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ABSTRACT: Human capital, scientific research, and technology are the three chief mechanisms promoting knowledge spillovers from universities to firms. Based on a study of the impact of Spain's 1983 University Reform Act (LRU), which opened the door to the foundation of new universities and faculties, this paper examines whether university (or faculty) location affects the creation of new firms within a given province. We conclude that the foundation of science and social science faculties has had a marked impact on the creation of firms.

JEL Codes: I23,O31,R12,R39,C23

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1. Introduction

Universities have long been recognized as key actors in technological change and economic development. In recent decades, many countries have increased both incentives to, and the pressures on, universities to become more involved with their wider regions. Most universities have responded by offering new programs and by building closer links with business[1]. A leading issue in this relationship between universities and regional government has been the fostering of entrepreneurship and the creation of firms. To achieve these goals, regional policy has typically sought to lever the presence of local research universities, increase the availability of venture capital, encourage a culture of risk taking, and create strong local informational and business development networks (Feldman, 2001).

In the literature examining business location, the existence of agglomeration economies is usually the main factor advanced for understanding the location decision. Today, we have recourse to a sizeable body of theoretical literature on spatial agglomeration. Most notably, perhaps, New Economic Geography (NEG) provides a theoretical framework for explaining the spatial distribution of economic activity by analysing the interaction of transport costs and firm-level scale economies (Krugman, 1991). In turn, such interaction creates spatial demand linkages that further agglomeration. Thus, firms are attracted to cities where they might serve large local markets from just a few plants while incurring low transport costs (Fujita et al. 1999). In these models, however, the degree of geographic concentration is limited by rising congestion costs.

The empirical literature has traditionally focused on Marshallian micro-foundations of agglomeration economies, namely, knowledge spillovers, labour market pooling and input sharing (Rosenthal, 2001). In this field, the presence of agglomeration forces can be confirmed in sectors in which knowledge spillovers[2] are most prevalent (Audretsch et al., 1996). The evidence also seems to indicate that the most agglomerated industries are those that are oldest and specialise in relatively low-tech sectors (Devereux et al., 2004).

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[1] See Goldstein and Drucker (2007) for an overview of the literature discussing the relationship between universities and regional development.

[2] Here knowledge spillovers are measured in terms of industry R&D, university research and skilled labour.

Taking a similar line, another body of literature has adopted an approach that seeks to understand the contribution made by universities to the generation of knowledge spillovers. Varga (2000) characterized three kinds of university spillovers: information transmission through personal networks of university and industry professionals; technology transfer via formal business relations; and spillovers promoted by universities' physical facilities. Audretsch et al. (2004), in testing whether knowledge spillovers generated by universities are homogeneous with respect to scientific field, provided strong evidence of the generation of knowledge spillovers in the German university system. By classifying research and education within either the natural or social sciences, they confirmed the influence of knowledge spillovers on firms' strategic location decisions. Audretsch et al. (2005b) further corroborated that new knowledge and technological-based firms have a high propensity to locate close to universities. They reported that the two main types of spillovers are research and human capital, proxied by scientific research published in scholarly journals and human capital embodied in students graduating from a university. It has also been demonstrated that university spillovers occur through geographically localized mechanisms, the impact being significantly greater for firms that are technologically closer to research universities (Jaffe et al. 1993, Kantor and Whalley, 2009), and over longer distances through collaborative research (Ponds et al. 2009).

Such studies have also been concerned with analysing the fundamental factors involved in the formation of an entrepreneurial culture. Feldman (2001) summarises these as supportive social capital, venture capital, entrepreneurial support services and actively engaged research universities. Thus, the birth of new firms, mainly in high-tech sectors (HT hereafter), should be positively associated with higher levels of educational attainment (Acs and Armington, 2002), university R&D expenditure (Woodward et al., 2006; Kirchhoff et al., 2007) and university research (Bania, 1993; Colombo et al. 2010). In the Spanish case, Acosta et al. (2009) reported that the main source of university spillovers that accounted for new HT-business location close to universities was the number of graduates.

In general, the literature has tended to consider only homogeneous spillovers. However, the universities carry out activities (both research and teaching) in many scientific disciplines with a highly varied degree of industrial and commercial applicability. As such, it is of interest to identify any underlying differences that might exist between the types of knowledge generated by universities. To date, only Audretsch (2004) has conducted such a differentiated analysis (see discussion above). Here, we adopt a similar approach and distinguish between three different fields of knowledge. However, we are able to take our analysis one step further by incorporating recent changes in the university regulatory framework operating in Spain. In this way, we capture effects that have previously been overlooked. The paper has two main goals: first, to contribute to the empirical literature on the relationship between universities and regional economic development, or more specifically to analyse the effect of the presence of a university on the creation of new firms; and, second, to identify more precise modes of knowledge spillover mechanisms by differentiating between the academic fields through which a university might influence the region in which it is located.

To achieve this, we first focus our study on a period in which significant university reforms were made. Spain's 1983 University Reform Act (LRU) encouraged regions to expand their existing universities and to create new institutions. As a result, the state university system underwent considerable territorial expansion. As such, the legislation represents a natural experiment that serves to estimate the effects of university spillovers on the creation of new firms, all the more so because any shifts in entrepreneurial activity before and after the introduction of the law can be compared. Second, by distinguishing between university faculties in terms of the main academic studies being offered, we are better able to identify more specific knowledge spillover mechanisms. In addition, we are also interested in observing which industrial sectors are influenced most. Thus, more specifically, we seek to determine whether the creation of faculties has had an effect on new firm start-ups in high, medium, and low technology sectors[3]. The main findings can be summarized as follows: the creation of faculties in academic fields such as the sciences and social sciences has had a positive effect on the creation of new firms.

The remainder of the paper is organized as follows: section 2 describes the main features of the 1983 University Reform Act and its implications for the creation of new universities and faculties; section 3 describes the data and outlines the empirical strategy; section 4 presents the results; and, finally, section 5 concludes.

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[3] In a similar context, Frenette (2009) assesses the impact of creating new universities on the university attendance rate among the local youth.

2. The University Reform Act (LRU)[4] of the early 1980s.

In the late 1970s and during the 1980s, Spain implemented a number of significant institutional changes. Among them, the higher education system was subject to substantial political and economic reforms. The most significant impact on Spain's universities was the transition to democracy and the new concept that was adopted of the state (Mora and Vidal, 2005). The first milestone was the inclusion within the 1978 Spanish Constitution of the three basic principles on which university legislation was to be based; the right of all Spaniards to education, academic freedom, and the autonomy of the universities (OECD, 2008). Later, in 1983, the enactment of the LRU sought to modernize the university system, improve its quality and enhance its competitiveness.

The Act introduced several radical changes, focussing primarily on the social embeddedness of the universities, their democratic organisation, and the need for a far-reaching modernisation of their scientific capabilities. Three aspects of this reform are of specific interest to us here. First, we examine the devolution of powers for the planning and administration of higher education, from the 1980s until the mid-1990s, from central to regional governments. The LRU introduced a decentralised model of governance for managing higher education organized in four tiers; the state, the autonomous regions, local governments and educational institutions. Today central government, through its Ministry of Education, controls the legal framework that guarantees the homogeneity and unity of the education system. The government elected in each autonomous region regulates and administers the higher education institutions (HEIs hereafter) within its territory. It has the jurisdiction to establish, authorise and supervise the running of public and private institutions, academic and administrative staff, and to build new educational facilities and renovate existing ones.

