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LOCAL POLICIES FOR INNOVATION: THE CASE OF TECHNOLOGY DISTRICTS IN ITALY

by Federica Bertamino[#], Raffaello Bronzini[*], Marco De Maggio[§] and Davide Revelli[**]

Abstract

In this paper we study a policy tool called *technology districts*, implemented in Italy over the last decade to foster local innovation activity. First, we examine the characteristics of technology districts and those of the firms within them. Next, we assess the performance of district firms. We find that in the southern regions technology districts are more numerous but smaller than those located in the Centre-North, are poorly diversified from a sectorial point of view and more distant from the economic structure of the area. We find that the firms that did join a district had previously been, on average, larger, more innovative and profitable, and also show higher leverage than the others. Our results show that overall after the birth of a district the performance of the firms that joined it did not differ significantly from that of similar firms that did not.

JEL Classification: O31, R0, H2.
Keywords: technology districts, innovation, patents, public policies, matching, differences-in-differences.

Contents

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1. Introduction[1]

The economics of innovation have extensively emphasized the role of national and regional innovation systems in promoting the innovative capacity of firms and geographical areas (Lundvall, 1992; Cooke et al., 1997; OECD, 1997). This literature highlights, both theoretically and empirically, the importance of the interactions among firms and institutions that are able to shape the innovative process, and which are typical of each territory. Such intangible assets are crucial determinants of the local innovation ability that are external to the firms but internal to the area where they are located (see e.g.: Capello and Faggian, 2005). Inspired by these theoretical frameworks, several place-based policies have been implemented in European countries to create and promote dynamic and successful clusters of technologically advanced activities concentrated in a particular area.

In this paper we shed some light on one of the policy instruments implemented in Italy in the early 2000s, namely Technology Districts (TDs). Grounded in the theory of regional innovation systems and the triple helix model (Etzkowitz and Leydesdorff, 2000), the policy aims to enhance firms' innovation capabilities and the competitiveness of local production systems by creating synergies among firms, universities and research centres located within limited territorial boundaries. One feature of the policy is the role played by regional government, which proposes the creation of the districts and, together with other local public authorities, coordinates the activities within them. The policy is widespread throughout Italy, involving almost all the Italian (NUTS-2) regions and utilizing a significant amount of public funds.

Our aim is mainly descriptive. By focusing on firms, we first map the TDs and identify their main features, such as size, sectorial specialization and diversity, together with those of the districts' firms, in terms of several balance sheet and innovative indicators. Next, we assess the performance of the district firms by matching those that joined a district with similar enterprises that did not join a district, and using difference-in-difference estimates to compare the performance of the two groups – measured by a number of balance sheet variables and the propensity to patent – before and after the district's birth.

While the literature on technological clusters and regional innovation systems is quite extensive (see among others: Cooke et al., 1997; Antonelli, 2000; Evangelista et al., 2002; Patrucco, 2003; Rychen and Zimmermann, 2008), the empirical papers on local policies for innovation in Italy are scant (see: Colombo and Delmastro, 2002; Miceli, 2010; Liberati et al., 2015). Our paper contributes to this stream of research in several respects. First, unlike most of the previous literature which is based on case

[1] We wish to thank Alessio D'Ignazio, Alessandro Fabbrini, Roberto Gabriele, Simone Martelli, Silvia Magri, Diego Scalise, Alessandra Staderini, and the participants in the Bank of Italy's workshops held in Rome (September 2012) and Perugia (December 2012), and in the annual conferences of AISRe (Palermo 2013) and ERSA (St. Petersburg 2014), for their valuable comments. The collection of the data on technology districts' firms was made with the important contribution of Stefano Maiolo, Alessandro De Iudicibus and Francesco Termite whom we would like to thank. The views expressed herein are those of the authors and do not necessarily reflect those of the respective institutions. The usual disclaimer applies.

studies, we focus on the technology districts nationwide and examine the universe of the firms that belong to TDs. Second, we use a wide set of firms' balance sheet variables together with key measures of firm innovation output, such as patent applications, in order to illustrate the features of the firms and measure their performance. Third, to evaluate the performance of the district firms we employ matching techniques combined with difference-in-difference estimates over a relatively long time period, from 2002 to 2012. This allows us to follow the firms over a relatively long time span and control, as far as possible, for unobservables that might have affected the performance of district enterprises.

It should be pointed out that our analysis mainly focuses on firms. The TD programme, which aimed to enhance local innovation systems where the districts are located, involved other actors as well as firms, e.g. universities, public and private research centres and local government bodies. Therefore, we believe that a comprehensive evaluation of the technology district policy should measure the policy's impact on the geographical areas and all the actors affected by the policy. This exercise, which is opened for future research, is challenging because of the difficulties in finding appropriate measures of the performance of the actors other than firms affected by the policy, and a suitable identification strategy to evaluate the policy's effects. However, even with its limits we believe that our study provides a valuable contribution to the knowledge of an underinvestigated, but important, innovation policy that deserves further attention in the future.

