by contributing to regional industrial development and generating knowledge spillovers. However, it is important to consider the UFC phenomenon at university and firm level, for which a summary table of motivations, types and impacts -on firms- of UFC is presented in **Table 1**. The impact of UFC on regional development is more deeply studied in the next section (**2.2**).

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Table 1 - University-Firm Collaboration Breakdown

Category	Classification	Description
Motivations	Operational Motivations	Solving day-to-day problems. Hiring workforce (interns and professionals). Seeking short-term results.
	Tactical Motivations	Introduction of new products and services. Accessing new markets. Solving production problems. Risks reduction. Costs reduction. Funding Obtaining. Accessing patents and intellectual property. Project Management. Seeking medium-term results.
	Strategic Motivations	Competitive Positioning. Image and Reputation Improvements. State of the Art Knowledge. Technology and Information Access. Seeking long-term results.
Types	Research-based	Joint and Collaborative Research. Contracted Research. Knowledge-transfer Agreements. Technology-transfer Agreements. Patents and licensing.
	Education-based	Training and formation of Workforce. Internships and joint thesis supervision. Specific Capacitation.
	Consultancy and Service Providing	Formal contracted consultancy. Informal Advice.
	Others	Firm creation (spin-offs) and collaboration (NTB's and Start-up's)
Impacts	Financial Related	Costs Reduction. Risks Reduction. Sales Increase. Productivity. Customer service. Exports. Access to new markets.
	Product Innovation	Development and improvement of products. Market research.
	Process Innovation	Improvement of methods and techniques. Quality control. Security. Improvement of business practices and work procedures. Logistic improvements.
	Others	Patents and intellectual property generation. Societal benefits.

Based on Valmaseda-Andia et al. (2015). *The first category is classified into operational, tactical and strategic motivations, as the common timing and scope of firms for planning and making decisions considered in management studies, as in Bilgen & Ozkarahan (2004). The second category is classified into research, education, consultancy and others, considering the nature of university activities that are source of the collaboration. The third category is classified into financial impacts, product innovation, process innovation and others, considering the benefits gained by firms through university-firm collaboration; however, product and process innovation could be considered intermediate effects for financial impact, as will be discussed in the next section.*

2.2. The impact of UFC on regions

UFC should represent benefits for collaborating universities and firms, but it also should generate positive impacts on the regions where the collaborations take place, translating into economic growth and societal development. These impacts can take place either directly or indirectly. In the first case, UFC can approach societal needs affecting citizens' life in a region. This is the case, for instance, of the projects and programmes promoted by the European Commission to support regional development (e.g. Cohesion Policy, Horizon 2020), in which universities and firms play a central role, and research-based UFC is seen as a tool for economic growth and societal development (Manrique, 2018A). In the second case, UFC is used to tackle corporate issues in terms of the innovation and improvements of products and processes at firms, leading to a better economic performance. Such positive effect might subsequently translate into economic growth in regions, and new or improved regional knowledge assets can end up being transferred to society.

Economic growth at regions has been mainly explained through productivity, which can be highly affected by innovation (Cooke *et al.*, 2011). If a positive effect of UFC on the productivity and innovation of firms is assumed, one could also argue in favour of a positive indirect effect of UFC on economic growth at regions. However, how can UFC be used in order to generate economic growth at regions?

- Firstly, and considering the key role of universities in the development of regional knowledge (Charles, 2006), UFC could be a potential channel of unexplored opportunities for regional industrial path development (Neffke *et al.*, 2011; Grillitsch *et al.*, 2018). As universities might contribute to shape regional knowledge assets, one could expect that the technological relatedness in regions can be achieved through smart knowledge transfer from academia to industry, for which UFC can result determinant.

- The potential of successful UFC's in a region can potentiate the entrance of industries that are technologically close to the areas in which a region is strong. The formation of such technological strength could be highly dependent on the interaction between academia and industry, especially in

terms of knowledge transfer. In this sense, UFC can be a source for regional diversification (Boschma, 2017; Neffke *et al.*, 2011), due to its potential in shaping related variety and knowledge capabilities in a region.

- Knowledge assets in regions, however, are not necessarily explained by university-industry spillovers, and regional innovation could mainly revolve around the flow of students and graduates from university to industry (Faggian & McCann, 2006). Nevertheless, UFC also contributes to the formation of such human capital, having an -indirect- effect on regional knowledge assets.

- UFC can take place in the framework of regional -and national- innovation systems (Cooke *et al.*, 1997). Beyond that, if the relevance of regions as innovation spaces, in terms of policy-making and implementation (Uyarra & Flanagan, 2010), is considered, the place-attached notion of UFC, mentioned in the previous section becomes more relevant, as the regional character of collaboration for innovation cannot be ignored. Firms might decide to collaborate with local universities to contribute to the local community and rely on localised knowledge spillovers (Fitjar & Gjelsvik, 2018). However, this regional character does not constrain formation of cross-country and cross-region UFC's, which can also generate positive effects across countries and regions. UFC stands beyond the traditional systemic and neo-liberal view of regional innovation, and under adequate policy-making (Tödtling & Trippl, 2018), the collaboration can foster new path development at and across regions.