The Act granted regional governments the power to implement their own higher educational policy, including decisions to create new universities. As a result, many regions created new universities, and others opened at least one new faculty (See Figure 1), and hence bringing about a marked rise in the number of such institutions. Since 1983, a total of forty new HEIs (new universities or new campuses) have been created.

[4] *Ley de Reforma Universitaria* – henceforth LRU, in its Spanish acronym.

The Spanish Constitution allows for the public and private ownership of universities. Public universities can be established either by law enacted in the national parliament in accordance with the local regional governments, or by legislation drawn up directly by the legal assemblies of the autonomous regions. With the approval of the autonomous government, any person or legally recognized entity can found a private university, which can either be owned and run by the Catholic Church or have lay university status. Although the number of private universities has increased since the 1990s, Spain's university system is still largely dominated by public institutions. Between the introduction of LRU and 1994, twenty-two universities were founded, i.e. 32% of all institutions were created during our period of analysis. At the same time, most of the existing universities increased their operations, expanding into new territories. Thus, during the 1980s, the number of students enrolled at Spain's universities rose rapidly. In 1970 the number of university students stood at 352,000, by 1980 it had risen to 698,000, and by 1985 935,000 students were enrolled (Hernández, 1983). Thus, in short, the university system underwent unprecedented expansion (see Table 3).

Second, the LRU ushered in much greater university autonomy. It granted university governing bodies control over their own planning and management, including financial autonomy. This autonomy means they are entitled to draw up their own statutes and choose, designate, and change their governing and representative bodies. The third consequence of the reform was the universities adopted a clearly defined dual-dimension - teaching and research - in line with their European counterparts. Incentives to encourage joint R&D projects involving universities and the private sector were also introduced. As a result, university R&D expenditure increased from 0.11% of GDP in 1983 to 0.28% in 1994.

In sum, the LRU radically changed the framework regulating Spain's universities. In methodological terms, the Act represents an exogenous source of variation, because the establishment of a new university, which is the central causal parameter of interest in this study, derives from a political decision.

3. Data and estimation strategy

One of the main empirical challenges faced in identifying the impact of a new faculty on the creation of new firms is the fact that the opening up of new faculties is usually endogenous to the economy, in the sense that the strongest economic agglomerations constitute the demand for founding new faculties. Moreover, the marginal impact of a new faculty (or university) may be small, in relative terms, within very large agglomerations, and therefore difficult to detect. For this reason, we have excluded from our econometrical analysis those provinces that created faculties before the onset of our period of analysis.

In order to determine the impact of the presence of a university on the creation of new firms, we assembled a data set for the Spanish provinces (NUTS 3) for the period 1980 to 1994. Below we describe the data base and define our variables. We then outline our estimation strategy and include a brief explanation as to our empirical approach. Finally, we present the specification adopted for conducting the econometric analysis.

Spain has 50 public universities located in 43 of its 52 provinces[5]. This public university system comprises 470 faculties operating across the range of academic fields (INE, 2009). We have obtained information for 224 of these faculties, 38% of which were founded after the enactment of the LRU. Our study exploits the differential timing of faculty foundations in each academic field across Spanish provinces, to identify how the presence of a university can affect new firm start-ups.

3.1 Data

As noted, because our main hypothesis assumes that the relationship between universities and the creation of firms depends on the academic disciplines being offered by that institution, the presence of a university is classified in accordance with three broad fields: sciences and engineering (SCI+Eng), social sciences and humanities (SSCI+Hum), and health sciences (HEALTH)[6]. For each province, we noted the year in which the faculties dedicated to each of these fields were founded. We were only

[5] Some of the largest Spanish universities have campuses in different provinces. For instance, the Universidad de Castilla-La Mancha has four campuses across four different provinces: Albacete, Ciudad Real, Cuenca and Toledo.
[6] The category includes medicine, pharmacy, and nursing.

interested in those faculties founded during the period of analysis[7]. As such, this particular setting provides a unique opportunity to analyze the linkages between the presence of a university and new firm start-ups.

Our main outcome variable is the creation of industrial firms throughout the Spanish provinces in a given year. The database on new firm formations comes from the Register of Industrial Establishments (RIE), constructed by the Spanish Ministry of Industry and Energy. It provides administrative information about the opening of industrial establishments by sector, their initial investment, number of workers, electrical power supplied, and geographical location. Unlike other sources, the RIE takes the establishment as its unit of information, rather than the company - an attribute that allows us to be more geographically accurate. During the period considered 124,957 new firms were created in the Spanish manufacturing sector, 14% of which were in medium and high-tech (MHT) industrial sectors. A notable feature of these enterprises is that 87% of them started with fewer than 10 workers, and that 99.4% of them started with fewer than 100 workers[8].

We further complement our panel with a set of variables that allows us to study agglomeration economies. First, we include the Herfindahl index and the population of each province. Second, to test the role of the market on the location of a new firm, a market potential measure is introduced. The exact definition of variables is described below. These data were obtained from the National Institute of Statistics (INE) and the BBV foundation (1999). Table 1 provides descriptive statistics of the data.

3.2 Estimation strategy

Following the enactment of the LRU, most regions founded at least one new faculty in each of the three academic fields defined. However, the exact year of foundation of each new university varied from region to region (as illustrated in Table 2), as did that of their new faculties (Table 3). Exploiting this geographical and temporal variation in the foundation of faculties, we were in a position to compare the creation of firms before and after the foundation of the faculty in the different regions. Hence, we used a difference-

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[7] This information was, in most cases, complemented and confirmed by faculty staff via email.
[8] This is consistent with the size distribution of firms in Spain, a country with a traditionally high share of SMEs.

in-differences approach (DD) to estimate the effect that the foundation of faculties had had on the creation of new industrial firms in the period. By adopting this strategy we were able to avoid the endogeneity problems that typically arise when making comparisons between heterogeneous individuals (Bertrand et al., 2004).

The fundamental idea underpinning the DD-estimator can be explained graphically with the help of Figure 2. The DD-estimator takes the "normal" difference between the treatment and control group as the distance CB and estimates the treatment effect as the distance AC. Here, the underlying assumption is that the trend in Y is the same in both treatment and control groups. Also, the DD-estimator assumes that any differences in the change in means between treatment and control groups are the result of the treatment. Finally, the DD method is based on the idea that the unobserved provincial component does not vary over time within a group. If any of the assumptions listed above do not hold then we have no guarantee that the DD-estimator is unbiased. For example, one of the most common problems with DD estimates is the failure of the parallel trend assumption[9]. One way to help avoid this problem is to obtain more data for other time periods before and after treatment to determine whether there are any other pre-existing differences in trends.

The DD-estimator has the following form:

$$Y_{it} = \beta_0 + \beta_1 X_i + \beta_2 T_t + \beta_3 X_i * T_t + \varepsilon_{it} \qquad (1)$$

Where X_i is a dummy variable taking the value 1 if the individual is in the treatment group, 0 if it is in the control group, and T_t is a dummy variable taking the value 1 in the post-treatment period and 0 in the pre-treatment period. In this specification, the DD-estimator is β_3, the coefficient on interaction between X_i and T_t. It is a dummy variable that takes the value 1 only for the treatment group in the post-treatment period. In addition, the DD approach is based on the assumption that the influence of other factors can be controlled for by a comparison with a province that is similar in every aspect as regards effects on firm formation, but which has not created a faculty.

