INNOVATION POLES AND SCIENCE PARKS IN ITALY: AN EMPIRICAL ANALYSIS OF THEIR IMPACTS ON FIRMS AND THE SURROUNDING AREA

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ABSTRACT

The increasing interest of EU towards specific structures devoted to stimulate innovation as innovation poles (IP) and science parks (SP) obliges to investigate their role in the overall economic context. The paper examines how performances and characteristics of innovation poles and science park affect various aspects of Italian regional economies at NUTS 2 level. Our main aim is to assess the importance of IP and SP in stimulating growth through innovation, as well as entrepreneurship in the area they are established. First, we test the strength of the relationship between poles activities and the performance of firms located in the same geographical region. Second, we investigate whether the presence and number of poles have an impact on both incentives to entrepreneurship and economic growth within their respective region. Finally, we shift our focus to each specific structure in order to test how their characteristics affect market performance of associated firms. Each of the three parts include also an aggregation of results by macro-area. It is important to note that our empirical research is mostly descriptive, notwithstanding we are able to deliver a few useful insights that might be relevant to public decision makers.

Keywords: Science Parks, Innovation, Growth, Patents

JEL Classification: O30, O31, O38, L26

<u>Short Running Title</u>: *Science Parks in Italy: empirical evidences*

Introduction

This study seeks to investigate upon the possible relationships between the specific features of innovation poles and science parks (IP and SP from now on) and the economic success of such entities, measured as the revenues growth rate of the affiliated firms. In recent decades there has been a large investment in structures as SPs, with the aim of fostering an entrepreneurial culture based on innovation and research, and directly stimulating and supporting innovative start-ups.

They constitute physical loci where the co-location of industry and research should facilitate knowledge flows and innovation (OECD 1997). The literature is not coherent about the precise definition of Science Park (Link and Scott 2003, Link and Link 2003, Saublens et al. 2007), mainly due to the fact that a plethora of similar institutional arrangements exist

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and each one is carrying its own name, which turns out to be the only real difference among them. . One of the most used description of IP/SPs, which can now considered as equivalent, is provided by the International Association of Science Parks (IASP):

A Science Park is a business support and technology transfer initiative that:

a. encourages and supports the start up and incubation of innovation led, high growth knowledge based businesses;
b. provides an environment where larger and international businesses can develop specific and close interactions with a particular center of knowledge creation for their mutual benefit;
c. has formal and operational links with centers of knowledge creation such as universities, higher education institutes and research organizations.

As reported by Bellavista and Sanz (2009), by incorporating diverse public and private organizations (including innovative enterprises, technology-based start-ups, technology centers, research institutes and universities), Science Parks have become significant instruments of business innovation, regional development and integration of micro/mini and macro level stakeholders within innovation systems. In its report on Intensive Innovation Clusters and Science Parks also the European Commission (2007) attribute to such structures a prevailing role for sustaining competitiveness and local growth.

In this paper we focus on the relationship between IP/SP features and performances of both on-park firms and the regional surrounding area. Our main aim is to perform an explorative analysis in order to highlight possible patterns in the distribution of data about Italian SPs, on-park firms and their features. Following Hodgson, studies that quantitatively investigate the links between SPs' features, activities, and outcomes. These assessments exercises generally rely on cross sections, follow simple estimation strategies, and aim to uncover relationships rather than assessing causes, as data quality and availability often constrain the possibility to fully address selection, self-selection and endogeneity concerns (Squicciarini 2008b). This study is carried out by looking at a relatively high number of variables, which describe different characteristics belonging to three different unit measures, namely: the IP or SP itself, the affiliated firms, the regional economy. The choice of three different levels of analysis is driven by the attempt to shed light on IPs/SPs performances and their effects on regional economy. The complexity and difficulties of assessing these issues are well summarized in Phan, Siegel and Wright (2005).

However, the relationship between SPs' features and performances both of affiliated firms (firms incubated, located or associated to the SP) and the surrounding area is still an open issue.

Felsenstein (1994) describe SPs more as "enclaves" of innovation rather than "seedbeds", arguing that their role is more innovation-entrenching rather than innovation-inducing. Wallsten (2004) finds no positive effect of SPs on regional development and, in particular, he documents evidence of no correlation with job growth, increase in the number of start-ups in the surrounding region and increase in venture capital operations. Taking this viewpoint, stories of success do exist (see for example Goldstain and Luger 1991 or more recently Battaglia, Lamperti and Siligato 2012) but are the exception rather than the rule. On the other side Colombo and Delmastro (2002) report evidence of better performances for incubated firms, suggesting a positive role played by SPs at local level. Similar conclusions are drawn in Squicciarini (2008a, 2008b) where the focus is centered on the effects of being affiliated to the SP on the innovative output: results are shown to be robust across sectors. Siegel, Westhead and Wright (2003) find that affiliated firms display higher research productivity than their off-park counterparts. In general the debate on the effectiveness of structures as SP is still open (Schwartz, 2009 and Sofouli, Vonortas 2007 among others) and there is substantial lack of cross-country studies making evidences coming from different realities hardy generalizable.

1. Data and Methodology

The study is carried out by using data of different sources. We combine survey data from Italian's IPs/SPs with the dataset on Italian regional e provincial economies provided by the Istituto Tagliacarne and with IPs/SPs firms' balance-sheet data obtained from the Bureau Van Dijk AIDA dataset; patent data are obtained through the EPO-PATSTAT Database. Results of the analysis, evaluated also in view of IP/SP relevance from a policy perspective (Castells and Hall 1994; Cook 2001), might provide meaningful insights for all institutions supporting regional development.

2. Tenants Performance Compared to Regional Averages

Let us begin our analysis by the following question: "*firms affiliated with IPs and/or SPs show an higher, lower or equal performance compared to the regional average?*"

An answer to such inquiry might be obtained by analyzing over time the performances of the affiliated firms, comparing the results of the latter with the local averages in a *difference-in-difference* framework. In this model, the *treatment* is represented by the affiliation to the IPs or SPs.

Further studies are needed to test this relevant inference strategy. Leaving apart this strategy, we start focusing on the specific trends of revenue growth rate observed in the 2008-2010 biennium. Results are shown in *Figure 1*.