- UFC can serve as a channel for entrepreneurship and intrapreneurship, which are determinant processes for regional economic development (Fritsch & Wyrwich, 2017). In the first case, nascent firms, which could or could not be originated within universities (science parks, incubators), might support on universities for the development of innovation capacity and for accessing technology and talented graduates. In the second case, established firms that collaborate with universities, which sometimes locate facilities at science or technology parks, can also end up generating new

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business lines or developing large-scale pilot projects to exploit new technologies -see a case in Spain (Manrique, 2018B)-. UFC can be the base of regional entrepreneurships, especially in the context of triple helix systems (Kim *et al.*, 2012); such entrepreneurial outcomes influence innovation and economic growth regionally.

- Sustainability, in its broadest sense, is a central issue for society and regions nowadays, and many of the efforts done in this respect join universities and firms (Karatzoglou, 2013). As mentioned before, UFC can also be meant to directly tackle societal issues, with sustainability -both at firm and regional levels- as one of the priority issues. Societal-oriented UFC, however, must count with the support and will of governments and policy-makers.

This group of bullet point comprises some of the ways in which UFC can be used towards impacting regional development, especially from an economic geography perspective. In some sense, this bullet points explain the economic geography of UFC.

An example

Sony Corporation, one of the larger manufacturers of electronic products around the world, has recently set an agreement with University of Wales Trinity St. David (UWTSD), a higher education institution located in South West Wales, to bring the next generation of education technology, called Vision Exchange, across the university's campuses (Mutter, 2017). The solution, developed closely between Sony and UWTSD since 2015, allows students to work in small clusters connecting to other students and teachers wirelessly to the platform via their own devices. With Vision Exchange, the company sets its entrance to a new market that joins students, teachers and lecturers. This technological solution may become a pioneering platform that facilitates cutting-edge learning spaces and enables collaborative and interactive learning, bringing benefits both to Sony and to education institutions, also with potential professional applications and benefits for society in general. Other relevant examples can be found in a report of the European Commission that presents UFC case studies to measure the impact of university-business cooperation (Healy *et al.*, 2014).

In order to illustrate the functioning of the relationship between UFC and regional development, the next conceptual scheme has been designed:

Figure 1 - UFC - Regional Development Conceptual Scheme
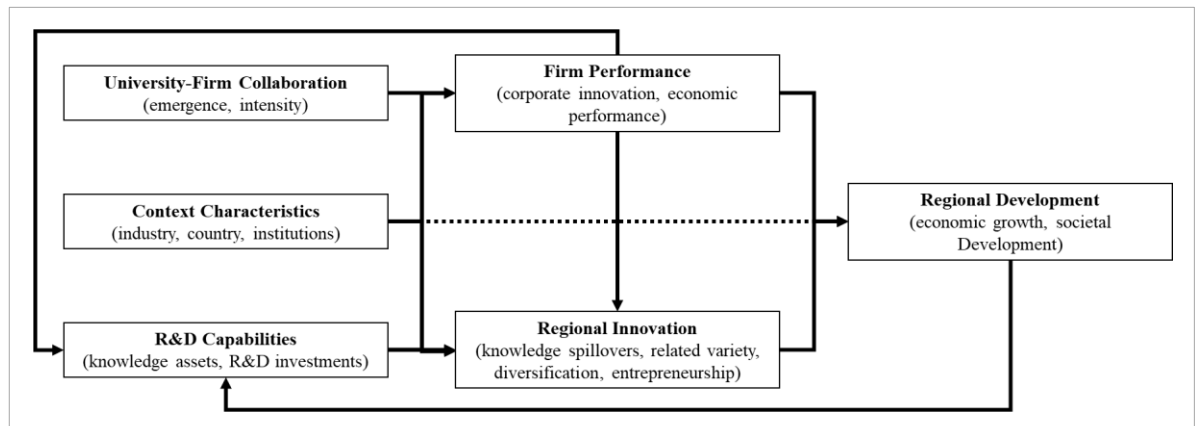
What **Figure 1** portrays is that UFC could generate impacts on the economic growth and societal development of regions through different paths and passing by diverse intermediate effects, taking place especially at firm and industry levels. The UFC – regional development relationship will be analysed in descriptive statistical terms through the next sections of this paper.

3. Research Design

This section provides a description of the empirical part of this research paper, aimed at exploring the relationship between the practice of UFC and the regional development of regions in terms of economic growth and societal development.