Our analysis shows that technology districts in the Italian southern regions are more numerous, but include fewer firms than those located in the Centre-North, poorly diversified sectorially and more distant from the economic structure of the area. These characteristics might limit the synergies among firms, and hinder the economies of scale and scope that the policy would implicitly like to trigger. Overall, firms that did join a district are larger and more innovative than other firms of the same sector located in the same region; moreover they also show higher investment rates and leverage. Our exercise shows that, on the whole, after the birth of a TD, district firms did not outperform similar non-district firms; only the profitability of larger district firms in the North-West turned out to be higher than that of the control group after the policy.

The rest of the paper is organized as follows. In the next section, we discuss the theoretical framework of the policy and the related empirical literature. In Section 3 we present the main characteristics of the TDs and the most important features of district firms compared to those of non-district firms in the same region. In Section 4 we provide some evidence on the performance of district firms. Section 5 sets out our conclusions.

2. Technology Districts: theoretical and empirical background

The usual policies for innovation aim at increasing the level of innovative investment by reducing its costs through grants, fiscal incentives or facilitated loans. From a theoretical point of view, public intervention to spur innovation is justified by a typical market failure argument. Since knowledge is a public good, innovative firms are unable to fully benefit from the returns of an innovative investment because of knowledge spillovers, and consequently under-invest with respect to the social optimal level (Arrow, 1962). The rationale for the policy is to boost innovative investment towards a level that maximizes social wellbeing by decreasing the cost of the investment.[2]

In the last few decades new polices for innovation have been implemented across several advanced countries. These policies were influenced by theories that stressed the systemic nature of the process of innovation. A number of scholars have argued that innovation and technology development depend not only on the innovative efforts of the enterprises, but is also related to the specific economic and institutional characteristics of each national or local system of innovation (Lundvall, 1992; Nelson and Rosenberg, 1993). In this context, a crucial role is played by various forms of agglomeration economies associated with geographical proximity, such as those emerging from R&D collaborations among firms, face-to-face interactions and informal contacts. Moreover, it is argued that an innovative performance is promoted by the sharing of rules and values, which are characteristic of the socio-economic environment and support the exchange of tacit knowledge and learning mechanisms among the actors (Dosi, 1988; Capello, 1999; Audretsch and Feldman, 2004; Cooke et al., 2004; Capello and Faggian, 2005).

In the late 90s, with the "Triple Helix Model", Etzkowitz and Leydesdorff (2000) re-elaborated the concept of national and local innovation systems in the light of the development of information and communication technologies (ICTs), and the intensification of economic globalization. This model refers to the need for a strategic integration of the three drivers of development – research, government and industry – that enable the activation of knowledge flows, thereby stimulating the innovation ability of the local system.

In this framework, the rationale for public intervention has moved from market failures to system failures: public policies are justified in order to overcome imperfections in the innovation systems because some essential elements are missing, or the linkages within them are not working well. The goal of an innovation policy is thus to create and promote the favourable conditions that enhance the functioning of innovative systems.

[2] For recent empirical surveys on the impact of R&D incentives see: Zúñiga-Vicente et al. (2014), Becker (2014); on the econometric methods see Cerulli (2010).

In Italy, a technology district is a region-oriented policy instrument implemented in the early 2000s to foster innovation and firms' competitiveness, which is largely grounded on the theoretical framework of regional innovation systems and the triple helix model. The aim is to act as an instrument of governance and coordination of the processes in order to streamline learning mechanisms appropriate for innovation.[3]

2.1 Empirical evidence

Public policies to promote and enhance local clusters of innovative activities have been implemented in many European countries and in the US. See for example: Albert et al. (2002) for the case of France, Dohse (2000) for Germany, Viladecans-Marsal and Arauzo-Carod (2012) for Spain, and Moretti and Wilson (2014) for the US.

As regards the Italian case the empirical literature is scant and mainly focused on case studies. Colombo and Delmastro (2002) compare 45 new technology-based firms located in Italian incubators within science and technology parks – a local innovation policy similar to TDs – with a control sample of off-incubator firms in the same industry and area. Using a firm-level survey, the study shows how on-incubator firms invested more in human capital and were more likely to adopt technological innovations than similar off-incubator firms. By contrast, the two groups of firms did not differ in terms of innovative indicators such as the intensity of R&D expenditure and number of patents. Liberati et al. (2015) analyze a larger sample of firms located in Italian science and technology parks, and find that firms residing in the parks did not show a substantially different business or innovative performance from those of similar firms outside the parks. As far as we know, only a couple of papers are focused on technology district policy. Miceli (2010) compares each district's sectors of specialization with the specialization of the areas where they are located. She finds that in several regions (8 regions, principally in the South) there is no consistency between the technology district's specialization and that of its home area.[4] However, in her paper no micro-economic information on district firms is used. Ardovino and Pennacchio (2014) study the inter-firm R&D cooperation within a sample of six technology districts, out of 29, showing that the propensity to cooperate is heterogeneous across TDs and firms of different sizes.