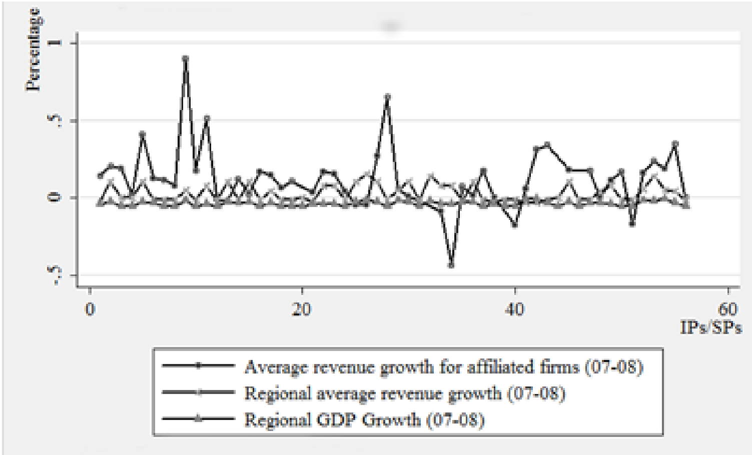

Fig. 1: Performance of affiliated firms and regional indicators

2.1. Regional revenue growth rate

As it clear from *Figure 1*, it requires an outstanding amount of effort to assign a precise direction to the (causal) relationship between affiliated firms performances and regional averages. However, we can easily observe two relevant features of the depicted relationship:

a. The variability of the firms average performances is significantly higher than the regional mean values. This is typical in sectors with an high number of *start*-ups.
b. By virtue of the preceding observation, we thus observe a great share of IPs and SPs whose firms' mean performance is significantly greater, even by far in some cases, than the regional average.

We are interested in studying the confidence interval of the difference between firms' mean growth rate and the regional average. More specifically, we will focus on whether the confidence interval contains the value zero. By setting the Type I error $\alpha = 10\%$ we obtain a confidence interval between 0.05 and 3.18, thus our difference is statistically greater than zero, and the firms' mean growth outperforms the regional average. Nevertheless, if we consider *macro*-area specific tests on such difference (North-West, North-East, Center, South and Isles), we lose a lot of statistical significance. The only difference that remains statistically greater than zero belongs to the firms in the North-West (between 0.06 and 1.14), although we need to set the Type I error $\alpha = 20\%$, which starts being an high value for the occurrence of false positives. *Figure 2* below illustrates the confidence intervals by macro-area, depending on the confidence levels which are set to be 80%, 85% or 90%.

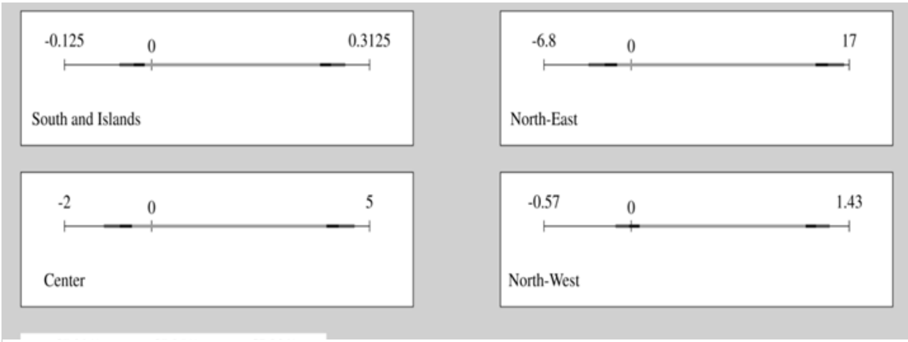

Fig. 2: Confidence Intervals (CI) for the mean difference of the firms' average revenue's growth and the equivalent rate at the regional level

Both *Figure 1* and *2* suggest that we can cautiously consider the affiliated firms to outperform, on average, their regional counterparts. More specifically, such feature is most evident in the North-West, which comprises regions like Liguria, Piedmont, Aosta Valley and Lombardy, even though it would be quite risky to explain such effect exclusively through the presence of IPs and SPs. Rather, there could be alternative ways to explain these results, such as the fact that affiliated firms might already beat the market on their own, so that they would have obtained similar performance even in the absence of membership. Thus, it is difficult, at this stage, to significantly identify an "IP/SP effect".

2.2 Regional R&D growth rate

Before turning to bivariate analysis, let us quickly observe *Figure 3*. In contrast to what was shown in *Figure 1*, here we are more than ever uncertain about the possible correlation between firms' mean performance and regional expenditures in R&D. This sensation is further confirmed by a statistical test, which does not yield sufficient significance levels. However, it might seem correct to assume that the amount of technological transfer brought by the IPs and SPs would positively influence the levels of regional R&D. Apparently, this is not the case, which suggests that the "IP/SP effect" previously isolated might not be that strong after all (at least at the regional level).

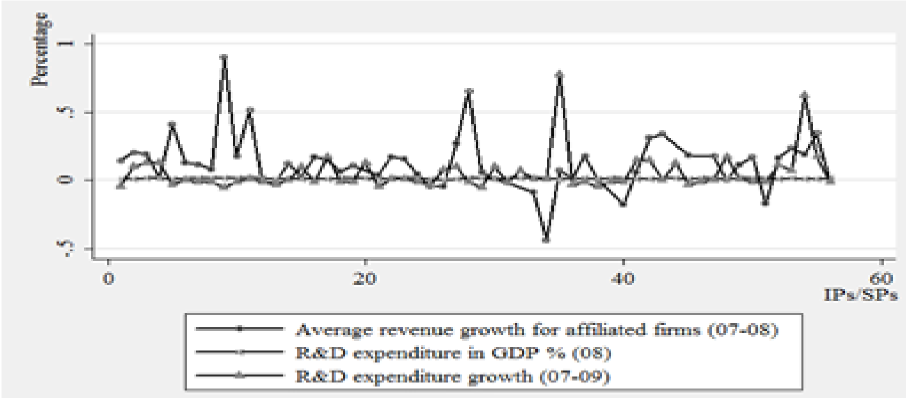

Fig. 3: Revenues' growth and R&D for affiliated firms

3. Descriptive Analysis: Variables and Correlations

In this section we will analyze a number of relevant variables gathered in our study. Each one portrays a relevant characteristic of either the IP (or SP), the affiliated firms, or the regional socio-economic background.

3.1 Graphical representation

In order to get an outlook on the contents of the following subsections, let us observe *Figure 4*, which contains all the significant correlations – with Type I error $\alpha = 5\%$ – among the main variables used in our dataset. So as to fully understand *Figure* 4, it is important to specify that each box represents a variable in the dataset. In particular its shape is:

1. An ellipse, if it represents an attribute of the IP/SP;
2. A rounded rectangle, if it portrays a characteristic of the affiliated firms;
3. A regular rectangle, if it constitutes a socio-economic feature of the corresponding region.

The most relevant variables are shown within bold contours. Moreover, note that the connecting lines are black if the correlation is positive and red if negative. Connecting lines are dashed if it is not possible to identify the exact direction of the correlation (*e.g*,. the variable might be nominal or non-ordered).