3.1. Data

The main input of information in this work is the Spanish Panel of Technological Innovation (PITEC), from which university-firm collaboration, sales, number of employees and location, among other variables, are retrieved. PITEC tracks R&D activities of Spanish firms, based on national surveys carried out by the National Institute of Statistics (INE) with the support of the Spanish Foundation for Science

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and Technology (FECYT). Originally, there is available information for more than 12,000 firms and 460 variables between 2003 and 2015. However, after ensuring complete information for all the needed variables, this paper's analysis is conducted on an unbalanced panel dataset of 9,267 firms between 2008 and 2015 (not all firms are present in all years), with a total of 51,298 observations. PITEC provides information of the firm headquarter location among the autonomous communities of Andalusia, Catalonia, Madrid and the Rest of Spain, which are the categories used to reflect on the firm's region in this research paper. **Figure 2** shows the distribution of firms per region along the studied period.

Figure 2 - Number of firms per Region and Year
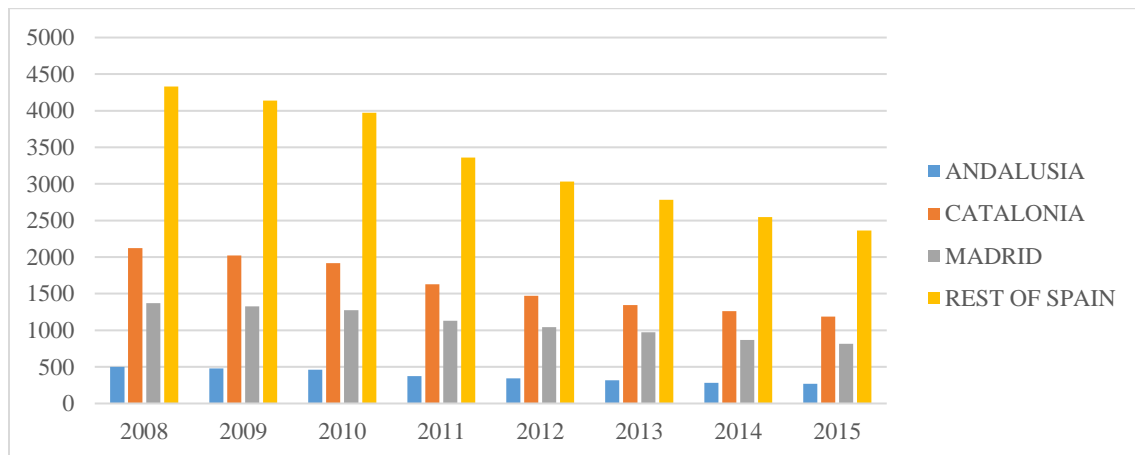
Additionally, data on GDP and population of regions has been retrieved from the National Statistics Institute (INE) website.

3.2. Variables

With the aim of exploring the relationship between UFC and regional development, the next set of variables has been constructed.

UFC Regional Indicator

The main explanatory variable of this study is university-firm collaboration (UFC) considered from a regional perspective. PITEC provides a set of dichotomous variables **COOPij** in which the index **i** stands for the type of partner (e.g., customer

supplier, university) and the index *j* stands for the location of this partner (Spain, Europe, USA and rest of the world); these variables takes values of 1 or 0 if the firm has or has not collaborated with partner *i* at location *j* between *t-2* and *t*. Firstly, only collaboration with universities and research and technology centres (excluding private research institutes and commercial laboratories) has been considered within the spectrum of UFC. Secondly, a regional profile of UFC has been constructed by computing a weighted average of the merged variable **COOPij** (for *i* = universities and research and technology centres) based on the participation of each firm at each year and region in terms of sales and number of employees as proxies of size. The new variable **UFC** then can take values from 0 to 1 for each region at each year (reflecting on UFC between *t-2* and *t*) representing the proportion of industry collaborating with universities and research and technologies centres at each region. This **UFC** regional indicator can then be disaggregated by its geographical scope, generating sub-variables of UFC taking place nationally, in Europe, in USA or in the rest of the world.

Regional Development

Regional development is measured exogenously and endogenously. Exogenously, two variables are constructed using macro magnitudes of regions from INE. Endogenously, two variables are constructed using information from firms at PITEC.

- The first exogenous variable is the GDP growth computed as the logarithmic variation between *t-1* and *t* using the GDP values provided by INE. Computations have been done using market current prices and not constant prices, in order to account for the effect of UFC innovation outcomes on prices. The new variable **GDP Growth** stands for the variation of the demanded total production of goods and services for each region at each year, as a proxy of economic growth.

- The second exogenous variable is the GDP per capita growth computed as the logarithmic variation between *t-1* and *t* using the GDP/population ratio with values provided by INE (population of *t* = average of population between 01/Jan and 31/Dec). Computations have been done using market current prices and not constant prices, in order to account for the effect of

UFC innovation outcomes on prices. The new variable **GDP per Capita Growth** stands for the variation of regional economic productivity.