In our econometric framework only the foundation year of each faculty is assumed to be exogenous. The estimations consider solely those provinces in which a faculty was founded during our period of analysis, i.e. provinces which had a faculty before 1980 are excluded. Moreover, according to Varga (2000), Audretsch (2005b) and

[9] Figure 3 illustrates the performance of this assumption for our data.

Acosta (2009) the main source of university spillovers is the number of graduates, hence, it is fair to assume that the effects of university presence on regional economy occur at least five years after its foundation.

The DD equation, for our panel data for the creation of firms in 50 provinces over 15 years, is given in equation (2)

$$Y_{ijt} = \alpha_{ij} + \beta_1 Fac_{i,\, t+5} + \beta_2 lnMP_{i,\, t} + \beta_3 lnPop_{i,\, t-1} + \beta_4 HI_{i,\, t} + \gamma_t + \varepsilon_{ijt} \qquad (2)$$

The dependent variable is the number of new industrial establishments in province i, year t and industrial sector j. The main explanatory variable is the dummy variable $Fac_{i,\, t+5}$, which equals one for province i in year t+5 (where t is the year when a faculty was founded), and zero otherwise. As one objective of this study is to analyze whether the kind of science matters in the production of knowledge spillovers, the variable *Fac* alternates between the three academic fields (SCI+Eng, SSCI+Hum, and HEALTH).

As discussed above, agglomeration forces are a key factor affecting the choice of a firm's location. We include urbanization and localization economies proxied by a province's population ($lnPop_{i,\, t-1}$) and employment specialization index ($HI_{ij,\, t}$), respectively. As in Rosenthal and Strange (2003), the diversity of economic activity is incorporated using a Herfindahl index of employment by 11 two-digit manufacturing industries, defined as

$$HI_{ij,t} = \sum_s \left(\frac{e_{si}}{e_i} \right)^2$$

Where $HI_{ij,\, t}$ is the Herfindahl index for region i and year t. e_{si} is the employment in sector s in province i, e_i is the total employment in province i. An increase in $HI_{i,\, t}$ reflects less diversity in the environment. Duranton and Puga (2001) suggested that if diversity plays a more important role for firm births, the coefficient for this index is expected to be negative and significant.

Furthermore, agglomeration forces draw firms towards places characterized by better access to customers ('demand or backward linkages') and suppliers ('cost or forward linkages') (Ottaviano and Pinelli, 2006). An empirical way to introduce this effect is a market potential measure. Harris (1954) proposed a classic gravity-type measure, in which the potential between two locations is positively related to their size and negatively related to the distance between them. Market potential is given by the following expression[10]:

$$MP_{j,t} = \ln\left[\sum_k \frac{M_{k,t}}{d_{jk}}\right]$$

Where $M_{k,t}$ is a measure of the market size of the destination k (e.g. measured in terms of population or GDP), d_{jk} is the distance between origin j and destination k. These variables are expressed as a logarithm to reduce heterogeneity and to detect non-linear relationships.

Finally, the panel specification includes annual time dummies[11] (γ_t) and in order to control for unobserved regional heterogeneity, province and industrial fixed effects (α_{ij}) are also introduced. We use 34 industry sectors to better control for aggregation effects in regions with a different distribution of industries. Industry codes are based on the two-digit National Classification of Economic Activities (NACE 93 Rev.1).

Arauzo et al. (2010) synthesize in two categories the basic econometric tools adopted in empirical studies on industrial location: Discrete Choice Models (DCMs) and Count Data Models (CDMs). Thus, when the unit of analysis is the firm/plant and the main concern is how its characteristics (size, sector, etc.) and/or those of the chosen territory (population, infrastructures, etc.) affect location decisions, DCMs are used. When the unit of analysis is geographical (municipality, county, province, region, etc.), and the factors that affect location decisions therefore refer to the territory, then CDMs are used.

From a statistical viewpoint, given that the dependent variable has the features of count data, it can be assumed that this variable follows a Poisson distribution. That is, it has large numbers of the smallest observation and remaining observations taking the form of small positive numbers[12].

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[10] Head and Mayer (2005) calculate and compare complex alternative measures of market potential. However, the results are very similar to the specification suggested by Harris (1954).

[11] We also estimated a version of the model by including an interactive term between annual and industrial sector dummies, in order to better absorb specific shocks for industrial sector and year. The results are very similar to those reported below.

[12] Following Arauzo et al. (2010), the underlying assumptions in empirical studies on industrial location using count data models imply the existence of an equilibrium allowing the derivation of the number of new firms/plants created in a given region over a given period. This equilibrium results from the existence of stochastic, unobservable, and location-specific demand and supply functions of potential entrepreneurs.

A key issue in count data models is the presence of overdispersion, and therefore, the choice between the Poisson model and the negative binomial model. In order to solve this, Cameron and Trivedi (2009) suggest that the Poisson panel estimators rely on weaker distributional assumptions - mainly, correct specification of the mean - and it may be more robust to use it with cluster-robust standard errors, than with the negative binomial estimators[13]. Figure 4 shows the distribution of the dependent variable.

4. Results

The first set of regressions estimate the aggregate effect (rather than the separate effect by industrial sector) of university creation on new firm start-ups. As discussed above, the assumption is that the effect takes place five years after the creation of the university, as the first year intake graduates. Thus, this specification includes a dummy that takes the value one commencing five years after the foundation of the university (or faculty). In all regressions, we include cluster-robust standard errors so as to account for both overdispersion and serial correlation. Two empirical issues should be mentioned: Firstly, although we included a lagged value of the logarithm of province population in the initial model (equation 2), we had to eliminate it because of multicollinearity problems both with the university variable and market potential. In an attempt at avoiding this, we changed the method of calculating market potential by introducing provincial GDP rather than population. However, the multicollinearity could not be solved. Secondly, we did not include spatial econometric techniques because Moran's I statistic rejected the presence of spatial autocorrelation in the geographic distribution of new firms in Spain in our period of analysis.

Table 4 shows the results from this first model[14]. In column 1, the effect of university foundation on firm creation is positive and statistically significant. Likewise, the coefficient of market potential is positive and significant. Since our unit of analysis is the province, the adoption of a fixed effects (FEs hereafter) estimation helps to control for

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[13] In order to rule out overdispersion from our data, after applying this specification the test suggested by Cameron and Trivedi (2005) was computed, and the null hypothesis of no overdispersion was accepted.
[14] Both Poisson and negative binomial models are reported in this case in order to verify consistent estimations.

unobserved heterogeneity specific to each province[15]. As shown in column 2, the significance of our explanatory variables disappears when FEs were included. FEs capture province specific determinants of location such as regional policy, institutional framework, and remoteness. Thus, province determinants absorb all the explanatory power of the creation of universities. Finally, Table 4 (columns 3 and 4) shows the results when we re-ran the same specification using a negative binomial estimator. In both cases, the magnitude of coefficients and the statistical significance were very similar.