Unlike previous studies, our paper examines all the technology districts in Italy and provides a broad overview of the characteristics and performance of the universe of firms within the districts using a wide set of firm-level information.

[3] In Italy similar policies include the science and technology parks, and the more recent poles of innovation and poles of excellence.
[4] For recent assessments of regional innovation policies in Italy see: Corsino et al. (2012), Fantino and Cannone (2013), Bronzini and Iachini (2014) and Bronzini and Piselli (2016).

3. The characteristics of Italian Technology Districts

The Italian Technology Districts were defined by the 2002-2004 and 2005-07 National Programs of Research (NPR) of the Italian Ministry of Education, University and Research (MIUR). They are defined as local aggregations of high-tech activities, made up of geographically concentrated universities or public research centres, firms and local governments, which aim to foster firms' innovation capabilities and local competitiveness. TDs are legally constituted by an act issued by the MIUR following the proposal of the Regional Government.[5] A district is formally created by a legal agreement between the Region and the Ministry (Framework Agreement Programme – Accordo di programma quadro – APQ). The legal status of the entity responsible for the management of the initiatives in the district is usually that of a limited liability consortium with a majority of public shareholders, participated in by firms, universities, the region and other public entities. TDs and district firms can benefit from public funds from the European Union, and national (or regional) funding. According to preliminary information provided by the MIUR, public funds disbursed to the TDs, excluding regional funds, amounted to 450 million euros by the end of 2011.

As mentioned previously the three main subjects of the TDs are firms, public research centres or universities and local public authorities. For firms the main benefits of participating in a TD come from establishing collaborations with other firms, research centres and universities. Moreover, they may benefit from public funds and the use of common laboratories, equipment and services available in the district. Universities and public research centres support firms by providing services related to innovation activities, carrying out basic research and coordinating the largest projects. Additionally, some of them are also involved in promoting spin-offs. Finally, public authorities belonging to the TD – such as regions, provinces, municipalities or Chambers of Commerce – participate in the government bodies of the district, provide public funding and coordinate and promote the activities within the districts. The region is the link between the TD and the Ministry. Our study focuses on the Italian TDs created by the end of 2011; our sample represents almost all the TDs since only a few districts were established afterwards[6].

For the empirical analysis we use three main datasets. First, the dataset built by the Ministry of the Economic Development (Department for Development and Economic Cohesion), which collects identifiers of enterprises belonging to the TDs existing on the 31st December 2011 (2,298 firms). Unfortunately, the dataset does not include information about the year in which firms joined a district, so it is not possible to study the birth of new firms (start-ups). Second, the balance sheet dataset for all

[5] There are three main strategic sectors of intervention: 1) environment, energy and transport; 2) agri-food and wealth; 3) production systems, biotechnology, new materials and nanotechnology, ICT and cultural activities.

[6] We have not been able to collect the balance sheet data for the districts established in Emilia Romagna (NE) because of some shortcomings in the information: the fiscal codes of the firms for the "advanced mechanics" district were not available in the dataset provided by the Ministry; we do not know the year of establishment for the "biomedical" district (the website of the district reports that it has not been recognized by the Ministry yet).

the Italian limited companies sourced by the Cerved group, which provides us with the financial statements of the firms together with other information such as economic activity, localization and year of birth of the enterprises. In the last year covered by the analysis (the end of 2012) there were 1,236 firms in the Cerved database out of 2,298 existing district firms. Presumably the missing firms are those too small to be registered in Cerved, such as general partnerships or individual companies. Third, we employ the PATSTAT dataset which collects the information on patent applications to the European Patent Office. Finally, other information on TDs, such as year of establishment and the sector of specialization of the districts, is gathered from the institutional websites of the Ministry of Education, University and Research, the regions and each technology district.

3.1 Structure and territorial distribution of technology districts

By end of 2011, 29 technology districts had been formally recognized in Italy by the Ministry of Education, University and Research. These districts were in 18 of the 20 Italian regions, with 2,298 district firms (Table 1). The vast majority of the districts (21) were created between 2003 and 2005.

There is a strong heterogeneity of the districts in terms of distribution across the regions, size, and economic activities. There are only two regions with no districts (Marche and Valle d'Aosta), whereas in many regions (6) there is more than one district. Notice that three of them are in the South, an area traditionally under-specialized in technological advanced sectors. Overall, 14 districts are in the South of Italy while in the North West, North East and Centre there are 5 districts based in each area.[7]

TDs differ substantially in size. For example, the largest districts are in Piedmont and Lazio with 439 and 221 firms, respectively, while in the South there are the smallest ones (fewer than 10 firms in some districts of Puglia and Basilicata). On average, north-western and central TDs are the biggest, including on average 174 and 125 firms, respectively. In north-eastern TDs there are on average 66 firms, while the smallest are in the South with an average of only 34 firms. This evidence suggests how the agglomeration economics that TDs are supposed to trigger might involve the TDs of southern regions less because of their limited size.