▪ The first endogenous variable is a regional weighted average of firm innovation. PITEC provides the dichotomous variables **INNPROD** and **INNPROC** that take value of 1 or 0 if a firm claims to have or have not innovated in terms of products and processes between **t-2** and **t**. These two variables are merged and a weighted average per region and year is computed based on the participation of each firm at each year and region in terms of sales and number of employees as proxies of size. The new variable **Innovation** can take values from 0 to 1 indicating the proportion of industry that innovates for each region at each year (reflecting on innovation between **t-2** and **t**), as a proxy of regional industrial innovation.

▪ The second endogenous variable is a regional weighted average of labour productivity growth. PITEC provides the sales (**CIFRA**) and number of employees (**TAMANO**) for each firm at each year. The sales/employees ratio and its logarithmic variation between **t-1** and **t** are computed. Then a weighted average of this variation per region and year is determined based on the participation of each firm at each year and region in terms of sales and number of employees as proxies of size. The new variable **Productivity Growth** indicates the variation of labour productivity for each region at each year, as a proxy of regional industrial productivity.

4. Preliminary Results

This section firstly presents a characterisation of the variables of interest in descriptive statistical terms, and then moves to studying the relationship between UFC and regional development, also using descriptive statistical tools such as dispersion graphs and a correlation matrix. These results are preliminary.

4.1. Describing the variables

To start, the different variables of interest are described in terms of their evolution along time and the differences among regions. **Figure 3** presents the evolution of GDP growth and GDP per capita growth between 2008 and 2015 for the four studied regions and the national total.

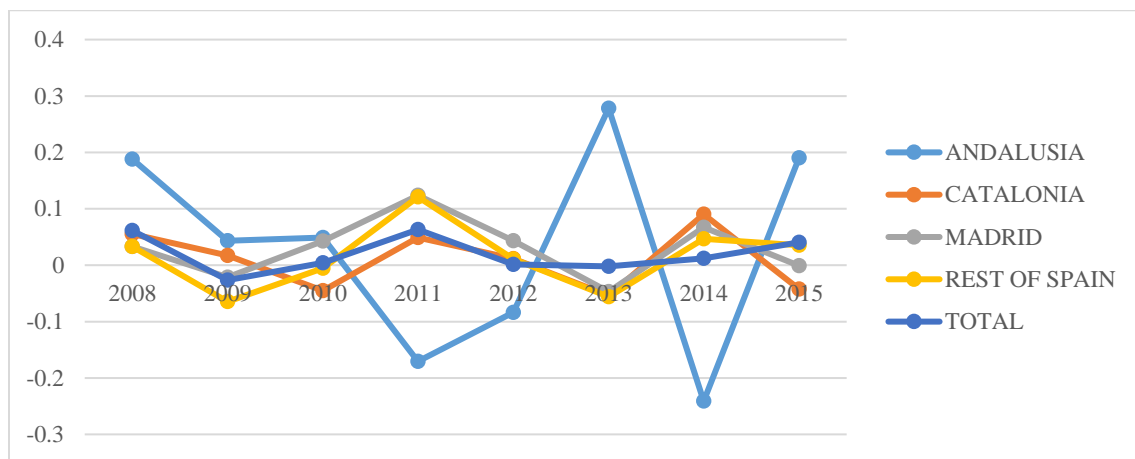*Figure 3 - GDP and GDP per Capita Growth per Region and Year*
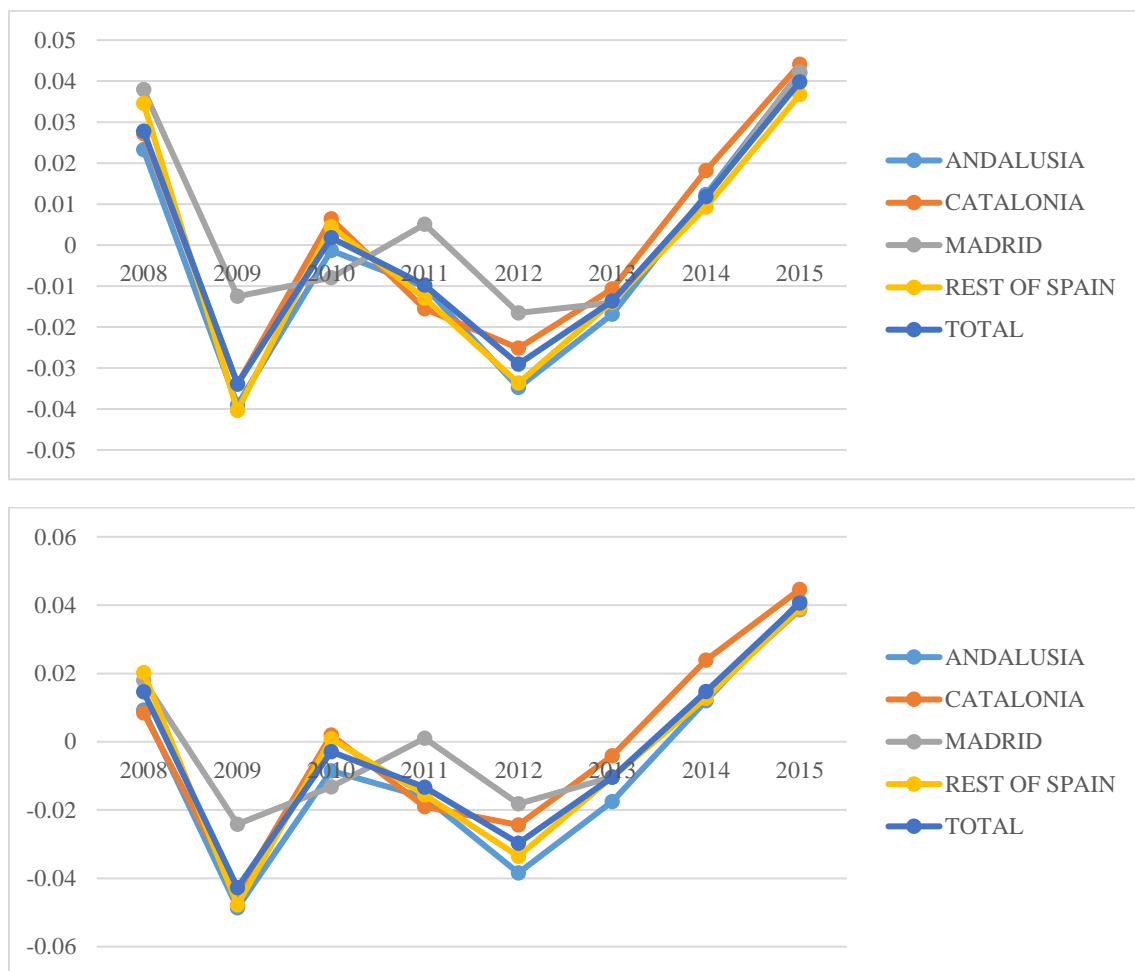
The computation of national growth is done through a weighted average of the regional growths based on the participation of each region in terms of GDP and population.

