The effects of technopoles and science parks on regional economies in Italy

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Abstract: The increasing interest of EU towards specific structures devoted to stimulate innovation as technopoles (TP) and science parks (SP) obliges to investigate their role in the overall economic context. The paper examines how performances and characteristics of technopoles and science park affect various aspects of Italian regional economies at NUTS 2 level. Our main aim is to assess the importance of TP 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 region. Second, we investigate whether the presence and number of poles have an impact on both incentives to entrepreneurship and survival rates 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 how empirical research is mostly descriptive, notwithstanding we are able to deliver a few useful insights that might be relevant to public decision makers.

Key–Words: Technopoles, Science Parks, growth, patents, entropy

1 Introduction

This study seeks to investigate upon the possible relationships between the specific features of technopoles and science parks (TP and SP from now on) and the economic success of such entities, measured as the revenues growth rate of the affiliated firms. In addition we focus on the relationship between TP/SP performances and regional economic growth. Recalling the importance that recent report developed by the European Commission (2007) on Intensive Innovation Clusters and Science Parks attribute to such structures for sustaining competitiveness and local growth, we concentrate on what it defines as SP (see sec. D2), Innovation, Technology Centers/Parks and BICs (Business Innovation Centers); to be more concise we label the last triticum as TPs. In this rather uninvestigated field of innovation research, our main aim is to perform an explorative analysis in order to highlight possible patterns in the distribution of data, gathered both via electronic surveys and extraction from specialized Italian firm databases. Results of the analysis, evaluated also in view of TP/SP relevance from a policy perspective (Castells and Hall 1994; Cook 2001), might provide meaningful insights for all institutions supporting regional development.

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 TP or SP itself, the affiliated firms, the regional economy.

2 TPs and SPs Performance Compared to Regional Average

Let us begin our analysis by the following question: *"firms affiliated with TPs 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 many years 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 *TPs* or *SPs*. Further studies are needed to test this relevant inference strategy. For the time being, we will focus on the specific trends of revenue growth rate observed in the 2008-2010 biennium. Results are shown in *Figure 1*.

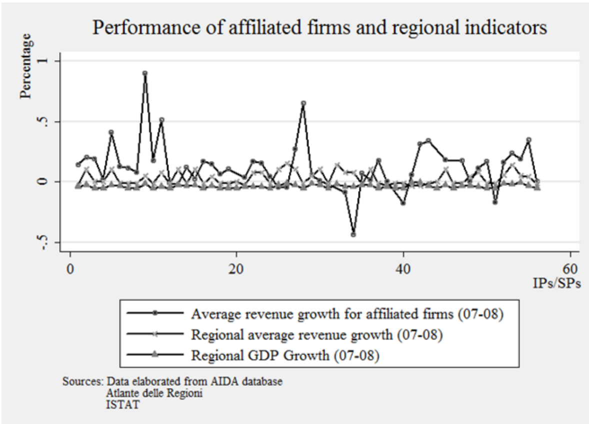

Figure 1

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 relationship between affiliated firms performances and regional averages. However, we can easily observe two relevant features of the depicted relationship:

i. 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.

ii. By virtue of the preceding observation, we thus observe a great share of TPs 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%.

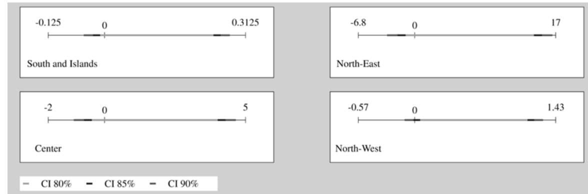

Figure 2: Confidence Intervals (CI) for the mean difference of the firms' average revenue's growth and the equivalent rate at the regional level.

Both *Figure 1* and *Figure 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 TPs 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 "TP/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 TPs and SPs would positively influence the levels of regional R&D. Apparently, this is not the case, which suggests that the "TP/SP effect" previously isolated might not be that strong after all (at least at the regional level).

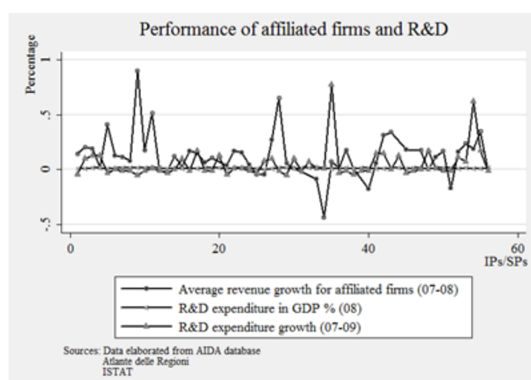

Figure 3

3 Bivariate Analysis

In this section we will analyze a number of relevant variables gathered in our study. Each one portrays a relevant characteristic of either the TP (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:

- i. An ellipse, if it represents an attribute of the TP/SP;
- ii. A rounded rectangle, if it portrays a characteristic of the affiliated firms;
- iii. 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 polytomous).