The genesis of the southern districts is quite different from that of the other areas and this can help to explain the reason why in the South there are more districts, but those districts are also relatively smaller in terms of the number of firms. In the North, especially in the North West, TDs were often created on existing high-tech clusters of firms. In these areas, the legal constitution of the districts acknowledges or sometimes formally ratifies the existence of local productive systems strongly specialized in high-tech activities. In contrast, in the southern regions the creation of the districts was

[7] The geographical areas are: North West (Piedmont, Liguria, Valle d'Aosta, Lombardy); North East (Veneto, Friuli Venezia Giulia, Trentino Alto Adige, Emilia Romagna); Centre (Tuscany, Umbria, Marche, Lazio); South (Molise, Abruzzo, Campania, Puglia, Basilicata, Calabria, Sicily, Sardinia).

often driven by the regional government. In such areas the TDs were largely used as an instrument to favour the innovation of small local enterprises, by creating networks between them and intensive research activities carried out by other local players. In these circumstances, national and local authorities had pinpointed the strategic activities of the territory, which could be enhanced by the technology districts, and guided the adhesion of the players to the districts, such as big national or multinational firms. Another important difference between central and northern districts and southern districts is that the latter take more advantage of the national public funds (Fund for Underutilized Areas – FAS) and European cohesion funds (European Regional Development Fund – ERDF) than the former.

For the subsample of district firms present in the Cerved data base we are also able to look at the economic activity of the enterprises. Most of them belong to industrial or service sectors, 600 and 534 enterprises, respectively (Table 2). The most represented branches are information and communication technology, with 259 firms, professional activities and electronic products, with 175 and 151 enterprises, respectively; the less represented branches are paper and publishing and textiles and clothing. The activities carried out in the districts often reflect some features of the geographical areas in which they are located. For example, in some districts relevant factors are: a) the presence of big firms that may influence the activity of the district and encourage the participation of smaller enterprises (as in Lazio's aero-spatial or Catania's microelectronic districts); b) the role of universities or research centres highly specialized in certain fields (as in Pisa's micro-technology and bio-medical districts or Milan's advanced materials and bio-technology districts); c) the importance given to specific socio-environmental aspects (as in Trentino Alto Adige's sustainable-building district); d) a combination of different factors (as in Piedmont's ICT district, where the presence of important aero-spatial and electronic firms, a technical university, research centres and banking foundations enabled the establishment of the biggest district in the country).

3.2 TD's specialization and sectorial variety within the districts

For descriptive purposes, in this section we compare the sectorial specialization of the districts with that of the areas in which they are located, and we also study the sectorial variety within the districts.

The first exercise aims to evaluate to what extent the technology districts are grounded on the specialization of the area in which they are located. The correspondence between district and area sectorial specialization was a requirement of the public program and was supposed to affect the effectiveness of the policy.[8] In Table 3, the sectorial distribution of all the firms and the sectorial

[8] Our exercise is similar in spirit to that carried out by Miceli (2010), who verified the coherence between the specialization of the TD and the characteristics of the region of establishment. She clustered the Italian regions into four groups based on two criteria: specialization (the importance of a sector in a specific region compared to Italy) and concentration (the importance of the region over the country for a specific sector). She found a strong coherence only for a few TDs located in the northern regions.