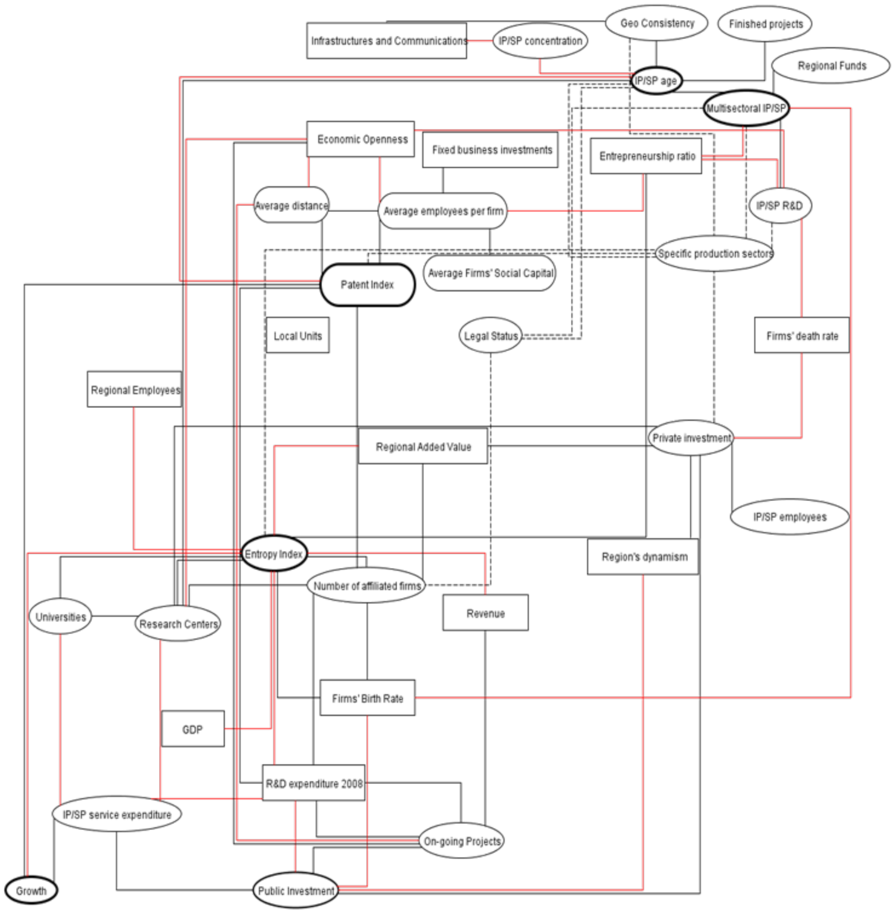

Fig. 4: Graphical representation of correlations

Also note that *Figure 4* has been previously filtered from so-called spurious correlations, *i.e.* statistical dependencies that cannot be logically justifiable. Nonetheless, *Figure* 4 still depicts a very intricate network of direct and indirect effects. We can also note how some specific variables behave as "hubs", catalyzing the indirect effects of secondary variables.

In the following subsections we will analyze the correlation patterns of selected variables in our dataset. By doing so, we will hopefully disentangle the intricate net of correlations, as depicted in *Figure 4*.

3.2 Number of patent applications and patent index

The number of patent applications for each firm is a count variable which has been obtained through the EPO Worldwide Patent Statistical Database (PATSTAT). We use a weighted sum of patent counts to determine the patent index we attribute to each IP/SP: Weights corrects for the relative propensity to patent of each industry, which is known to be highly heterogeneous (Mansfield 1986, Levin et al. 1987, Brower and Kleinknecht 2000). Weights are associated to industries at NACE 2-digit level: each category of economic activity is matched with the ratio between the average patent applications by firms in our sample belonging to that NACE 2-digit category and the full sample average.

We are able to identify a relevant number of correlations that offer us precious insights about the distributional patterns. First, the patent index

correlates positively with average revenues' growth and size, suggesting some positive relation between firms' growth and their innovativeness. Moreover, we find that it is positively correlated with the regional expenditure in R&D. These relationships, easily predictable, cover nonetheless an important role in showing the validity of the data we gathered throughout our study.

We find additional and significant correlations among the patents index and a number of IP's or SP's attributes, namely the age of the infrastructure, the average distance between the affiliated firms and the entropy index. In particular, we can identify an "age effect" on patenting, meaning that younger IP/SP tend to file more patents than their older counterparts. Such an effect might uncover a certain loss of efficiency of the IP/SP, leading to the unsustainability of high patenting rates in the long run. Alternatively, this feature might also hint to a dynamic change in the management of the IP/SP, for which the dominant model of innovation is not centered around the patent anymore. Indeed, such supposition is supported by a number of experts in the field. We might also think of a third reason: if the sectors of production in which the former structures operate have become mature or even stagnating, we could easily explain a significant difference between the rate of patent filing among IP/SP because of this.

Our patent index is negatively influenced by the average distance of the affiliated firms to the park itself. This means that firms that are on average closer to the IP/SP tend to apply for more patents. This would suggest the presence of knowledge spillovers between SPs and associated business and that those spillovers are bounded or at least decreasing in spatial distance. This would be in line with much of the literature about spatial spillovers and the geography of innovation (Audretsch and Feldman 2004, Krugman 1991, Feldman 1999).

Finally, let us remark the positive correlation between the patent index and the firms' average revenue growth rate in the 2007-2008 biennium[1]. Despite the fact that we are dealing with an historical period in which the economic crisis was present, though at its earliest phases, we find that the best performing firms were those that innovated more, for example through patent filing.

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[1] As further explored in the following sections, the positive correlation between the patent index and the firms' revenue growth is mostly due to the strong (and positive) correlation that takes place at the tails of the distribution of the latter variable. In the interquartile range of the firms' revenue growth the correlation loses its significance and becomes actually negative.

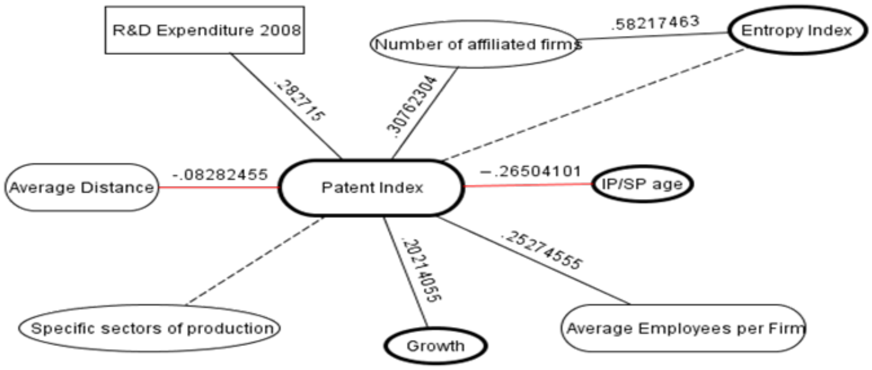

Fig. 5: Significant correlations of the patent index

3.3 Number of affiliated firms

The number of affiliated firms has an internal and external validity as an indicator of performance for IPs and SPs, that is widely demonstrated by its significant correlation with numerous important regional economic indicators. More specifically, an high number of affiliated firms is positively correlated with an high regional added-value, as well as the expenditure in R&D. Not surprisingly, we also find a positive correlation with the firms' birth rate index.