Our last model adopts the specification corresponding to equation 2, i.e., by clustering the dependent variable for industrial sectors across each region, and where year and regional-industrial sector FEs are both included. The results are shown in columns 1 to 3 of Table 5. The results are presented for separate regressions for each academic field. Thus, the specification in column (1) of Table 5 includes the dummy for the creation of SCI+Eng faculties. Similarly, in columns (2) and (3) the specifications alternate the variable Fac for each academic field. The results present two patterns. In the first of these, including SCI+Eng and SSCI+Hum, both the signs and statistical significances of the coefficients are as expected.

Regional and national market access, proxied by a market potential measure, produces ambiguous results. In the case of SCI+Eng, it is revealed to have a substantial positive influence on firm location, whereas for SSCI+Hum it is not statistically significant. We find no evidence to support the presence of localization economies. Systematically, the coefficient of the specialization index is not statistically significant. This outcome is probably due to the fact that FEs absorb all the explanatory power, as industrial structure shows only small variability across time.

As for urbanization economies, when the regression includes the SCI+Eng faculties, the coefficient of the lagged logarithm of population is not statistically significant. We obtain statistical evidence of the presence of urbanization economies when the faculty of SSCI+Hum is included. Nevertheless, this result should be taken with caution because population and establishment of faculties are correlated - the probability of creating a faculty is as large as the size of the province's population. Despite this, we wish to control for this key variable and so have kept it in our analysis for the following reasons: firstly, both the magnitude and the statistical significance of coefficients are very

[15] A Hausman test was performed, indicating that the differences between the fixed and random effects' coefficients are not systematic. Therefore, both procedures are appropriate.

similar when the variable of urbanization economies is dropped from the regressions; secondly, in the current analysis, the number of observations is higher than in the previous one conducted at the level of the province; and, finally, the variable is introduced in a logarithm in order to reduce collinearity.

In the second pattern presented by the results, the creation of health faculties seems to have no statistically significant impact on new firm start-ups (see column 3, Table 5). It could well be argued on this point that the number of health faculties founded during the period of analysis was smaller than for those created in other academic fields, and that influence of health faculties on regional development occurs through other channels. As the OECD (2008) suggested, HEIs have actively taken part in promoting community service in areas such as public health and the arts throughout history. In this model, the market potential does not have a significant effect on the dependent variable either. Only the coefficient of the variable for urbanization economies is positive and statistically significant.

It is also interesting to examine whether the kind of faculty founded has a specific impact on a particular industrial sector. Here, we are interested in testing the existence of a relationship between the creation of faculties and HT firm formations. In order to test this link, we split the sample into three groups; high, medium, and low tech. The results are presented for each group in Table 5.

It was not possible to determine whether there was a relationship between the foundation of faculties and the creation of HT firms (see columns 4 to 6). Three arguments can help explain this result. First, our data only include firms from the industrial sector, and perhaps this linkage is strongest in service sector firms. Second, the period under analysis could be characterized by a lower dynamism in the creation of high tech industries. In fact, during the period analyzed only 2,620 firms were created in HT sectors, representing just 2% of total firms. Third, only recently has the creation of science parks or the increase in the volume of contracts of the Offices for the Transfer of Research Results (OTRI) shown an expansion of the relationship between the universities and the firms in the transmission of knowledge (Barrio and Garcia-Quevedo, 2005).

Columns 7 to 9 show the results for medium tech sectors. Only the faculty variable SSCI+Hum yields a statistically significant coefficient. Here again, market potential seems to have an important influence on firm formation when the faculties of SCI+Eng are included (See column 7).

The regressions for low tech industrial sectors are shown in columns 10 to 12. In general, the results are similar to those of the whole sample. Two patterns also emerge: the faculties of SCI+Eng and SSCI+Hum have a significant positive effect on firm formations (see columns 10 and 11), but health faculties have no significant effect on the dependent variable (see column 12). Both market potential and urbanization economies show similar results to those of the whole sample. A key difference between the other groups is that the coefficient of localization economies, measured by an employment specialization index, is statistically significant.

A further key issue to analyze in the relationship between universities and the regional economy is the impact of the former on employment. HEIs fulfil a leading role in preparing people for employment, along with their more traditional roles of teaching and conducting research. Indeed, over recent decades, some countries have allocated specific funds to encourage HEIs to embed the learning of the key skills required by employers in academic programmes. It is also known that in the labour market, highly skilled workers show a higher economic activity rate and lower unemployment rate than their low skilled counterparts.

To verify the robustness of our previous results, we changed the dependent variable. Thus, we analysed the effect of the presence of a university on the generation of employment. The new dependent variable was the number of new jobs in province i, year t and industrial sector j. We introduced a set of explanatory variables including the dummy of faculty creation, province population, specialization index, and the total number of firms created in province i, industrial sector j, and year t-1. Table 6 presents the results and it can be seen that they do not change to any considerable extent. For instance, the result for the SCI+Eng faculties is confirmed (see column 1 and 10). The coefficient for the creation of faculties in this academic field is once more statistically significant, indicating it has an important and positive effect on the generation of employment. The lag in the new firm start-ups exerts a considerable influence on the generation of new jobs, a feature that is retained across all industrial groups. An exception to this result is produced in the case of SSCI+Hum and HEALTH faculties (see columns 2, 6 and 9).

If we examine the corresponding results for the specialization index, which here can be interpreted as a measure of labour market specificity, they confirm its explanatory power on the dependent variable in the case of medium and low tech sectors (see columns

8, 9 and 12). Conversely, market potential does not show a significant statistical relationship with the generation of employment.

A second verification of robustness concerns the assumption that a university's effects are felt five years after its foundation or the establishment of a new faculty. In unreported regressions, we modified the value of the dummy variable $Fac_{i,t+5}$ to $Fac_{i,\ t}$ where t is the year of faculty establishment (or university creation). The results indicate that there was no significant contemporaneous effect on new firm formations from this alternative specification. These results confirm the importance of the university effect on human capital via graduated students with a time lag.

5. Concluding comments

Universities have long been recognized as a key element in regional economic development. In more recent years, universities have increased their attempts at raising regional entrepreneurial culture, above all by generating knowledge spillovers. As a result, an understanding of these spillover mechanisms has become an issue of increasing interest in the literature. In this paper, we have sought to explore this field further by incorporating a new methodological approach that has allowed us to examine, more accurately, the effect of the foundation of new universities on new firm start-ups. Thus, by taking into consideration the exogenous changes in the foundation of university faculties ushered in with the Spanish University Reform Act of 1983 (LRU), this paper has analyzed the linkage between the presence of a university and new firm formations. By drawing on data from the register of new industrial establishments and faculty foundation dates, it has been possible to examine the effect of knowledge spillovers on the creation of new firms in Spain.

Our results consistently show that the creation of universities had a marked impact on new firm start-ups, with the foundation of SCI+Eng and SSCI+Hum faculties presenting a positive affect on firm formations. For these two academic fields, therefore, we confirm the central hypothesis of this paper. By contrast, the creation of health faculties did not have a significant effect on new firm start-ups during the period analyzed. In short, the Spanish case presents strong evidence that the presence of a university is a key factor taken into account by firms when reaching their locational decisions.

Furthermore, it has been possible to validate that the most important effect of the universities on the economy occurs via human capital. However, as university research and technology transfer have only just recently received a significant boost in Spain, these effects have not been captured in our analysis.