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The growth of GDP and GDP per capita is consistent along time, having a similar evolution. Decreases (growth < 0) are observed between 2009 and 2013, possibly explained by the effects of economic crisis in Spain, followed by a recovery period after 2014. This growth in the observed period moves around -5% and 5%. There is not a clear outperforming region in terms of GDP and GDP per capita growths, despite Madrid moderately outstands during the period of crisis having lower rates of GDP decrease. **Figure 4** presents the evolution of productivity growth between 2008 and 2015 for the four studied regions and the national total.

Figure 4 - Productivity Growth per Region and Year

The computation of national growth is done through a weighted average of the regional growths based on the participation of each region in terms of GDP and population.

The growth of industrial regional labour productivity has behaved similarly in all regions, excepting in Andalusia, where some extreme growths and decreases are observed. The rest of regions seem to move consistently with the national evolution with some differences in terms of magnitude. **Figure 5** presents the evolution of industrial innovation between 2008 and 2015 for the four studied regions and the national total.

Figure 5 - Innovation per Region and Year
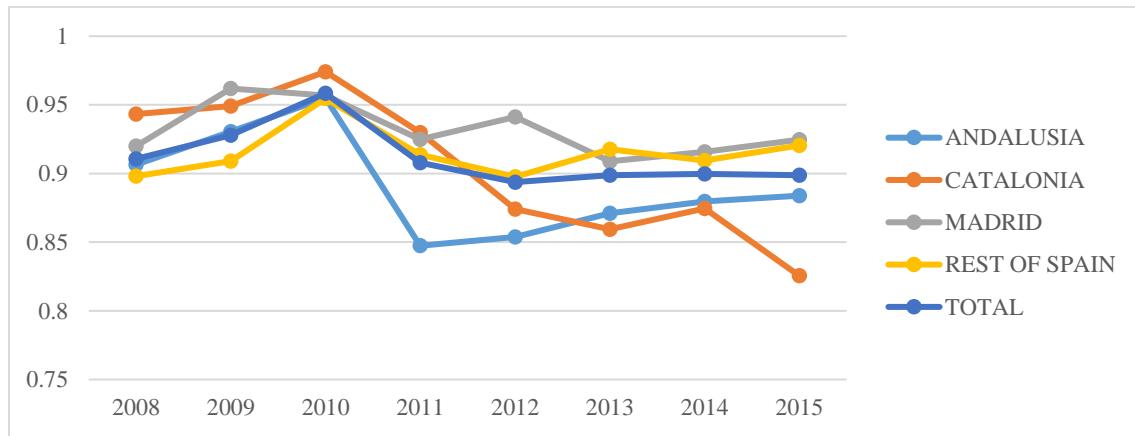
Industrial innovation seems to have a negative tendency. Only Catalonia (in 2010) and Madrid (in 2012) present outstanding results. However, the innovation rate of Catalonia in 2015 represents the lowest point for all regions and years. Finding innovation rates of around 90% seems strange. This can happen for two reasons: 1) Innovative firms are also the largest ones and there're fore have a greater weight in the computation of this variables, and 2) there can be a selection bias towards innovative firms in the PITEC database. **Figure 6** presents the evolution of UFC between 2008 and 2015 for the four studied regions and the national total.