Also note that *Figure 4* has been previously filtered from so-called spurious correlations, i.e. statistical dependencies that cannot be logically justifiable (*Note that the presence of spurious correlation might constitute a threat while performing a multivariate regression, as it can be the reason behind the existence of confounding variables*). 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.

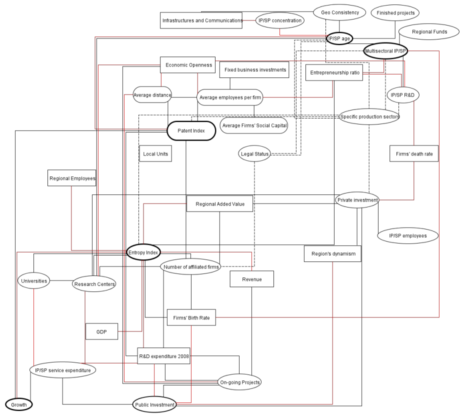

Figure 4: Map of the correlation among variables

3.2 Bivariate analysis for selected 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*.

3.2.1 Number of filed patents

The number of filed patents is an index variable, for which the pure value had to be necessarily weighted against the different patenting propensity of each sector. Although we must once again refrain from assigning any *cause-effect* relationship to such index, we are able to identify a relevant number of correlations that offer us precious insights about the distributional patterns.

First, the patent index is a function of the number of affiliated firms, as well as the size of the latter. 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.

Secondly, the patents index depends on the specific sector in which the TP/SP operates (which also represents the sector in which a large majority of the affiliated firms competes). Therefore, our strategy to weight the number of patents taking into account the *Pavitt taxonomy* proved to be correct in the first place.

We find additional and significant correlations among the patents index and a number of TP'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 TP/SP tend to file more patents than their older counterparts. Such an effect might uncover a certain loss of efficiency of the TP/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 TP/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 TP/SP because of this.

Our patent index is negatively influenced by the average distance of the affiliated firms. This means that firms that are on average closer to the TP/SP tend to file more patents. If we add to this the effect of the *entropy index*, which operates through the number of the affiliated firms, we find that the Italian productive model, strongly based on the concept of *industrial clusters*, offers a good performance in terms of creating knowledge and innovation.

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.

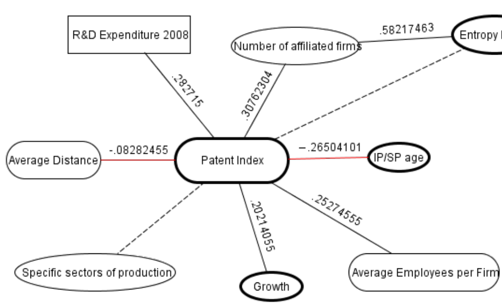

Figure 5: Significant correlations of the patent index

3.2.2 Number of affiliated firms

The number of affiliated firms has an internal and external validity as an indicator of performance for TPs 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 TP/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 TP/SP managing company. To sum up, we can identify three main features of "attractiveness" of the TP/SP for what concerns potential affiliates, *i.e.* factors that make the association with an TP/SP more or less advantageous:

- i. 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;

- ii. The diversification of operative fields, represented by an higher entropy index, which creates a more favourable environment for the establishment and affiliation of new firms.

- iii. The peculiar legal form of the managing subject of the TP/SP. Our empirical evidence shows that an higher number of firms is encountered in TP/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.

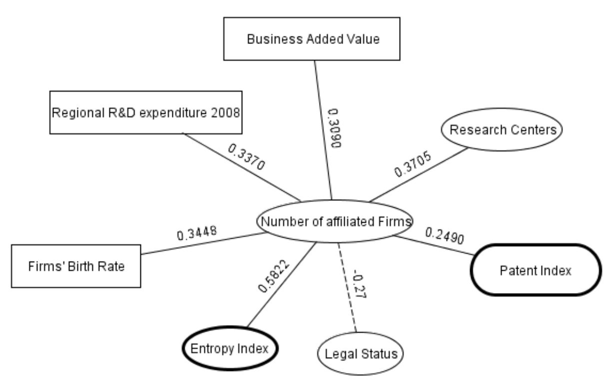

Figure 6: Significant correlations of the number of firms

[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.