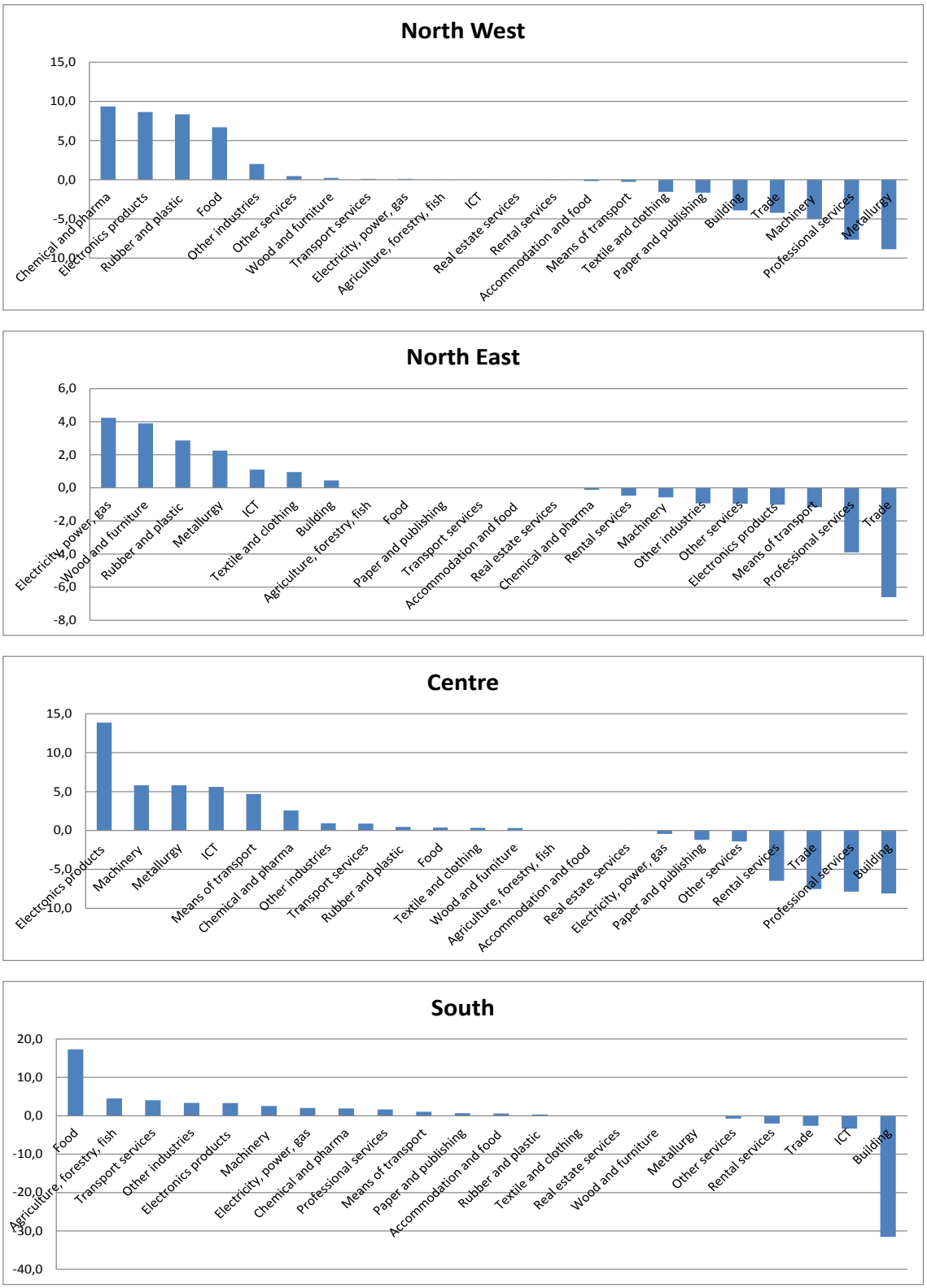
distribution of district firms are reported for each geographical area. Both are calculated over the number of firms using a 4-digit sector of activity. A sectorial diversity index is reported in the last five columns, calculated as the difference between the sectorial share of district firms and the sectorial share of all firms within the area: [(Number of district firms in sector j, area i) / (Total number of districts firms in area i)] – [(Number of firms in sector j, area i) / (Total number of firms in area i)]. For each area, values greater (smaller) than zero indicate that districts are more (less) specialized in sector j compared to the area; values close to zero mean that the specialization of the districts reflects the specialization of the area. From Table 3 and Figure 1 we are able to find some interesting information.

First, TDs are strongly concentrated in some sectors within each geographical area and the TDs' specialization is quite heterogeneous across areas. In the Centre a higher share of firms in TDs are in ICT and electronic products, in the North-West they are also in rubber and plastics and chemical and pharmaceuticals; in the North-East more firms are in building and professional services, while in the South they are mostly in food, professional services and trade. Second, the TDs' specialization partially reflects that of their areas. The correlation among the share of district firms and the share of total firms across sectors varies from 0.45 in the South, to 0.95 in the North-East (in the North-West and Centre it is 0.64 and 0.72, respectively); in Italy the correlation is 0.70. This means that in the north-eastern regions the TDs were settled mainly in the local sectors of specialization, whereas in the other areas larger differences arise. This is confirmed by the diversity index which measures the diversity between the economic structure of the TDs with that of the area (Figure 1; Table 3). The mean of absolute values of the diversity index is 1.4 per cent in the north-eastern regions, against 3.1 in North-West, 3.4 in the Centre and 3.8 in the South. The Italian average is equal to 2.7 (over a mean share of 4.3): i.e., in the TDs the sectorial shares deviate on average by about 60 per cent from the overall sectorial shares.

We move now to the analysis of the sectorial variety within the district (Table 4). Sectorial variety is important because firms might benefit from larger economies of scope if the variety within the district is wider. As expected the variety is correlated with the dimension of the districts. In the largest districts, like Lazio (aerospace), Piedmont (ICT) and Trentino Alto Adige (sustainable buildings), the variety is the highest (firms operate in about 14 sectors), while it is lower in the smaller districts: in the southern districts there are on average 4 sectors (some include only one sector, like Calabria, Basilicata and Molise), against about 9 sectors in the North-West and Centre, and 6 in the North-East. As expected, the higher the number of sectors involved in the district, the lower the relative importance of the main sector. The most represented activities are ICT and professional services (5 districts each).