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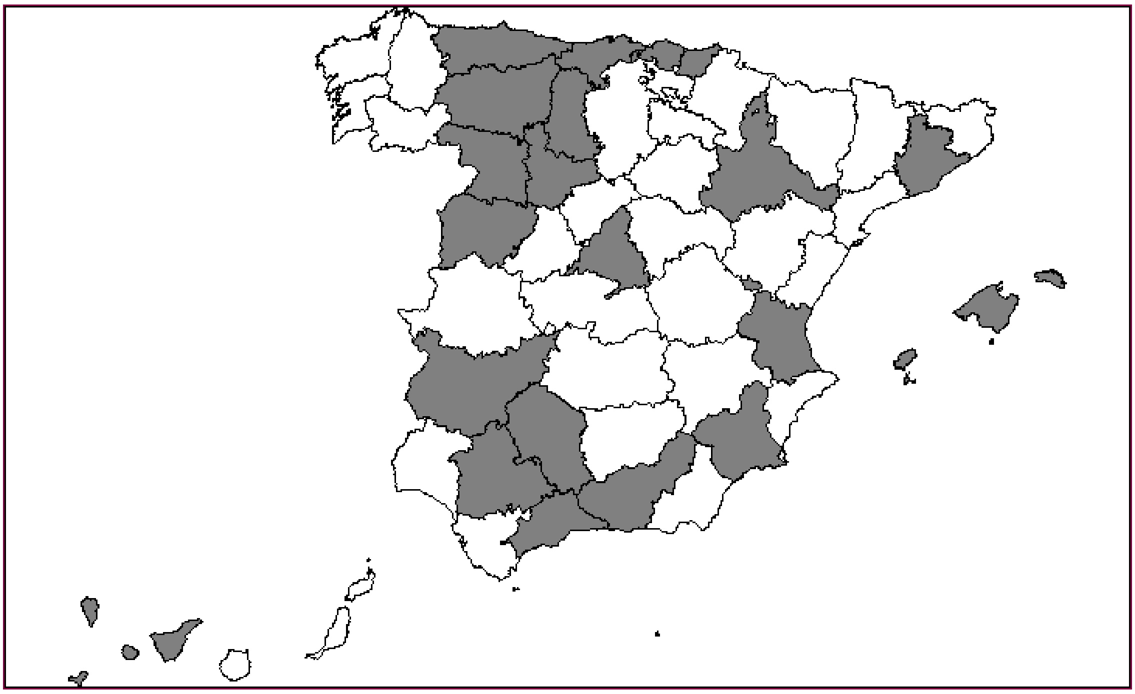
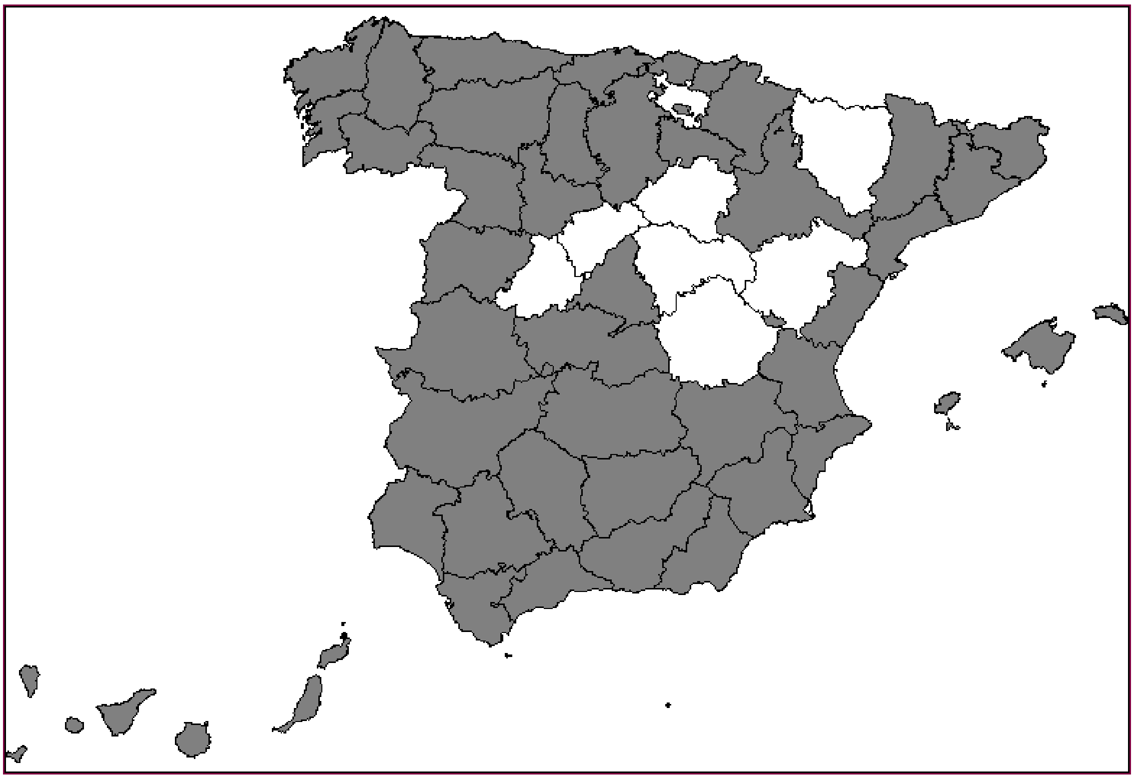
Figure 1. Change in the geographic distribution of Spain's University System 1980 - 1994.

1980



1994



■	Spanish provinces with at least one university or faculty.
□	Spanish provinces without university.

Figure 2. Difference-in-differences analysis.