3.2.3 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 TP/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 TP 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.

3.2.4 Multisectorality of the TP/SP

Another important attribute of TPs/SPs, that is worth measuring, is the extent to which its operations are diversified, *i.e.* if it operates in more than one specific field of research. 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 TPs/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 TP/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 TP/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 TPs/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 TPs/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 TP/SP" in the following subsection.

3.2.5 Age of TP/SP

By analyzing the age of our 56 TPs/SPs, we are able to highlight several relationships, almost all of them relative to the intrinsic characteristics of the structure itself. The only one representing an attribute of the affiliate firms is the patent index, upon which we have already discussed. Attributes of the TP/SP that are related to their 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 TP/SP, the finalized projects, the legal status and, as anticipated, the multisectorality. We also identify selected sectors for which age shows a significant correlation.

Although it is easy to provide intuitions for the existing correlations with specific productive sectors, and even more for what concerns the finalized projects (thus they serve more as a tool to verify the internal validity of this variable), it is perhaps a bit more challenging to explain the relationship with the "geo consistency" feature.

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

[3] *Missing at random*, that is: $Pr(r|y_o, y_m) = Pr(r|y_o)$ and r, the mechanism generating missing data, is independent from the unobserved data y_m

This particular feature might be explained as yet another strategic choice of an TP/SP. At first, the main objective of such structures might simply have been the aggregation of local industrial and economic actors in order to promote innovation through technological transfer. Then, once this large networks were established, the purpose of the TP/SP might have switched towards the inclusion of firms whose affiliation would constitute a *per se* added value. In such perspective localization of firms becomes less relevant in the eyes of the TP/SP. Note also that the outstanding developments in the field of ICT have deeply changed the way firms interact, almost canceling all physical constraints. For instance, we may consider the case of the DLTM pole in Genoa, which recently inaugurated its *cloud-based* platform for design, simulation and implementation of prototipes in the nautical field. This platform was made available for all affiliated enterprises through DLTM's web portal.

We may also think that this relationship explains the "nature" of the TPs/SPs to some extent, above all in an historical perspective. Let us assume that structures hosting an 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 TPs/SPs by looking at the age of each structure. Our results indicate that older structures are more easily definable as "vocational" than are the younger ones.

Finally, let us denote a significant "age effect" which is even apparent in the legal statuses of TPs/SPs. We find that the dominant judicial status has changed through time, increasingly assuming the form of "Temporary Scope Associations" (TSA) rather than conventional limited liability companies.

3.2.6 Additional variables

In this paragraph, we will consider three variables describing peculiar features of the TPs/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 TPs/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 TP/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 technopoles.

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: TPs/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 TPs/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 TPs/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 TPs/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 TP/SP's service expenditure and the num-

[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 TPs/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.

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

3.2.7 Conclusions

In these pages we have presented a thorough 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 TP/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 are yet 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 Technopoles and Science Parks: an historical analysis

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 TPs/SPs active each year.

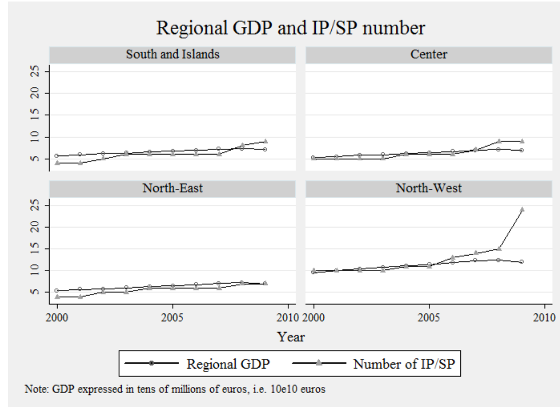

Figure 7

We can see in *Figure 7* that the growth of TPs/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 TPs/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.

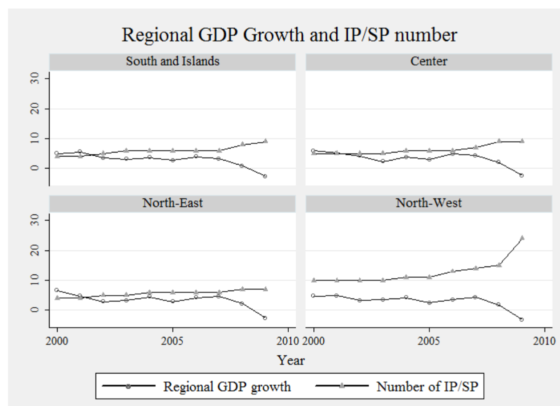

Figure 8

Figure 8 illustrates the growth of TPs/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 TPs/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 TPs/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 TPs/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 TPs/SPs might have influenced the region in its entirety.