Figure 1

Economic specialization of the districts by area (1)



(1) The economic specialization of the districts by area is measured with the diversity index, built as follows: ((number of district firms in sector *j*-area *i*) / (total number of districts firms in area *i*)) - ((number of firms in sector *j*-area *i*) / (total number of firms in area *i*)). For each area, values greater than zero mean that a district's firms are more specialized in sector *j* compared to the total firms of the area; values near zero mean that a district's firms are as specialized in the sector *j* as the total firms of the area; values smaller than zero mean that a district's firms are less specialized in sector *j* compared to the total firms of the area.

To sum up, there emerges a strong heterogeneity in the structure and the characteristics of the TDs across areas. In the North-West the districts are larger and more sectorially diversified than in the other areas; at the same time their specialization only partially reflects the local economic structure. In the North-East the TDs are smaller in size than in the North-West, however they are rather diversified and strongly mirror the sectorial specialization of the area. In the Centre the structure of TDs is similar to those in the North-West: they are rather big, sectorially diversified and only partially reproduce the specialization of the area. In contrast, in the South there are more TDs, but they are small, poorly sectorially diversified and far from the economic structure of the area.

3.3 The characteristics of district firms: Evidence from balance sheet and patent data

In this section we examine the main characteristics of the district firms by comparing their balance sheet indicators and patent applications with those of similar firms outside the districts. The comparison is carried out the year before the birth of the district, to avoid the differences being due to the effects of the policy. District firms are compared with non-district firms drawn from the Cerved dataset that belong to the same 4-digit sector and are localized in the same NUTS-2 region of the on-district firms. We are able to find balance sheet data for about 900 and 62,000 district and non-district firms, respectively, in the Cerved dataset the year before the establishment of the TDs (Table 5; Figure 2).[9] We decided to exclude 14 district firms and 37 non-district firms with sales of more than 1 billion euros because otherwise they might have driven the results of both the samples.

The first striking characteristic of district firms is that they are, on average, much larger than those of the same sector localized in the same region: the median assets, sales and added value are more than 8 times bigger. Furthermore, for both variables the 10^{th} and the 90^{th} percentiles are considerably higher for district enterprises than for non-district ones. In relative terms such differences are less marked in the northern districts (about 6 times) than in central and southern ones (up to 10 times). Moreover, in all the geographical areas, but especially in the North-East of the country, firms inside the districts are more homogeneous in terms of size than firms outside the districts as shown by the coefficients of variation. As regards the overall profitability measured by the return on assets (ROA), district and non-district firms are on average rather similar. On the other hand, if we consider the operating profitability, measured by the gross operating margin over assets (EBITDA/ASSETS), non-district firms seem to perform better than district firms, in particular in the South and in the North-East (the smallest areas in terms of number of firms).

District firms show a higher investment propensity compared with non-district firms, considering both the investment rate and the ratio between investment and sales. However there is a large

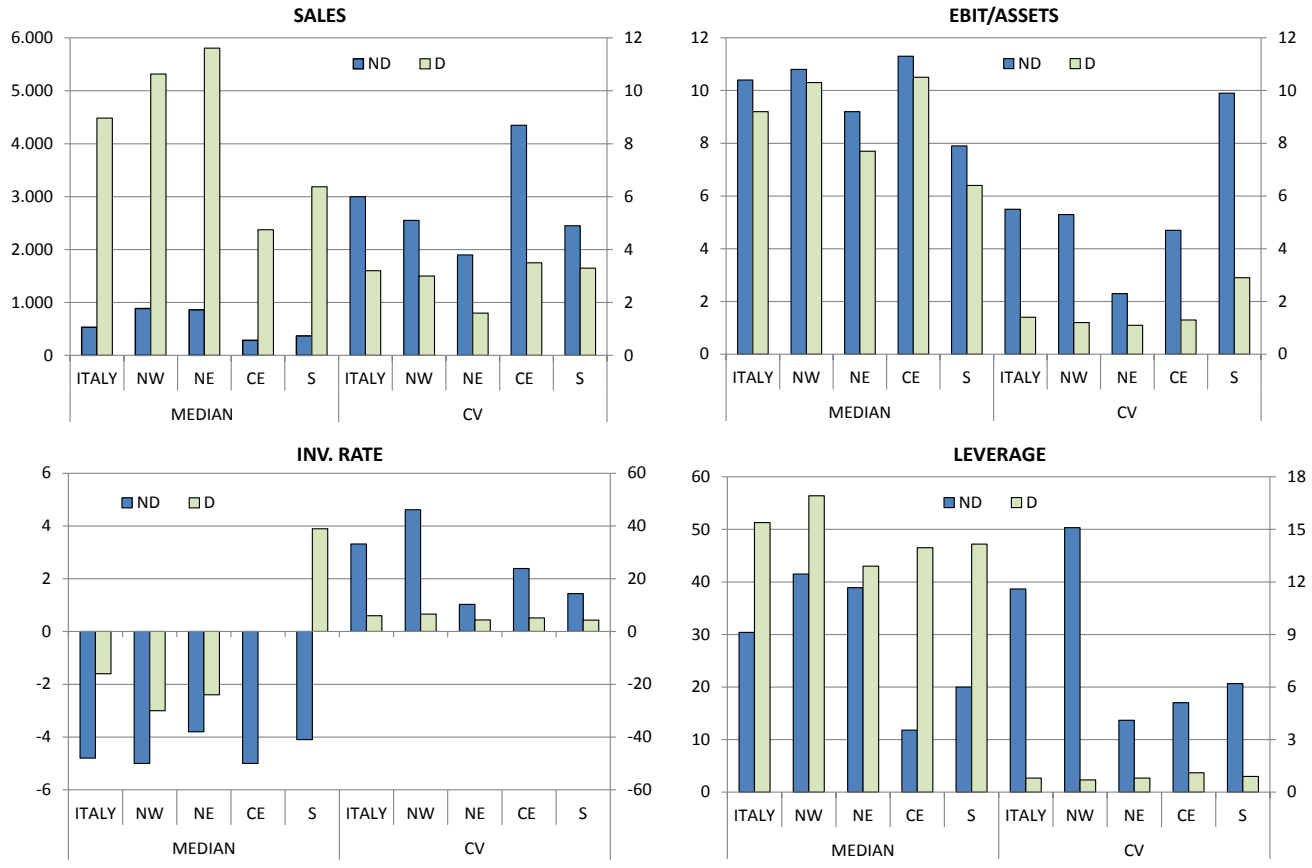
[9] We considered just once the data of the firms belonging to more than one district. The analysis includes only the firms with positive assets and sales (or, in alternative, the added value).