As elicited before, we encounter a positive relationship with the patents index. For what concerns the IP/SP attributes, we find a statistical significant correlation with the number of research centers, as well as the entropy index and the legal form of the IP/SP managing company. To sum up, we can identify three main features of "attractiveness" of the IP/SP for what concerns potential affiliates, *i.e.* factors that make the association with an IP/SP more or less advantageous:

1. The presence of many research centers, which may on one hand offer more heterogeneous and customizable services, and on the other hand provide sufficient capacity for the higher number of associated firms;
2. The diversification of operative fields, represented by an higher entropy index, which creates a more favorable environment for the establishment and affiliation of new firms.
3. The peculiar legal form of the managing subject of the IP/SP. Our empirical evidence shows that an higher number of firms is encountered in IP/SP whose legal status is S.p.A., *i.e.* a limited liability company, with respect to being a "Temporary Scope Association" (A.S.T.). On one hand, this evidence might hint at the fact that an increased freedom of action of the managing subject might enhance the affiliation rates. On the other hand, it might be that

subjects having private-law legal statuses are considered by firms more stable in the medium-long run.

Figure 6 illustrates the main findings.

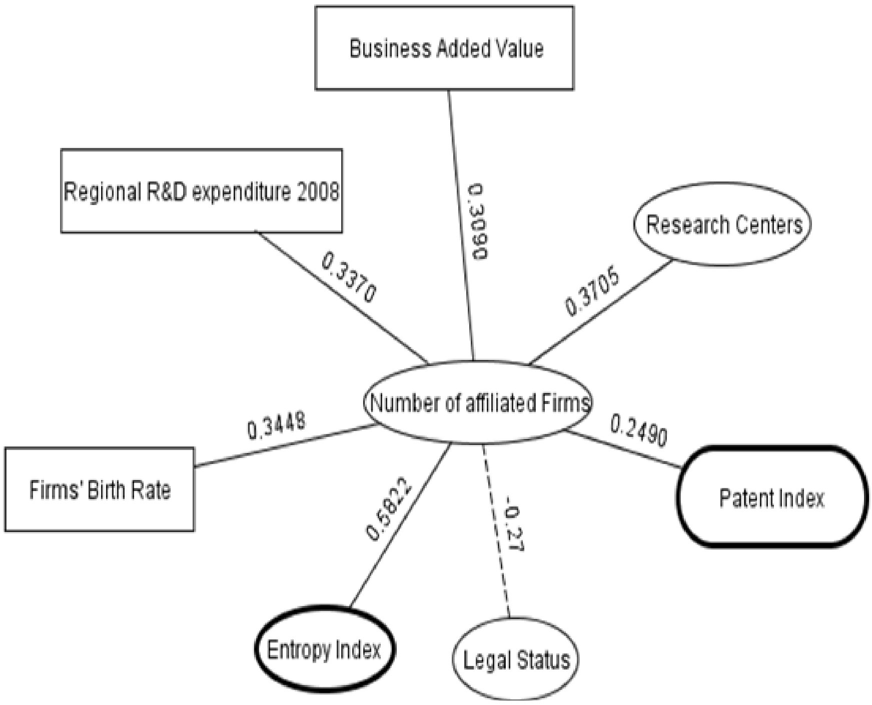

Fig. 6: Significant correlations of the number of firms

3.4 Entropy index

The entropy index plays the important role of catalyst within our dataset. Indeed, such index shows statistically significant correlations with many variables used in our study. From the perspective of the socio-economic regional background, we find many aspects strengthening the internal validity of this measure, namely the (positive) correlation with regional entrepreneurship and firms' birth rate. Furthermore, we can also provide internal validity through the negative correlation with the expenditure in R&D, if we think that the role of *industrial clusters* is to enhance the technological transfer through *spillovers*, reducing the need to increase R&D investments. Finally, a negative correlation with the average number of employees signals the peculiar nature of *industrial clusters* themselves, generally composed by small-size firms.

For what concerns regional GDP, revenue and added-value, and even the average growth rate of firms' revenues, we must point out the dominant role of the recent economic crisis. Therefore, many negative correlations are forcibly linked to this aspect, and thus pertains most especially to the 2008-2010 biennium. Nevertheless, it would not be illogical to think that the resiliency of the *industrial clusters* allowed the latter to overcome better the effects of the crisis. However, it is impossible at this stage to define a cause-effect relationship, without providing an in-depth study. Besides this, the negative correlation between the entropy

index and the average growth rate of firms' revenue is relative only to the 2008-2010 triennium, whereas it is not significant when referring to the 2007-2008 biennium[2], *i.e.* when the impact of the crisis mostly concerned the financial institutions.

From the point of view of IP/SP attributes, we identify an analogous pattern previously encountered in the number of affiliated firms. In other words, the positive correlation with the number of research centers and universities gives the idea that the increase in the size of IP and SP occurs through the diversification of operations. Indeed, this aspect is supported by the significant correlation we observe between the entropy index and specific sectors of production (*e.g.* Biotechnologies and Nanotechnologies) which tend to be more diversified than others.

3.5 Multisectorality of the IP/SP

Another important attribute of IPs/SPs that is worth measuring is the extent to which it hosts business working within heterogeneous industries. At the regional level, we find that multisectorality is negatively correlated with the entrepreneurship rate and the firms' birth rate. This may suggest that multisectoral IPs/SPs tend to be located in areas where the presence of medium-large size enterprises is the norm.

Additional correlations pertain to the intrinsic characteristics of the IP/SP, namely the operative sectors – where some are more prone to diversification than others, *e.g.* Natural Sciences, Engineering and Mechanics, ICT – and the legal status of the managing body. We also find a significantly positive correlation with the regional funds allocated – upon which we are a bit skeptical, since the underlying variable is full of missing data, perhaps not even MAR[3] –, the amount of Research and Development and the age of the IP/SP. Let us focus briefly on this last result.

As previously highlited when dealing with the patent index, we also find that multisectorality shows an "age effect", in the sense that older IPs/SPs are more prone to be multisectoral than younger structures. Given the cross-sectional nature of our data, it is not possible to exclude the case that IPs/SPs may have changed their focus on productivity, so that they became increasingly multisectoral in response to historical events or other external factors. An historical analysis, which goes beyond the scope of this study, would prove the reliability of this statement. Given the sizable number of variables showing an "age effect", we will deal directly with the variable "age of IP/SP" in the following subsection.

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[2] Even though, on average, it remains still negative.

[3] *Missing at random,* that is:

$$\Pr(r \mid y_o, y_m) = \Pr(r \mid y_o)$$

and r, the mechanism generating *missing* data, is independent from the unobserved data y_m

3.6 Age of IP/SP

By analyzing the age of our 56 IPs/SPs, we are able to highlight several relationships. Attributes that are found to be significantly correlated with IPs/SPs' age are: the number of research centers (-), the "geo consistency" (+), *i.e.* the share of firms that are located within the same district of the IP/SP, the finalized projects (+) and, as anticipated, the multisectorality (+) and the patent index (-).