Figure 6 - UFC per Region and Year
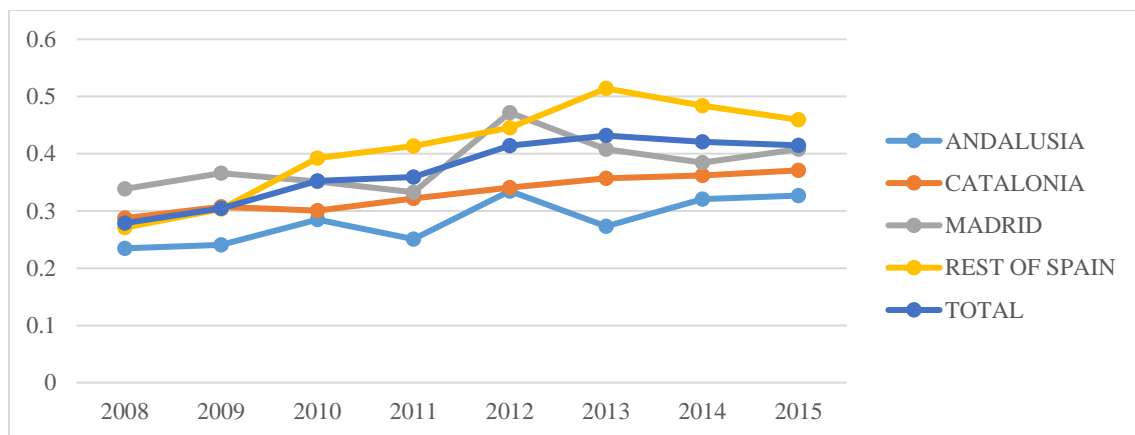
The computation of the national UFC indicator is done through a weighted average of the regional growths based on the participation of each region in terms of GDP and population.

This UFC indicator represents the intensity of UFC taking place in a region, weighted by the size of firms in terms of sales and workforce. In this sense, a higher result in this variable can be explained either through few large firms (with high weight) and/or several small firms (with low weight) conducting UFC. Nevertheless, it is important to notice that for all years and regions this variable takes values higher than 20%-25%, indicating a relevant base of collaborating firms for all Spanish regions along time. Only Madrid and Rest of Spain have overcome the national mean. **Figure 7** presents the UFC indicator disaggregated by its geographical scope for the four studies regions and the national total in 2008 and 2015.

Figure 7 - UFC Geographical Scope per Region for 2008 and 2015
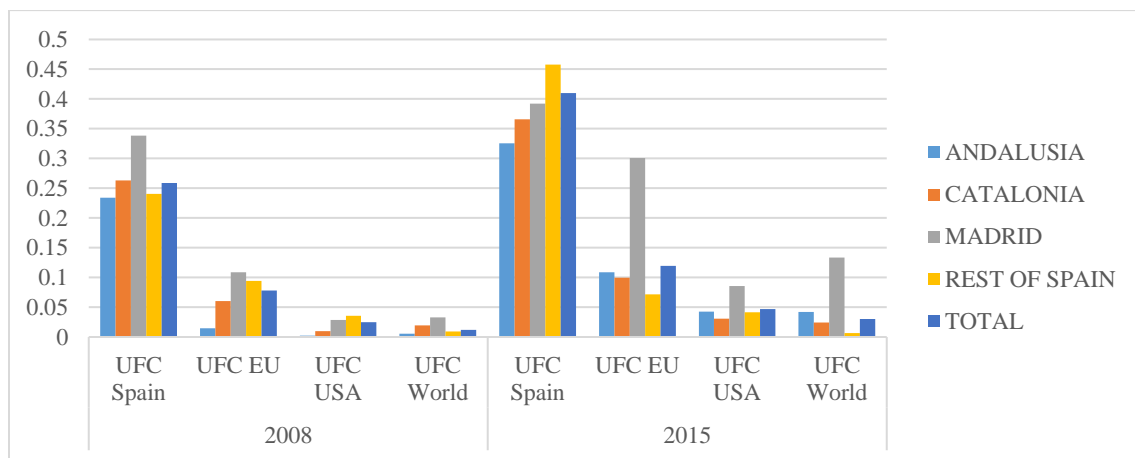
An increase in the UFC intensity is observed between 2008 and 2015 for all regions and geographical scopes. National UFC clearly predominates, followed by European UFC. However, different results are observed for Madrid region in 2015, when a relevant increase of European and other international UFC is observed. In 2015, for instance, close to 30% of the industry in Madrid collaborated with European universities.