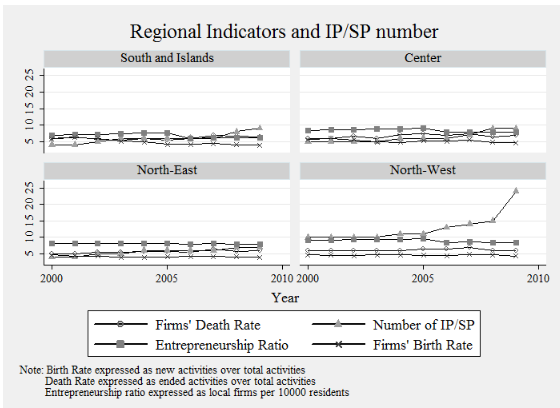

Figure 9

4.1 Dynamic panel estimation

The regional effects of TP/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 TP/SP might have on economic growth at the same geographical level.

Our estimated model will be the following:

$$\begin{aligned} GDP_{i,t} = \alpha_i + GDP_{i,t-1} + \beta_1 structures_{i,t} + \\ + \beta_2 entrepreneurship_{i,t} + \beta_3 birthrate_{i,t} + \\ + \beta_3 deathrate_{i,t} + \nu_{i,t} \end{aligned} \quad (1)$$

In order to prevent potential biases due to autocorrelation 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.

	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).

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

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 TPs/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 TP/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.

4.2 Conclusions

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 TPs/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 TPs/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 TPs/SPs is evident only on a local scale, whereas on a larger scale, such as regions, such effect might become highly diluted.

[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.

5 Multivariate Analysis

In this last section we investigate upon which characteristics pertaining to the nature of TPs/SPs may activate or simply enhance the growth rate of the affiliate 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.

5.1.1 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.

[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.

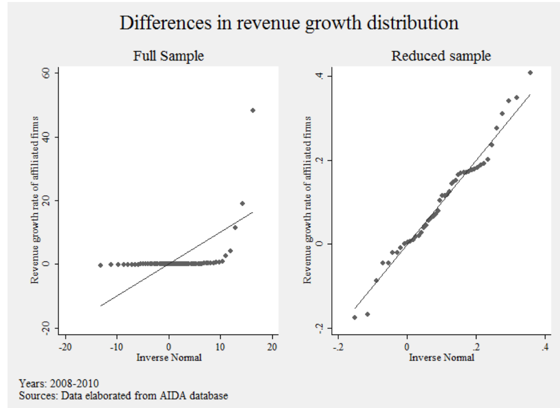

Figure 10

5.1.2 Multivariate analysis of growth

In order to find a credible model that would help to discover which characteristics of the TPs/SPs have a significant impact on *growth*, we follow the strategy used in the previous section concerning *Bivariate analysis*. Therefore, we will focus on three main types of controls, namely *regional characteristics*, *TP/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 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.

Our estimated model will be:

$$\begin{aligned} growth_i = \beta_0 + \beta_1 patent\_index_i + \\ + \beta_2 avg\_social\_capital_i + \beta_3 entrepreneurship_i + \\ + \beta_4 num\_firms_i + \beta_5 avg\_distance_i + \\ + \beta_6 research\_centers_i + \beta_7 entropy\_index_i + \epsilon_i \end{aligned} \tag{2}$$

Results are shown in Table 2.

	(1)	(2)	(3)
Number of affiliated firms	0.0006 (0.00065)	0.0010^{*} (0.00058)	0.0012^{**} (0.00066)
Average distance from the TP/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)

Table 2: OLS estimates of model (1.2)

5.1.3 Observations

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 TP/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 counter-intuitive 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 TPs/SPs are more successful than others: this finding excludes the sometimes perceived possibility that bigger TPs/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 TPs/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 TP/SP system. It is widely believed that a crucial role for TPs/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 TP/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 TP/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 TPs/SPs, generally more diversified, do not suffer in terms of *growth* with respect to their older counterparts.

5.1.4 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.