Although it is easy to provide intuitions some of these correlations (finalized projects and multisectorality), it is perhaps a bit more challenging to explain the relationship with the "geo consistency" feature.

A positive correlation suggest than older IPs/SPs tend to host businesses, which are more geographically clustered. This feature seems to confirm the positive role played by Science Parks as a stimulus for innovative entrepreneurship at local level. Typically IPs/SPs born under the joint effort of different institutions, including big firms (e.g. Brembo at Kilometro Rosso in Lombardy or Vodafone at Polo ICT Piemonte in Piedmont), universities and regional administration. The presence of big firms act in two directions: one hand it guarantees the supply of competences coming from the firm itself and its network, and, on the other, it is a catalyzer for potential entrepreneurs. However it might take time for local business to get aware of new opportunities and new competences and to undertake the selection process in order to enter the park or start collaborating. The positive relation suggests exactly that increasing the age of the Park firms locate closer (on average) to the park itself.

We may also think that this relationship explains the "nature" of the IPs/SPs. Let us assume that structures hosting a higher share of local enterprises are more "vocational" than the others, where by the term "vocational" we mean exploiting the capital and human resources available at the local level. Then, we could even differentiate the specific nature of IPs/SPs by looking at the age of each structure. Our results indicate that older structures gest more "vocational" as the time passes by. Finally we notice that the negative correlation between the age of Science Parks and the number of research centers is in line with the negative relationship between age and the patent index: older structures seems to be less devoted to research activities.

3.7 Additional variables

In this paragraph, we will consider three variables describing peculiar features of the IPs/SPs: the private and public investment on equities of the managing agency, as well as the services expenditure.

The information on private investment does not provide sufficient internal validity within our study, representing only 46% of the total sample. On the other hand, public investments performs fairly better, with 73% of sample representativeness. First of all, let us note that regions with

IPs/SPs characterized by high private investments possess strong socio-economic indicators. Most especially, we find significant positive correlations with the regional added-value, the aggregate-firm added-value and the dynamics of entrepreneurship. Similarly, we find a negative correlation with the mortality of firms, thereby confirming the results previously obtained. Once again, a number of significant correlations with the number of research centers, as well as operating in a particular sector, suggest that private investors also have their "ideal attributes" that enhance the attractiveness of the IP/SP. Among them, we find that belonging to a particular sector (*e.g.* such as *Energy and Environment)*, as well as having an high number of affiliated research centers, are both critical factors in deciding whether to invest or not in innovation poles.

Private investment and public investment are indirectly intertwined through the rate of entrepreneurship. In particular, we find that private endowments and entrepreneurship are strongly positively correlated, with a correlation coefficient $\rho = 86\%$[4]. Not surprisingly, the correlation of public investment and entrepreneurship is instead negative. The dynamics depicted here are clear: IPs/SPs mainly financed by public institutions are indeed located in areas that would have not guaranteed a sufficient participation of the private sector. We can support this view also through the firms' birth rate, whose relation with the public investment is significant and negative.

Let us now consider two additional aspects concerning IPs/SPs: the on-going projects and the service expenditures. Once we filter these variables from spurious correlations, we find that they are significantly correlated with public investment. On one hand, we observe that on-going projects are positively correlated with structures whose capital is mostly financed by the public sector. On the other hand, we recognize that these structures tend to be less efficient, mostly because of higher service expenditures. Again, one may deduce that this kind of IPs/SPs tends to strategically privilege efficacy, though it sacrifices efficiency.

Concluding this subsection, let us quickly analyze service expenditures. Both this statistic and public investments are negatively correlated with regional R&D expenditure[5] (expressed in percentage of GDP). This evidence indicates that IPs/SPs located in regions whose R&D spending is lower, might need to counterbalance such deficiency through higher service expenditures, *e.g.* consulting, software, *etc.*

Moreover, let us denote the negative correlation between the IP/SP's service expenditure and the number of affiliated universities. This

[4] Even though the shared support of the two variables cannot be considered sufficiently reliable. However, it seems correct to assume that most of the *missings* should happen in IPs/SPs with an high contribution from the private sector. If this were the case, then perhaps the correlation may not be much distorted, since it seems once again safe to assume that higher rates of private contribution take place where there has already been a relevant engagement of the public sector.

[5] Regional expenditure expressed in terms of GDP percentage.

figure actually validates our assumption that externalization of service is a mean of substituting the lack of exploitable partnerships with the academic world.

3.8 Discussion

In these few pages review of the main patterns identifiable in our dataset, and to some extent we were able to disentangle the intricate network shown in *Figure 4*. We obtained a sizable number of useful insights, through which we observed that attributes of the IP/SP are significantly influenced by specific socio-economic regional characteristics, and how both can have an impact on the performance of affiliated firms.

However, we have still to obtain satisfying results with respect to two fundamental aspects: what are the characteristics that mostly influence the firms' average growth rate of revenues? Also, what are the specific dynamics taking place behind the so-called "age effect"? In the next section, we try to solve the first topic from an historical perspective, by taking look at a panel we have specifically set up for such purpose. In the last section, we will tackle both issues with cross-sectional multivariate regressions.

4. The impact of Innovation Poles and Science Parks on the surrounding area

In this section we will analyze the impact of the number of poles located in a given region on selected indicators of characteristics of the territory, that is regional GDP, the rate of entrepreneurship, the firms' birth rate and death rate. The analysis will be carried out in a panel-data framework, which we have specifically set up for such purpose. The dataset contains observations for Italian regions from 2000 to 2009.

A panel-data approach is powerful in controlling for time-specific characteristics that might cause confounding effects in a *cross-sectional* framework. However, it is a true challenge to obtain reliable and detailed time series, even more at a local level. Further studies should focus on enriching the model we present here.

First of all, let us observe *Figures 7, 8 and* 9. These show the trend of the regional indicators in comparison with the number of IPs/SPs active each year.