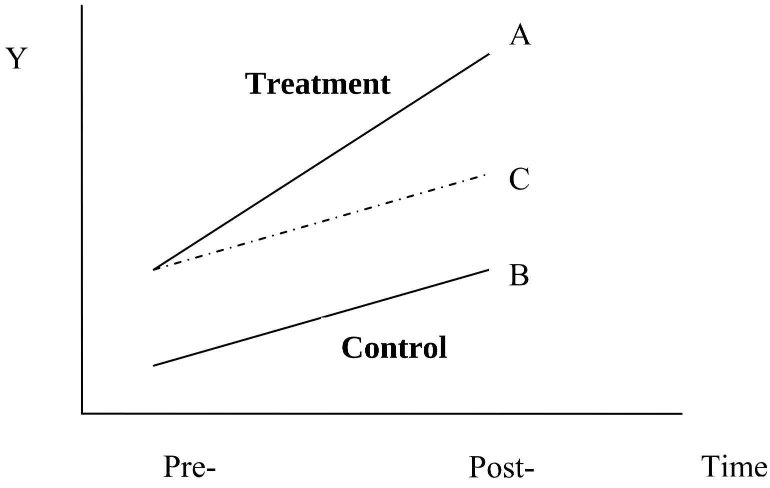
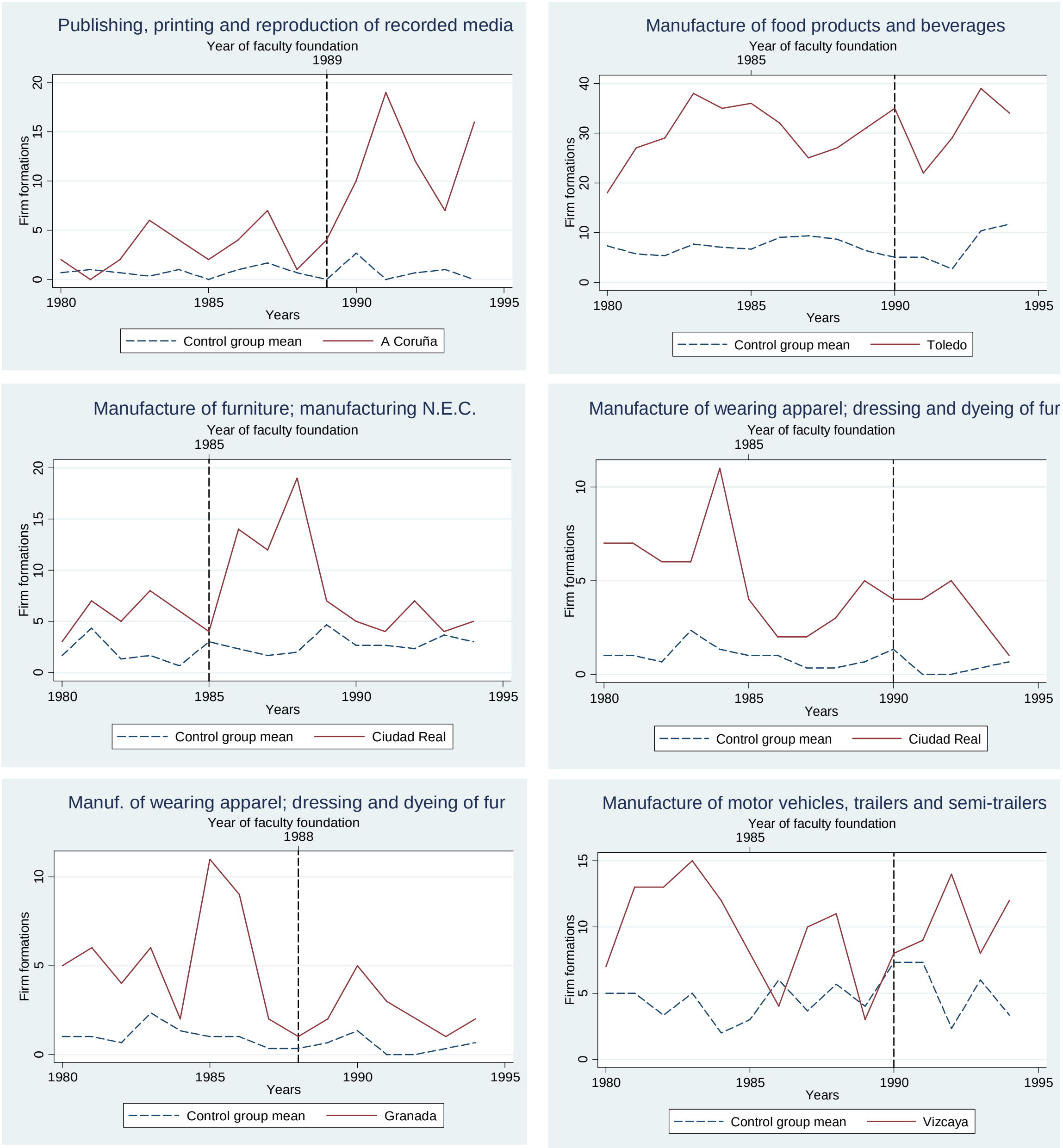


Figure 3. Treatment trends in firm formations in selected treated provinces and control group, at the time of the creation of faculty.

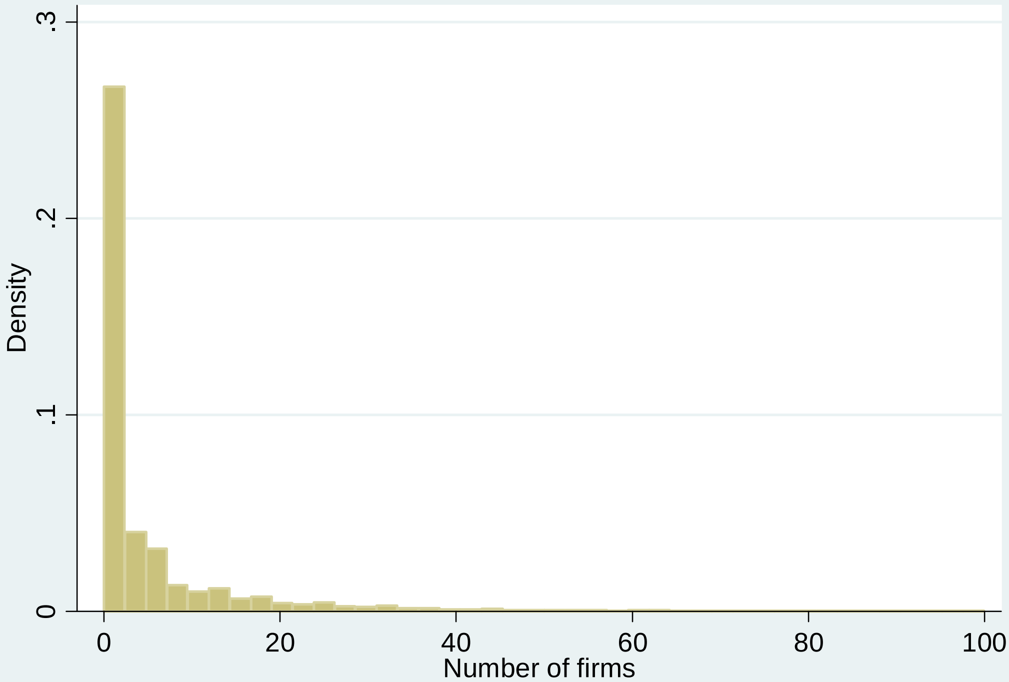
a) at time of the creation of faculty

b) five years after the creation of faculty



Notes: Figures illustrate the trend in firm formations.
(1) Control group comprises provinces such as Avila, Segovia, Soria, Huesca, Teruel.

Figure 4. Histogram of firm formations across industrial sectors and provinces



Note: Figure illustrates the distribution of the dependent variable for values lower than 100.

Table 1. Descriptive Statistics

Variable		Mean	SD	Min	Max	Observations
Number of firms	overall	6.646631	19.1718	0	408	N = 19365
	between		17.06832	.0666667	276.4	n = 1291
	within		8.743054	-223.7534	351.9133	T = 15
Fac. of Sciences and Engineering	overall	.5433514	.49813	0	1	
	between		.4412997	0	1	
	within		.2313631	-.1233153	1.476685	
Fac. of Health	overall	.5414924	.4982883	0	1	
	between		.4603435	0	1	
	within		.1911237	-.2585076	1.474826	
Fac. of Social Sciences and Humanities	overall	.5802221	.4935352	0	1	
	between		.428789	0	1	
	within		.2446424	-.2864446	1.513555	
Market potential	overall	3856.686	4888.254	660.9784	30718.94	
	between		4802.061	843.4212	25084.43	
	within		923.6286	-1456.061	9491.197	
Specialization index	overall	33825.98	1111975	1.952862	1.23e+08	
	between		634588.7	3.903821	1.86e+07	
	within		930245.2	-1.86e+07	1.05e+08	
ln Population$_{t-1}$	overall	13.24084	.8172677	11.45558	15.45459	
	between		.8147776	11.49133	15.39672	
	within		.0673671	10.88296	15.90394	

Table 2. Year of foundation of Spanish universities[16].