dispersion of these indicators as shown by the coefficients of variation. District firms appear much more leveraged, consistent with their bigger size: the difference between the two groups of firms is more marked in the Centre and in the South.

If we consider the data at single TD level, these differences between district and non-district firms within the same district become even more marked (data are not reported, but are available upon request).

Figure 2

Balance-sheet indicators



Data refer to the year before the establishment of the districts. Firms with sales larger than 1 billion euros have been excluded.
Sales: thousands of euros; EBIT/ASSETS, investment rate and leverage: percentage values.

We complete the descriptive analysis by examining the innovative capabilities of the firms. We measure innovation propensity through the number of patent applications submitted by firms to the European Patent Office (EPO), using the archive PATSTAT.[10] For each TD we consider the patent applications submitted to the EPO by district and non-district firms of the same region and 4-digit

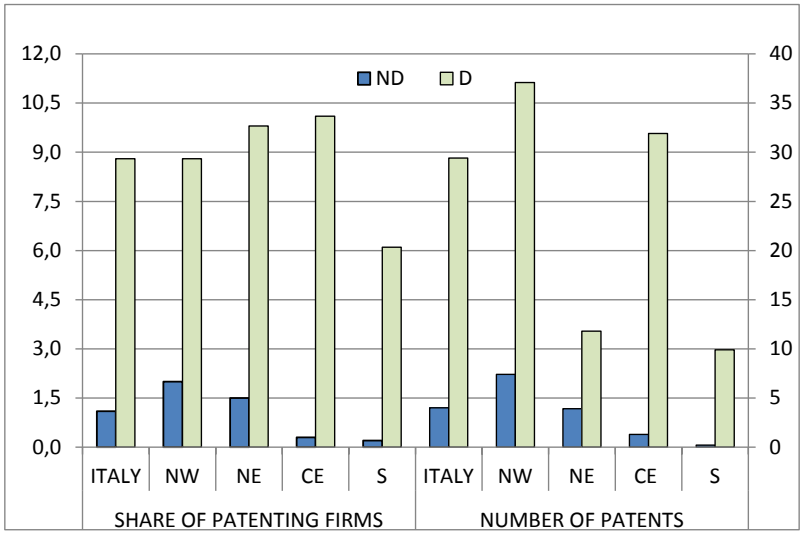
[10] We used the dataset provided by Francesca Lotti and Giovanni Marin whom we wish to thank (for details see Lotti and Marin, 2013). They combined information coming from the AIDA dataset of the *Bureau Van Dijk* and the PATSTAT dataset, which contains details about patents, including those of the applicants, provided by the *European Patent Office*. The correspondence between the AIDA and Cerved datasets is very high: only 32 patenting firms stored in AIDA (more than 8,500) are not in Cerved. The dataset refers to the whole of Italy for a period lasting from 1978 to 2011 (data are not yet definitive for 2011) and includes more than 48,000 patents, applied for by more than 8,500 firms. More than 5,000 patents refer to 259 district firms.

sector, in the five years before the birth of the districts.[11] As we did for the sample of firms for which we have the balance sheet data, we decided to exclude those with sales of more than 1 billion euros (Table 6; Figure 3).