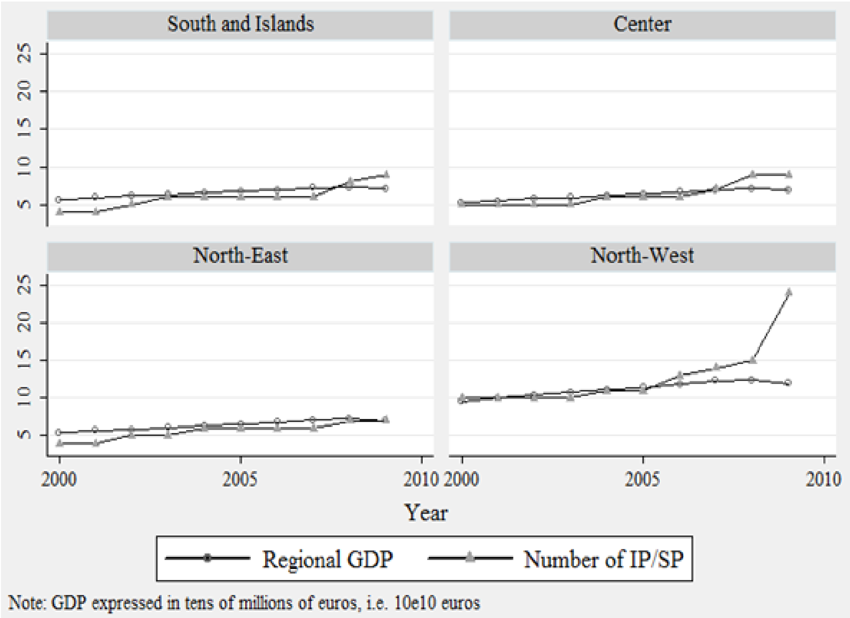

Fig. 7: Regional GDP and IP/SP number

We can see in *Figure 7* that the growth of IPs/SPs largely follows the trend of regional GDP. Moreover, we can observe in 3 out of 4 macro-areas (*i.e.* North-West, Center and South) a “boom” in the number of IPs/SPs that has occurred in the 2008-2009 biennium, whilst the regional GDP was facing a period of stagnation or even downturn, because of the global financial crisis. Therefore, we can infer a first *structural break* in the time series of regional indicators. It is important to take this into account in subsequent phases of the estimation.

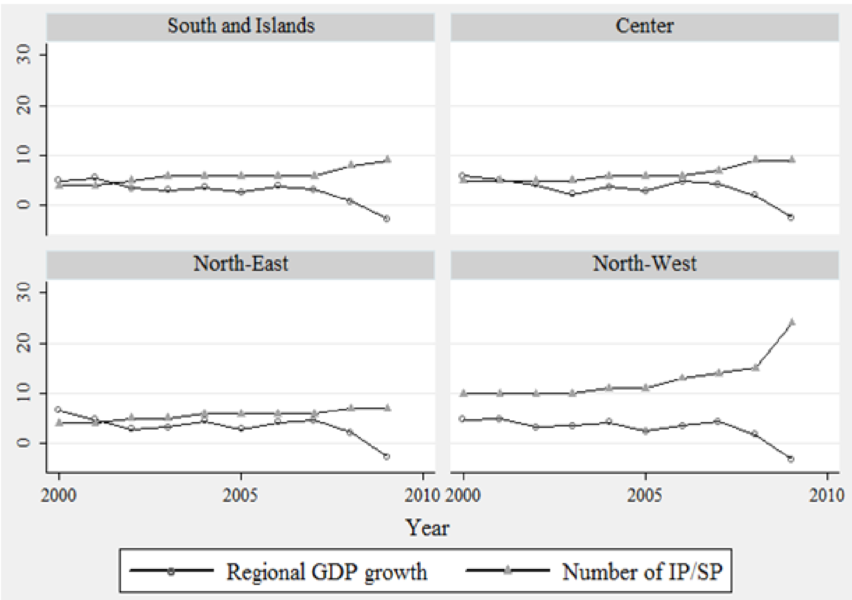

Fig. 8: Regional GDP growth and IP/SP number

Figure 8 illustrates the growth of IPs/SPs population against the growth rate of regional GDP from 2000 to 2009. We note how in this case

the trends are substantially different, most especially in the North-Western region. Here it is even more apparent the divergence of the two trends in the 2007-2009 biennium, confirming the *structural break* that took place as a result of the global financial crisis.

Figure 9 shows the trajectories of firms' death rate, birth rate and entrepreneurship, against the number of IPs/SPs per year. We can see that the trends of the 3 regional indicators are mostly stable throughout the period. Although *Figure 9* does not indicate any specific pattern between the regional indicators and the number of IPs/SPs, there is a slight divergence between the entrepreneurship rate and the latter. In particular, there is a negative and significant correlation between these two variables in the North-West, whereas we encounter a positive and significant correlation in the South. In other words, the increase of IPs/SPs in the North-West of Italy coincides with a decrease in the rate of entrepreneurship, whereas in the South the opposite is true. It is difficult to state that these findings indicate a causal relationship, as it is unlikely that the impact of the number of IPs/SPs might have influenced the region in its entirety.

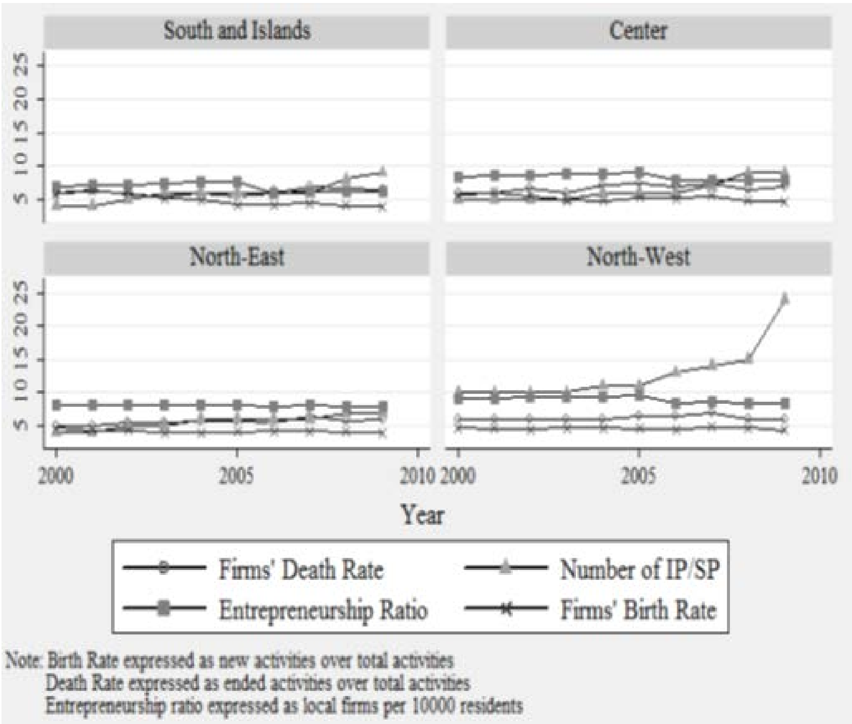

Fig. 9: Regional Indicators and IP/SP number

4.1 Dynamic panel estimation

The regional effects of IP/SP have been partially investigated in the literature: Scott (1993) in Southern California and Masser (1990) in Japan. In this section we present a new approach and we go a step beyond bivariate analysis and we propose a very basic model for assessing the impact a regional set op IP/SP might have on economic growth at the same geographical level.