No.	University	Province	Year of foundation	Type
1	U. San Jorge	Zaragoza	2005	Private
2	U. Abat Oliba CEU	Barcelona	2003	Private
3	U. Católica de Valencia San Vicente Mártir	Valencia	2003	Private
4	U. Europea Miguel de Cervantes	Valladolid	2002	Private
5	U. Cardenal Herrera - CEU	Valencia	1999	Private
6	U. Camilo José Cela	Madrid	1998	Private
7	U. Pablo de Olavide	Sevilla	1997	Public
8	U. S.E.K.	Segovia	1997	Private
9	U. Internacional de Catalunya	Barcelona	1997	Private
10	U. de Vic	Barcelona	1997	Private
11	U. Mondragón Univertsitatea	Guipúzcoa	1997	Private
12	U. Miguel Hernández de Elche	Alicante	1996	Public
13	U. Rey Juan Carlos	Madrid	1996	Public
14	U. Católica de Ávila	Ávila	1996	Private
15	U. Católica San Antonio	Murcia	1996	Private
16	U. Europea de Madrid	Madrid	1995	Private
17	U. de Burgos	Burgos	1994	Public
18	U. Oberta de Catalunya	Barcelona	1994	Private
19	U. de Almería	Almería	1993	Public
20	U. de Huelva	Huelva	1993	Public
21	U. de Jaén	Jaén	1993	Public
22	U. de La Laguna	S. Cruz de Tenerife	1993	Public
23	U. Alfonso X El Sabio	Madrid	1993	Private
24	U. Francisco DE Vitoria	Madrid	1993	Private
25	U. San Pablo - CEU	Madrid	1993	Private
26	U. Rovira I Virgili	Tarragona	1992	Public
27	U. de La Rioja	Rioja (La)	1992	Public
28	U. de Girona	Girona	1991	Public
29	U. de Lleida	Lleida	1991	Public
30	U. Jaume I de Castellón	Castellón	1991	Public
31	U. Pompeu Fabra	Barcelona	1990	Public
32	U. Ramón Llull	Barcelona	1990	Private
33	U. de A Coruña	Coruña (A)	1989	Public
34	U. de Vigo	Pontevedra	1989	Public
35	U. Carlos III de Madrid	Madrid	1989	Public
36	U. Pública de Navarra	Navarra	1987	Public
37	U. Antonio de Nebrija	Madrid	1985	Private

[16] The table only includes full-time universities. Our analysis does not take into consideration universities (or faculties) created after 1994 and before 1980.

38	U. de Castilla-La Mancha	Albacete	1982	Public
39	U. de Cádiz	Cádiz	1979	Public
40	U. de Las Palmas de Gran Canaria	Palmas (Las)	1979	Public
41	U. de León	León	1979	Public
42	U. de Alicante	Alicante	1979	Public
43	U. de Las Islas Baleares	Islas Baleares	1978	Public
44	U. de Alcalá de Henares	Madrid	1977	Public
45	U. de Córdoba	Córdoba	1972	Public
46	U. de Málaga	Málaga	1972	Public
47	U. de Cantabria	Cantabria	1972	Public
48	U. de Extremadura	Cáceres	1972	Public
49	U. Politécnica de Cataluña	Barcelona	1971	Public
50	U. Politécnica de Valencia	Valencia	1971	Public
51	U. Politécnica de Madrid	Madrid	1971	Public
52	U. Autónoma de Barcelona	Barcelona	1968	Public
53	U. Autónoma de Madrid	Madrid	1968	Public
54	U. del País Vasco	Vizcaya	1968	Public
55	U. de Navarra	Navarra	1952	Private
56	U. Pontificia De Salamanca	Salamanca	1940	Private
57	U. de Murcia	Murcia	1915	Public
58	U. Pontificia de Comillas	Madrid	1890	Private
59	U. Deusto	Vizcaya	1886	Private
60	U. de Oviedo	Asturias	1574	Public
61	U. de Zaragoza	Zaragoza	1542	Public
62	U. de Granada	Granada	1531	Public
63	U. de Sevilla	Sevilla	1505	Public
64	U. de Valencia (Estudi General)	Valencia	1501	Public
65	U. Complutense de Madrid	Madrid	1499	Public
66	U. de Santiago de Compostela	Lugo	1495	Public
67	U. de Barcelona	Barcelona	1450	Public
68	U. de Valladolid	Valladolid	1292	Public
69	U. de Salamanca	Salamanca	1218	Public

Table 3. Faculties founded during the period 1980 - 1994.

University	Province	Year of foundation	Year of foundation by faculties		
			Health	Social Sciences and Humanities	Sciences and Engineering
U. Carlos III de Madrid	Madrid	1989		1989	
U. Castilla-La Mancha	Albacete	1982	1982	1989	
U. Castilla-La Mancha	Ciudad Real	1985		1985	1985
U. Castilla-La Mancha	Toledo	1985	1985	1985	1985
U. de Alicante	Alicante	1979	1984		1979
U. de Almería	Almería	1993	1994		1993
U. de Burgos	Burgos	1994	1994	1994	1994
U. de Cádiz	Cádiz	1979	1979	1990	1990
U. de Cantabria	Cantabria	1972		1982	
U. de Extremadura	Badajoz	1968			
U. de Extremadura	Cáceres	1972	1983		
U. de Girona	Girona	1991	1992	1991	1991
U. de Granada	Granada	1531			1988
U. de Huelva	Huelva	1993			1992
U. de Jaén	Jaén	1993	1985	1992	1992
U. de La Coruña	Coruña (A)	1989	1990	1994	1989
U. de La Rioja	Rioja (La)	1992		1992	1992
U. de Las Palmas de Gran Canaria	Palmas (Las)	1979	1989	1989	1989
U. de Lleida	Lleida	1991	1992	1991	
U. de Malaga	Málaga	1972			
U. de Murcia	Murcia	1915			
U. de Santiago	Lugo	1495	1983		1991
U. de Vigo	Ourense	1990		1990	1994
U. de Vigo	Pontevedra	1989		1994	
U. del País Vasco	Vizcaya	1968		1981	
U. Jaume I de Castellón	Castellón	1991		1991	1991
U. Politécnica de Cataluña	Barcelona	1971			1992
U. Politécnica de Valencia	Alicante	1971			
U. Politécnica de Valencia	Valencia	1971			1986
U. Pompeu Fabra	Barcelona	1990		1990	
U. Publica de Navarra	Navarra	1987		1987	
U. Rovira I Virgili	Tarragona	1992		1992	

Table 4. Does the foundation of Universities affect the creation of firms?