5.1.5 Diagnostics and Conclusions

From a statistical standpoint, the resulting model shows to be sufficiently stable and reliable. *Figure 11* shows how the *residual-versus-fitted* graph is randomly distributed along the zero line, with no clearly visible trend. An additional check on the *Variance Inflation* Factors returns only values below 3, indicating that the presence of multicollinearity of the variables can be safely excluded. Finally, as already stated in the introductory part of this section, if we cluster the standard errors at the regional levels, it will result narrower confidence intervals, a feature that increases the acceptance rate.

Finally, we apply model (1.2) to the *growth* values relative to the 2008-2010 biennium. Results are qualitatively similar, whilst causing the loss of significance for a number of controls and variables, namely the number of affiliated firms, the average social capital and the average distance from the TP/SP. Now if we consider the coefficients which belongs to the patent index, to the entrepreneurship ratio, to the number of research centers and the entropy index (which actually *gains* significance in this period), we can see how, especially the latter, hints at the fact that *industrial clusters*, a typical feature of the Italian productive system, have shown greater resiliency throughout the on-going recession.

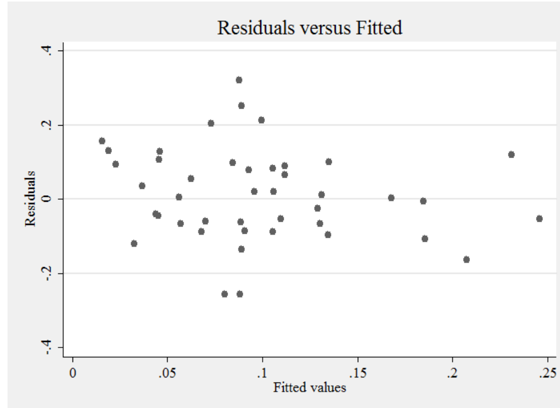

Figure 11

5.2 Unmasking the ”age effect”

Another aspect deserving further investigation is represented by the attributes related to the age of the TP/SP. In this case, it is even more apparent the fact that each coefficients helps only partitioning the age distribution by the specific regressor, and it is not in any case an indication of a cause-effect relationship. The next paragraphs will describe in a concise manner the obtained results.

5.2.1 Univariate analysis

A particular feature of the age distribution is its bimodality. As a matter of fact, we have already observed that there have been two ”waves” in the births of TPs/SPs. The first wave happened at the beginning of the new millennium (approximately in 1999-2000), while the second one, very recent, took place during the 2007-2009 period. Between these two waves we may observe a *structural break*, which was held approximately after the 10^{th} year of activity (*i.e.* year 2002). *Figure 12* summarizes our findings.

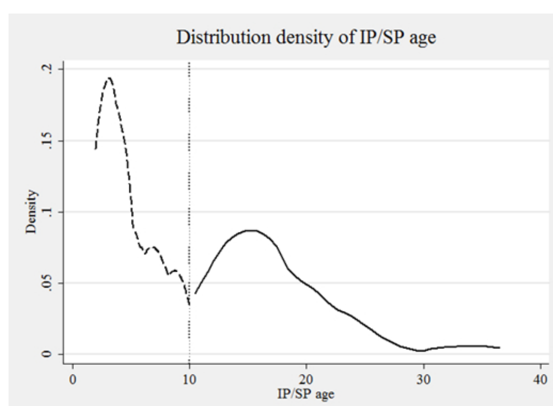

Figure 12

5.2.2 Setup of the model

In order to estimate the regressors of the dependent variable ”age”, we follow the same strategy as our previous section. Once again, we will cluster the standard errors at a regional level. Given the high correlation between the age of the structure and its legal status, it is important in such model to control for its effects, which will be *absorbed* in the final model without considering its estimate.

We estimate the following model:

$$\begin{aligned} age\_polo_i = \beta_0 + \beta_1 patent\_index_i + \\ +\beta_2 growth_i + \beta_3 globdist_i + \\ +\beta_4 legal\_status_i + \beta_5 public\_inv_i + \epsilon_i \end{aligned} \quad (3)$$

Results are shown in Table 3:

	(1)	(2)	(3)
Patent Index	-0.383^{***} (0.15600)	-0.248 (0.16602)	-0.344^{***} (0.13498)
Average firms' revenue growth	-0.063 (0.07271)	-0.134^{**} (0.06847)	-0.135^{***} (0.03672)
Index of TP/SP concentration		-0.147^{***} (0.06569)	-0.138^{**} (0.07545)
Public investment in TP/SP social capital (thousands of €)			$-2.90*10^{-8**}$ (0.00000)
Intercept	9.759^{***} (0.69682)	13.823^{***} (1.91923)	13.884^{***} (2.36903)
n° of observations	51	51	40
R^2	0.34	0.41	0.48

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

Table 3: Estimates from model (1.3). The dependent variable is the age of the structure

5.2.3 Observations

Our estimation provides interesting results concerning the age of TPs/SPs. First, we consider the coefficient of the patent index: negative and significant. The latter repeats a concept we already encountered in the section dedicated to bivariate analysis, namely the fact that younger TPs/SPs tend, on average, to file a lower number of patents as opposed to their older counterparts.