Our estimated model will be the following:

$$\begin{aligned}\mathrm{GDP}_{i,t} = \alpha_i + \mathrm{GDP}_{i,t} - 1 + \beta_1 \mathrm{structures}_{i,t} + \beta_2 \mathrm{entrepreneurship}_{i,t} \\ + \beta_3 \mathrm{birthrate}_{i,t} + \beta_3 \mathrm{deathrate}_{i,t} \\ + \nu_{i,t}\end{aligned}$$

[1.1]

In order to prevent potential biases due to auto-correlation and endogeneity, we estimate model (1.1) with the GMM (Generalized Method of Moments) estimator by Arellano e Bond *(1991).*[6] Moreover, we restrict our estimation window to the 2000-2007 period, as to prevent errors induced by the *structural break* previously highlighted. *Table 1* shows the results of the estimation. Column 1 reports the coefficient on the overall Italian sample, whereas columns 2 to 5 show coefficients related to the specific macro-area.

[6] *Arellano, M. and S. Bond. (1991)*. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58. pp. 277 – 297.

Table 1 – Estimates from model 1.1. The dependent variable is regional GDP expressed in $\mathbf{10^{10}€}$

	Italy	South and Islands	Center	North-East	North-West
IPs/SPs number	0.1325*** (0.0442)	-0.0023 (0.0650)	0.1454 (0.1071)	-0.0202 (0.1108)	0.2762*** (0.0521)
Entrepreneurship ratio	-0.0066*** (0.0023)	-0.0053* (0.0029)	-0.0131** (0.0059)	-0.0098 (0.0258)	-0.0012 (0.0034)
Firms' Birth Rate	0.0045 (0.0228)	-0.0117 (0.0236)	-0.0719 (0.0502)	-0.0599 (0.1679)	0.0063 (0.0258)
Firms' Death Rate	0.0389** (0.0165)	0.0080 (0.0242)	0.0606** (0.0277)	-0.0191 (0.0762)	0.0418 (0.0289)
n° of observations	96	24	30	18	24

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (Clustered standard errors reported in brackets).

The results of our estimation show a positive and significant effect of the number of structures. However, as we can observe in the macro-area based estimation, such effect is mostly brought by the regions in the North-West, where the majority of IPs/SPs is located. As a result, it is difficult to express causality between the number of structures and the regional performance. Indeed, it seems logical to assume that the impact of a IP/SP is mostly local (perhaps measurable only at the province level or below), whereas the repercussions at the regional level might be strongly diluted, thus not significant.

In spite of the fact that the panel-data analysis we covered in this section is far from conclusive, it helps put into the right context the recent socio-economic dynamics of the Italian regions, so as to better understand where the presence of IPs/SPs might have played a relevant role. It is apparent how the North-Western regions, that have benefited from higher economic conditions, invested more in building innovation centers such as the IPs/SPs. These circumstances are the main cause for the present gap between the number of structures in the North and the ones located in the South.

Furthermore, our analysis shows that the impact of the number of structures on regional indicators of socio-economic development is mostly inconsistent. If we omit to restrict the sample to the 2000-2007 period, the resulting coefficient would actually be negative, as a result of the *structural break*. Hence, we are inclined to believe that the impact of IPs/SPs is evident only on a local scale, whereas on a larger scale, such as regions, such effect might become highly diluted.

5. Science Parks and the growth of affiliated firms

In this section we investigate upon which characteristics pertaining to the nature of IPs/SPs may activate or simply enhance the growth rate of the affiliated firms. Furthermore, we will analyze in detail the "age effect" we highlighted in previous sections.

5.1 Variables correlated with firms' average growth rate (growth)

In this paragraph we proceed to analyze the variables we elaborated in our investigation and study the ones that show to be consistently and significantly related with the firms' average growth rate of revenues (*growth* from now on). Note that in order to respect the time windows of most variables, we will use the average growth rate relative to the 2007-2008 biennium. However, results for the 2008-2010 period will be discussed as well. Moreover, we will consider the results for each specific macro-area, so as to distinguish the different dynamics taking place throughout the Italian territory. First of all, let us consider the dependent variable.

5.2 Univariate analysis of growth

A quick analysis of the distribution of *growth* uncovers the presence of several outliers. This feature of *growth* is particularly relevant for our estimation, since it is very likely that the latter might be influenced by those values located in the tails of the distribution[7]. By eliminating the outliers of *growth*, we are left with 47 observation, which is still a sufficient number for the Central Limit Theorem to be respected[8]. *Figure 10* shows the transformation of the underlying distribution of *growth* by comparing the normal probability plots before and after eliminating the outliers. This process will increase the stability of our coefficient, though at the cost of losing the applicability of such results to all available structures.

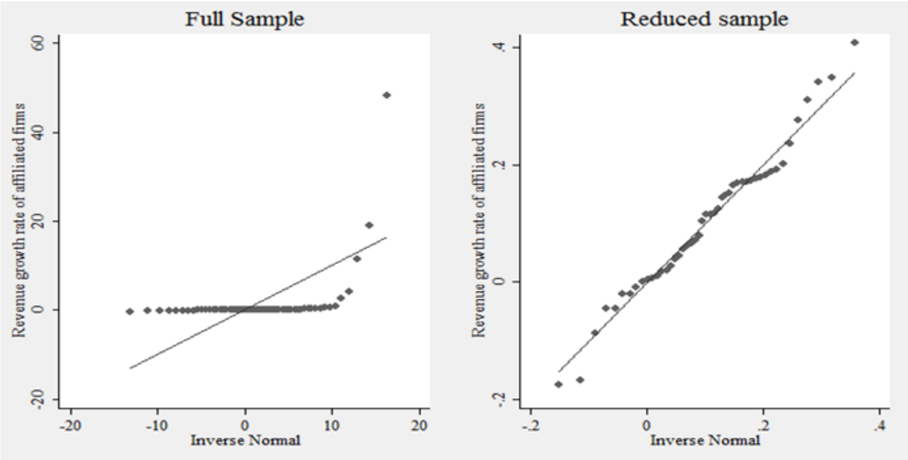

Fig. 10: Differences in revenues' growth distribution

5.3 Empirical evidences from an explorative model

In order to find a credible model that would help to discover which characteristics of the IPs/SPs have a significant impact on *growth*, we follow the strategy used in the previous section. Therefore, we will focus on three main types of controls, namely *regional characteristics, IP/SP attributes and* firms' *properties.*

In the absence of a precise structural model, we have tentatively set our explorative analysis up, using tune-up techniques such as *backward* and *forward selection* in order to choose the best-fitting model. In such a setting, a crucial role is played by the size of the standard errors, which need to be unbiased as far as possible in order to avoid their *inflation* and the resulting *over-rejection* issues. After a thorough analysis of the existing

[7] The *bias* induced by the small number of extreme values has been evaluated and confirmed in an alternative regression setting, whose results are omitted for the sake of brevity.

[8] Because of the *missing* observations present in some of the variables used in our regression, the total sample size will be 43, a number still sufficiently above the threshold needed to benefit from the properties of the *CLT.*

methods to reduce the standard errors' size, we found that the most efficient way is through clustering at regional level, which was indeed a predictable outcome.