4.2. Describing the relationship

To start, **Table 2** portrays the correlation matrix including the UFC and regional development variables previously described.

Table 2 - Correlations Matrix

	UFC	UFC Spain	UFC EU	UFC USA	UFC World	GDP Gr.	GDPpC Gr.	Innovation	Prod. Gr.
UFC	1								
UFC Spain	0.9890	1							
UFC EU	0.5364	0.5049	1						
UFC USA	0.7226	0.6900	0.7479	1					
UFC World	0.5045	0.4860	0.8764	0.7914	1				
GDP Gr.	0.0325	0.0334	0.1529	0.1360	0.0881	1			
GDPPC Gr.	0.1828	0.1741	0.2387	0.2657	0.1559	0.9661	1		
Innovation	0.0819	0.1064	0.1390	-0.0083	0.1194	-0.0805	-0.1805	1	
Prod. Gr.	-0.1042	-0.0959	0.0053	0.0106	0.0092	0.1753	0.1487	0.1505	1

The largest positive correlations are observed among the UFC variables. This occurs primarily due to the fact that UFC is composed by the geographically disaggregated UFC variables. However, it is also observed that variables of UFC in USA and the rest of the world have high correlations among them, indicating that in the regions where more UFC with universities from USA is observed mainly correspond to the regions where more UFC with other international universities is observed. In this sense, the geographical scope of UFC covering Spain and Europe is more likely to take place in some given regions, while the geographical scope of UFC covering USA and the rest of the world is also more liked to take place together for firms in other given regions.

Moving to the UFC – regional development relationship, the next findings from correlations are reached:

- **GDP Growth:** Very moderate positive correlation in all cases of UFC.
- **GDP per Capita Growth:** Very moderate positive correlation in all cases of UFC.
- **Innovation:** Very moderate positive correlation in the case of UFC in Spain, Europe and the rest of the world. Very moderate negative correlation in the case of UFC in USA. In general, very moderate positive correlation with UFC.

- **Productivity Growth:** Very moderate positive correlation in the case of UFC in Europe, USA and the rest of the world. Very moderate negative correlation in the case of UFC in Spain. In general, very moderate negative correlation with UFC.

These results can also be observed in the next dispersion graphs:
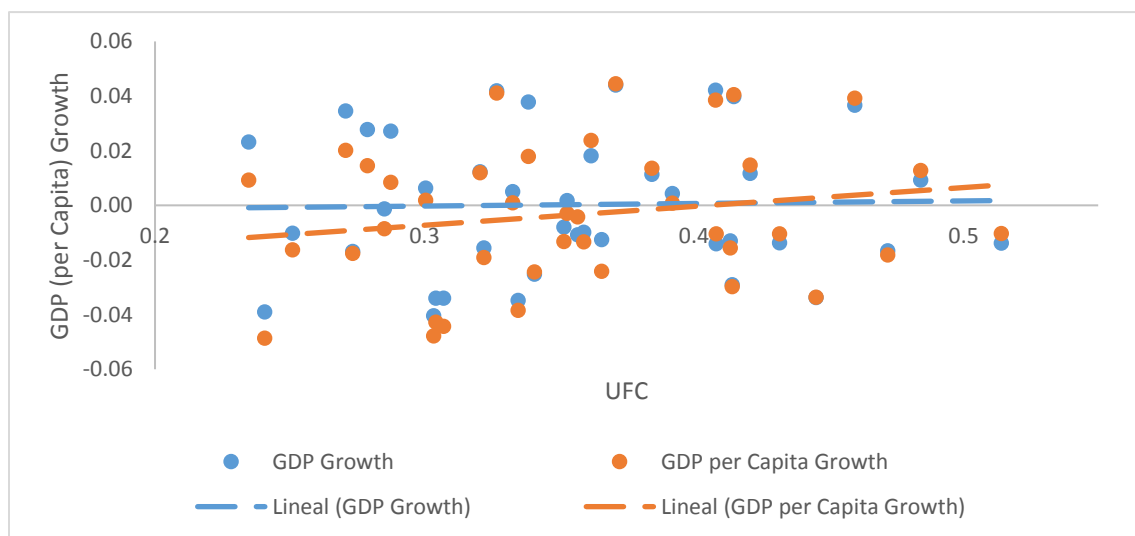
Figure 8 - GDP (per Capita) Growth VS UFC

Figure 8 shows a tendency line with a moderate positive slope when comparing GDP and GDP per Capita growths and UFC. In this sense, a moderate positive effect of UFC on GDP and GDP per capita growth could be expected. That is, UFC between **t-2** and **t** could have a positive effect on GDP and GDP per Capita growths between **t-1** and **t**.