Secondly, for what concerns the growth rate, we observe a negative and significant coefficient. There are many explanations to this particular feature, however, one of the most plausible refers to the maturity of the markets in which the older TPs/SPs operate, naturally characterized by lower profits and thus lower growth.

Thirdly, another attribute pertaining to the concentration of firms around the TP/SP (named *globdist* and corresponding to the average distance of firms from the physical location of TP/SP they are associated with /incubated in), demonstrates that younger structures are characterized by an higher dispersion rate. This result may hint the fact that many of the most recent TP/SP might have been established without the explicit purpose of innovating through the exploitation of local expertise, as it is always the case of older structures.

Finally, observe the role of the public investment. Its effect, though quite feeble, is negative and strongly significant, indicating that younger structures tend to have benefited more from public investment and its economic support in general.

5.2.4 Legal status and macro-area based analysis

In this paragraph we will briefly tackle the topic of legal status. Then, we will move onto the analysis of the differences between the estimation from 4 macro-areas. The effect of legal status, once controlled directly, reveals a purely descriptive relationship among selected legal statuses, namely *Foundations, Consortia* and *LLCs*. These different legal statuses undoubtedly define a *cluster* of structures characterized by an high average age.

Concerning the specific effects by macro-area, we do not see any specific particularity. Therefore, we do not highlight significant differences between the age pattern of structures in each specific macro-area. *Figure 13* clarifies most of the findings encountered in this paragraph.

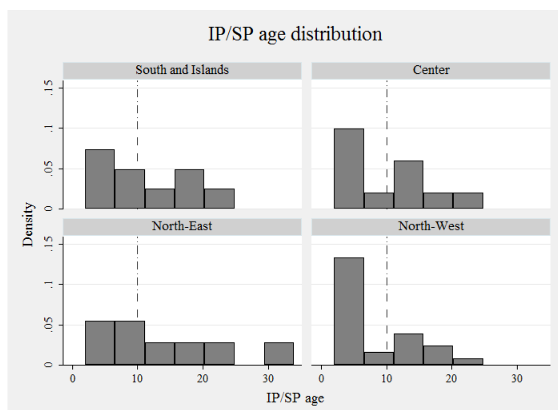

Figure 13: The dashed line indicates the *structural break* after 10 years of activity

5.2.5 Diagnostics and conclusions

Our model proves to be farly stable. The *residuals-versus-fitted* graph (omitted for the sake of brevity) is distributed around zero and does not show any identifiable pattern. The model also has a good fit, though it loses a sizable quantity of its validity at the tail of the distribution.

In this section we analyzed two main characteristics of the TPs/SPs. By comparing them by years of activity, we were able to uncover the interesting feature by which employers often discriminate.

First of all, we observe a difference in the amount of patents in favour of the youngest firms. This may be linked to two main processes. First, it might be possible that older structures have changed their original purpose by pursuing innovation and technological transfer without the need for patent filing. This aspect seems to be a common opinion among the experts on this field. It might also be that structures have strategically renounced to the patent as a tool for development, in favour of different tools with an higher reliability. Moreover, a reason can also be represented by the fact that young structures might decide to operate in sectors that notoriously have low levels of patent filing, such as ICT.

Secondly, note that *growth* levels are lower as time passes by, highlighting either a reduced efficiency, or the fact that structures operate in mature or even stagnant markets (as previously discussed). Thirdly, we already discussed the fact that younger structures tend to be more dispersed. Finally, the impact of public investment indicates that younger poles tend to have more money provided by the public institutions. Once again, this evidence brings up the question about the nature of each TP/SP, which might be political most of the time.

6 Conclusions

Despite constituting a pioneering and simplified analysis, our study has showed a lot of interesting features of TP/SP's effects on both regional economic growth and associated (or incubated) firms' growth in terms of revenues. In particular we found both that TP/SP impacts are different if analyzed by geographic location and that their effects are still evident even in the aggregate model. The number of TP/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 TP/SP and affiliated firms reduces the growing potential of the latter. In addition, firms within an TP/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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