The model will be:

$$\begin{aligned} \text{growth}_i = {} & \beta_0 + \beta_1 \text{patent}_{index_i} + \beta_2 \text{avg}_{social\_capital_i} \\ & + \beta_3 \text{entrepreneurship}_i + \beta_4 \text{num}_{firms_i} + \beta_5 \text{avg}_{distance_i} \\ & + \beta_6 \text{research}_{centers_i} + \beta_7 \text{entropy}_{index_i} + \varepsilon_i \end{aligned}$$

[1.2]

Results are shown in *Table 2*.

Table 2 – OLS estimates of model [1.2]

	(1)	(2)	(3)
Number of affiliated firms	0.0006 (0.00065)	0.0010* (0.00058)	0.0012** (0.00066)
Average distance from the IP/SP (in hundreds of Kms)	0.0052 (0.01130)	-0.0080 (0.01367)	-0.0406** (0.02056)
Entropy Index	0.0185 (0.02644)	0.0111 (0.02681)	-0.0374 (0.02569)
Number of affiliated research centers	0.0070*** (0.00292)	0.0074*** (0.00302)	0.0080*** (0.00331)
Patent Index		-0.0102** (0.00533)	-0.0125** (0.00629)
Average firms' social capital (in mlns of euros)		0.0041*** (0.00136)	0.0046*** (0.00131)
Entrepreneusrhip ratio per 100 inhabitants (active firms)			0.0146*** (0.00344)
n° of observations	43	43	43
R^2	0.45	0.51	0.58

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.05$. (Clustered standard errors reported in brackets)

5.4 Discussion

In this paragraph we will analyze the coefficients of model [1.2], trying to provide a logical explanation to the effects found in our estimation. Once again, note that in such setting it is very risky to interpret a given coefficient as an actual cause-effect relationship. Rather, we prefer to consider our estimations like a way to discover which characteristics tend to be correlated with higher values of *growth*, thus the *efficacy* of the IP/SP. Nevertheless, if a number of correlations proved to possess external validity, the latter could surely be of great help in the public *decision making* process.

The effects of the indicators belonging to the firms' properties category, as illustrated in *Figure 2*, show results that are in contrast with each other. On one hand, the higher the number of affiliated firms, the higher the *growth*. On the other hand, the higher the patent index, the lower the *growth*. This is a counterintuitive result.

In our model, the variables concerning the average social capital and the entrepreneurship ratio represent useful controls. Thus, rather than by empirical relevance, their presence is justified by the provision of internal validity, as well as the only viable solution to the *omitted variable* problem.

Another useful control is the number of affiliated firms. Its effect shows that, on average, bigger IPs/SPs are more successful than others: this finding excludes the sometimes perceived possibility that bigger Ips/SPs are set up artificially in order to gather a bigger amount of funds, or else to gain more publicity.

The second coefficient may be explained by considering two different reasons. The first is the structure of the sample. Once we excluded outliers, the resulting coefficient is as shown in *Table 2*. However, if we consider also the outliers we actually obtain a positive coefficient on the patent index. This result signifies that, at the highest levels of growth, the patent index is in fact a crucial indicator with a significant and positive effect. This effect is eventually propagated across the rest of the sample.

To analyze this aspect more in detail, we return to the reduced sample, dividing the sample by quartiles of growth. Consequently, we evaluate model [1.2] on the four different subsamples. Once again, we find that the negative coefficient is brought by a small fraction of the total sample, namely the last quartile. More specifically, we find that in the first three quartiles (*i.e.* the first 75% of the ordered distribution of *growth*) is positive though mostly inconsistent. Instead, we observe that the same effect in the last quartile is strongly significant and negative.

Therefore, it is important to put into the right context the result concerning the patent index: its negative value refers to a *mini-cluster* of Ips/SPs which operate in sectors with high productivity as well as low rates of patent filing. These characteristics are a common feature of the ICT sectors, and indeed we find that the largest majority of this *mini-cluster*

operates in such sector. In the end, we can assume that the patent index has a mildly positive effect on growth.

The coefficient belonging to the number of research centers shows a positive effect on *growth*, both in terms of statistical relevance and efficacy of the IP/SP system. It is widely believed that a crucial role for Ips/SPs is to deliver innovation through technological transfer, which eventually impacts in a positive way the overall *growth*. In such perspective, finding higher levels of *growth* in correspondence of an higher number of research centers, which supposedly increase the overall performance of the innovation process, can be seen as a validation of our theory.

Another extremely interesting result is described by the coefficient on the average distance from the IP/SP. Although in the former specifications this information does not prove to be significant, once controlling for an important characteristic of the territory, namely the entrepreneurship ratio, this value becomes highly significant and negative. Therefore, average distance from the IP/SP tends to identify those structures that perform worse than the average. This variable also denotes the fact that the *omitted variable bias* may significantly impact the sign of the regressor's coefficient, which was formerly positive though not significant.

Finally, let us consider the coefficient of the entropy index. Once again, controlling for the entrepreneurship ratio is fundamental in shaping the impact of this variable. However, we are not able to consider such coefficient as statistically different from zero, indicating that an higher diversification of production does not bring a particular advantage. Recalling what we previously stated about the "age effect" of the entropy index, it seems that younger Ips/SPs, generally more diversified, do not suffer in terms of *growth* with respect to their older counterparts.

5.5 Macro-area based analysis

We quickly augment our model by plugging in indicators for the four different macro-areas. Results on such coefficients (not listed for brevity) show that, all things being equal, the structures located in the North-East and Center obtain, on average, higher results than their counterparts situated in the North-West.

Such finding might be due to a different degree of competition which the structures need to face in order to be successful. This value might be lower in areas in which there are not many structures, such as North-East and Center. However, this explanation is somewhat fallacious in the sense that it casts a few doubts on why the Southern area (and the isles) shows results that are not substantially different from those obtained in the North-West. One possible way to explain this further observation is that we are not able to control for other important indexes, such as the efficacy and/or the efficiency, which quite plausibly differentiate the structures located in the North-West from those in the South.

Conclusions

Our study has showed a lot of interesting features of IP/SP's effects on both regional economic growth and associated (or incubated) firms' growth in terms of revenues. In particular we found both that IP/SP impacts are different if analyzed by geographic location and that their effects are still evident even in the aggregate model. The number of IP/SP per region seems to display a positive role in sustaining the economic growth of corresponding regions. In addition, the patenting activity and the creation of research centers foster the growth of affiliated firms, which in turns affects regional economy's parameters. To the contrary, the distance between the IP/SP and affiliated firms reduces the growing potential of the latter. In addition, firms within an IP/SP turn out outperforms (largely) the regional average. Finally, we find that more recent structures tend to be more prone to both patenting activity and high-level growth. Younger structures are also characterized by higher dispersion rates.

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