VARIABLES	Poisson estimator with cluster robust standard errors.		Negative binomial estimator	
	Pooled (1)	Panel fixed effects (2)	Pooled (3)	Panel fixed effects (4)
Foundation of university $_{i, t}$	0.497***	0.071	0.456***	-0.079
	(0.148)	(0.168)	(0.087)	(0.086)
Market potential $_{i, t}$	4e-04***	8e-05	5e-04	-1e-05
	(8e-05)	(4e04)	(5e-05)	(1e-04)
Specialization index $_{i, j, t}$	-8.30e-07	2.74e-07	-5.20e-07	2.22e-07
	(1.21e-06)	6.86e-07	1.09e-06	9.19e-07
Year fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	No	Yes	No	Yes
Number of cluster	21	21	-	21
Observations	308	308	308	308
Wald test	346.43	953.56	-	56.23
Log likelihood	-4149.27	-2728.93	-1562.95	-1353.01
Pseudo R2	0.41	-	0.05	-

Notes: 1) The endogenous variable is the number of new firm formations**.** 2) The faculty variable for every academic field is a dummy that takes the value one beginning from five years after the date the university was created, and is zero otherwise. 3) For the Poisson estimator, cluster-robust standard errors (in parentheses) are clustered at province level, and for the binomial estimator standard errors in parentheses. 4) Statistical significances reported by *** p<0.01, ** p<0.05, * p<0.10.

Table 5. Does the foundation of faculties affect the creation of firms?
Count model, Poisson regressions.

	All sectors			High tech sectors			Medium tech sectors			Low tech		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	SCI+Eng	SSCI+Hum	Health	SCI+Eng	SSCI+Hum	Health	SCI+Eng	SSCI+Hum	Health	SCI+Eng	SSCI+Hum	Health
Faculty $_{i,\, t}$	0.138**	0.144***	0.016	-0.343	0.120	-0.328	0.081	0.280**	0.157	0.150**	0.128**	0.004
	(0.063)	(0.055)	(0.074)	(0.369)	(0.379)	(0.377)	(0.123)	(0.142)	(0.149)	(0.069)	(0.060)	(0.082)
Market potential $_{i,\, t}$	2.2e-05**	9e-05	-2e-04	3.35e-06	-4.5e-05	0.001	2.32e-05*	-5e-04	-9e-05	2e-05*	(2e-04)	-2e-04
	(9.98e-06)	(1e-04)	(1e-04)	(3.28e-05)	(4e-04)	(0.001)	(1.6e-05)	(4e-04)	(3e-04)	(1e-05)	(1e-04)	(1 e-04)
Specialization index $_{i,\, j,\, t}$	-8.44e-08	-1.15e-06	8.65e-07	-3.3e-05	4.29e-06	-3.3e-05	-1.98e-07	-3.52e-06	-3.8e-06*	2.6e-05***	2e-05	1e-05***
	(1.23e-07)	(3.07e-06)	(2.62e-06)	(2.9e-05)	(3e-05)	(3.2e-05)	(1.51e-07)	(2.25e-06)	(2.1e-06)	(8.71e-06)	(5.08e-06)	(3.29e-06)
LnPop $_{i,\, t-1}$	0.185	0.655***	0.590**	-2.608	-3.198	-4.352	1.011	1.399	-0.237	0.197	0.672***	0.701**
	(0.413)	(0.248)	(0.274)	(3.176)	(5.194)	(3.625)	(1.296)	(1.508)	(1.054)	(0.440)	(0.256)	(0.273)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province and industrial sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12086	9398	10516	1634	1244	1394	2622	2034	2251	8219	6419	7185
Number of industrial sectors x region	813	633	708	110	84	94	182	142	157	548	428	479
Wald test	3297.49	1045.67	2370.72	156.81	52.23	110.58	646.60	278.81	430.46	2771.16	871.91	2046.87
Log likelihood	-23182.65	-15797.60	-19591.63	-1110.40	-644.19	-778.23	-3992.78	-2836.29	-3426.17	-18103.40	-12341.8	-15386.39

Notes: 1) The endogenous variable is the number of new firm formations**.** 2) The faculty variable for every academic field is a dummy that takes the value one beginning from five years after the date the faculty was created, and is zero otherwise. 3) Cluster-robust standard errors (in parentheses) are clustered at the (two-digit) industry and province level. 4) Statistical significances reported by *** p<0.01, ** p<0.05, * p<0.10.
SCI+Eng = Faculties of sciences and engineering.
SSCI+Hum= Faculties of social sciences and humanities
Health= Faculties of medicine, pharmacy, etc.

Table 6. Does the foundation of faculties affect the creation of employment?
Count model, Poisson regressions.

	All sectors			High tech sectors			Medium tech sectors			Low tech sectors		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	SCI+Eng	SSCI+Hum	Health	SCI+Eng	SSCI+Hum	Health	SCI+Eng	SSCI+Hum	Health	SCI+Eng	SSCI+Hum	Health
Faculty foundation $_{i,\,t}$	0.233***	0.070	-0.016	0.652	-0.310	-0.784*	-0.022	-0.105	-0.124	0.267***	0.094	0.014
	(0.079)	(0.081)	(0.093)	(0.665)	(0.462)	(0.458)	(0.217)	(0.234)	(0.181)	(0.084)	(0.087)	(0.101)
# of new firms $_{i,\,j,\,t-1}$	0.002***	0.004	0.002***	-0.027*	0.055**	0.004	-0.008**	-0.030**	-0.009	0.002***	0.006*	0.002***
	(4e-04)	(0.003)	(3e-04))	(0.015)	(0.021)	(0.035)	(0.004)	(0.013)	(0.009)	(3.5.e-04)	(0.003)	(3.6e-04)
Market potential $_{i,\,t}$	2e-05	2 e-04	-3e-04	5.3e-05	0.002	0.001	1.5e-05	1.6e-04	3.2e-04	2.4e-05	2.2e-04	-3.9e-04*
	(2e-05)	(2e-04)	(2e-04)	(4.7e-05)	(0.001)	(7.1e-04)	(5.2e-05)	(4e-04)	(3.2e-04)	(1.7e-05)	(2e-04)	(2.1e-04)
Specialization index $_{i,\,j,\,t}$	2.44e-07	5.51e-06	-5.42e-06	4.7e-05	8e-05	5e-05	-1.48e-07	-8.73e-06***	-7.33e-06**	5e-05	1.2e-05	1.2e-05**
	(3.96e-07)	(6.36e-06)	(5.97e-06)	(6.3e-05)	(8.3e-05)	(6.3e-05)	(1.35e-07)	(3.05e-06)	(3.43e-06)	(6e-05)	(6.38e-06)	(5.92e-06)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province and industrial sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12086	9398	10516	1634	1244	1394	2622	2034	2251	8219	6419	7185
Number of industrial sectors x region	813	633	708	110	84	94	182	142	157	548	428	479
Log likelihood	-169101.0	-108512.4	-128078.3	-15357.2	-6115.7	-8014.5	-40022.7	-23771.9	-27685.0	-113487.6	-79045.9	-92360.9
Wald test	30053.4	8890.9	17737.3	6804.5	1723.3	2446.5	7265. 7	3199.9	3845.0	25039.1	7063.5	15118.4

Notes: 1) The endogenous variable is the number of new jobs**.** 2) The faculty variable for every academic field is a dummy that takes the value one beginning from five years after the date the faculty was created, and is zero otherwise. 3) Cluster-robust standard errors (in parentheses) are clustered at the (two-digit) industry and province level. 4) Statistical significances reported by *** p<0.01, ** p<0.05, * p<0.10.

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