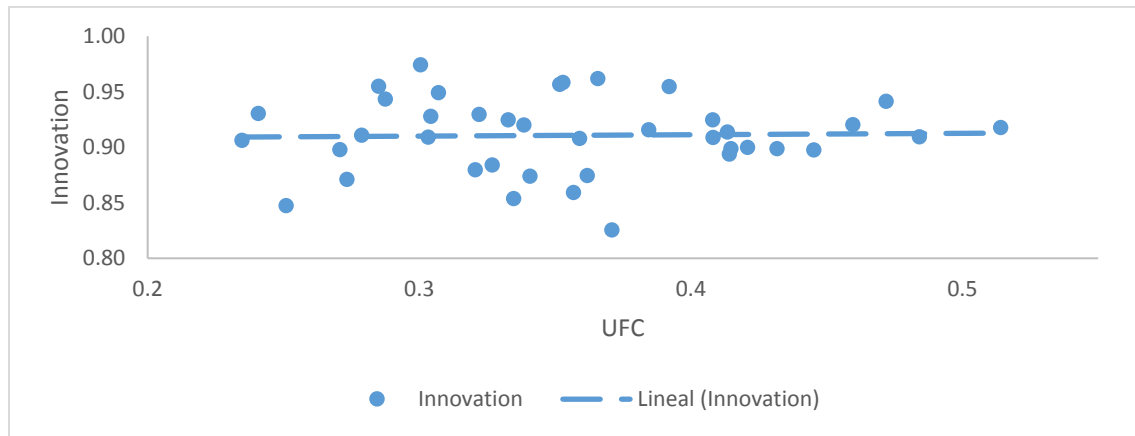*Figure 9 - Innovation VS UFC*

Figure 9 shows a tendency line with a very moderate positive slope when comparing Innovation and UFC. In this sense, a moderate positive effect of UFC on Innovation could be expected. That is, UFC between **t-2** and *t* could have a positive effect on industrial innovation between **t-2** and *t*.
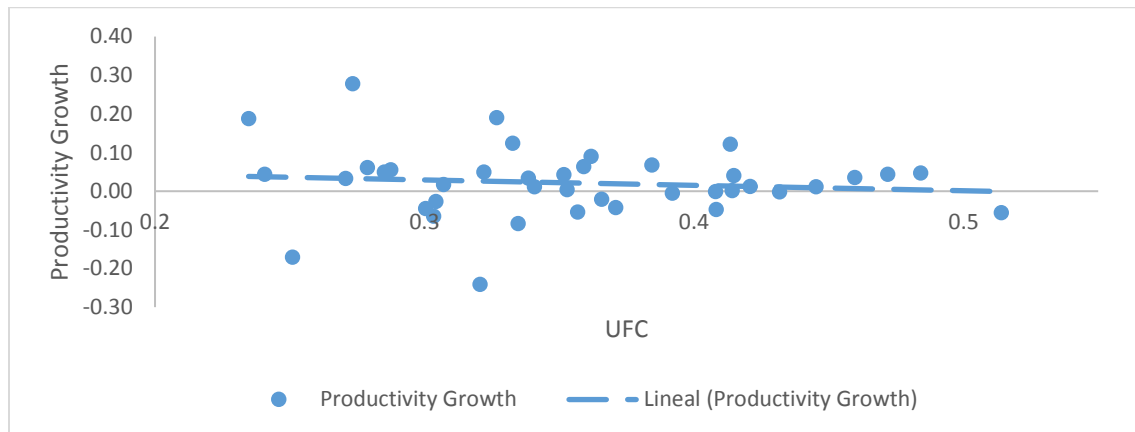
Figure 10 - Productivity Growth VS UFC

Figure 10 shows a tendency line with a very moderate negative slope when comparing Productivity Growth and UFC. In this sense, a moderate negative effect of UFC on Productivity Growth could be expected. That is, UFC between **t-2** and *t* could have a negative effect on industrial Productivity Growth between **t-1** and *t*.

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Limitations and Next Steps

So far, this working paper approaches the impact of university-firm collaboration (UFC) on regional development mainly conceptually and in descriptive statistical terms. More robust quantitative analysis using econometric tools will be required to effectively test the effect of UFC on regional development indicators. The variables used to describe regional development are economically traditional and might not reflect the aspects of development at regions related to environment, quality of life and societal development in a broader sense. Variables reflecting on such aspects should be included in the analysis, as this broader societal sense of regional development has already been partly considered in the conceptual framework of this work. The regional desegregation of industrial information among Andalusia, Catalonia, Madrid and rest of Spain might be insufficient, and more efforts need to be made in order to reach a more disaggregated regional scope in this study. This paper is still research in progress.

Acknowledgements

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