In all the areas, district firms seem to be much more innovative than non-district firms. The percentage of firms that applied for at least one patent in the 5 years before the district's birth is, on average, about eight times bigger for district firms. The average number of patents by firm, multiplied by 100, is almost 30 for district firms, against about 4 for non-district firms. For both indicators, the difference between the two groups of firms is remarkable in each area, but particularly in the Centre. Among the non-district firms, the northern ones show a better performance compared to those located in the other areas of the country.

Figure 3

Patent applications



On the left side: percentage shares of submitting firms; on the right side: number of patent applications by firm multiplied by 100.

After having examined the differences for each variable separately, we now examine the correlation between the probability to participate in a district and some balance sheet variables all together. Over the same sample of district and non-district firms we estimate a probit model in which the probability of participating in a district – measured by a dichotomous variable equal to 1 if the firm joins a district and zero otherwise – is regressed on firm size (proxied either by assets or added value), overall profitability, leverage and patent propensity (a dummy equal to 1 if the firm has applied for at least one patent in the five years before the establishment of the district, zero otherwise), with reference to the year before the establishment of the TDs. We find that when we use all the variables together, and also when controlling for sector and regional dummies, all regressors are statistically significantly correlated

[11] We believe that five years is a sufficiently long time span to measure a firm's patent propensity robustly.

with the dependent variable (Table 7). To sum up, the most profitable, innovative, leveraged and largest firms are those that are more likely to join a district.

4. The performance of the district firms

In this section we assess whether, after having joined a technology district, firms enjoyed a higher performance than those of non-district firms. Notice that the objective of our exercise is less ambitious than evaluating the effectiveness of the programme. Rather, our aim is mainly of a descriptive nature because the programme aimed to increase regional innovative performance by enhancing the performance of all the agents of the targeted areas, not only that of participating firms. Even with this limitation we believe that our exercise can provide a valuable contribution to the knowledge of an underinvestigated but widespread Italian innovation policy.

In general, we would expect that adhesion to a district might have a positive impact on the innovative capability of firms, as a result of the establishment of closer relationships (and synergies) among the various actors of the district and thanks to public aid. Furthermore, we envisage that the policy may lower district firms' costs, fostering tangible and intangible investments. Therefore, district firms might eventually increase their size, profitability, productivity and innovative propensity compared with non-district firms.

As a result, we evaluate firm performance in terms of size (assets, sales and added value), profitability (gross operating margin over assets and returns on assets), accumulation of tangible or intangible assets (investment rate), financial structure (leverage), labour productivity (added value over labour cost and sales per capita) and innovation capabilities measured by patent applications submitted to the European Patent Office. The analysis is based on the comparison between district firms and similar non-district firms, before and after the creation of the district, using matching methods and difference-in-difference estimates (see e.g.: Imbens and Wooldridge, 2009).

More in detail the procedure is the following. First of all, each district firm is matched with a non-district firm which is in the Cerved database, found in the same geographical area of the district firm (i.e.: North-West, North-East, Centre and South), belongs to the same 2-digit sector, and is among those that minimize the Mahalanobis distance (Rubin, 1980). The variables used for the Mahalanobis function are: sales, added value, the ratio of gross operating margin over total assets, and the ratio of investments over sales. (The variables are: proxy of the firm size, operating profitability and capital accumulation, respectively.) The matching is carried out using the nearest neighbour method after having imposed the common support; the procedure is based on data referring to the year before the birth of the districts (to exclude any potential effects of the policy on the district firms). The biggest district firms, those with more than 1 billion euros of sales, were excluded because it was not possible

to find appropriate controls for them.[12] Notice that the matching procedures allowed us to match 847 non-district firms to 900 district ones. In order to obtain a more robust assessment of firm performance, we exclude the firms corresponding to the observations exceeding the 1st and 99th percentiles for each variable. The exclusion of the outliers reduced the sample to 766 district firms and 727 non-district ones. Table a1 (in Appendix) shows that after the matching procedure for a large set of observables, district firms and non-district firms in the control group are very similar: the mean differences are almost never statistically significant, showing that the two groups of firms are highly comparable in terms of the available observables.

The second step is to compare the performance of district and matched non-district firms by diff-in-diff estimates to assess whether the two groups of firms show a different path. The diff-in-diff estimate allows us to control for the initial differences in the levels of observables and un-observables between the two groups of firms. At the same time, the methodology relies upon the hypothesis that in absence of the TD the two groups of firms would have followed the same path (parallel trend assumption), i.e., that firms of the control group mimic the path that district firms would have followed if they had not joined the district. Therefore, we test the common trend assumption for some of the main balance sheet variables of the two groups of firms (sales, added value, tangible and intangible investments), to prevent the results of the analysis from being biased by different pre-treatment trends: we used the T-test over the rate of growth of the variables over the two years before the establishment of the districts, and we did not find statistically significant differences (results are not shown but are available upon request). Moreover, we tried to make the assumption less restrictive by including some control variables, which also interacted with the time dummy in the empirical model.

For each district firm and its control we considered the year before the creation of the district as the pre-policy period. The post-policy period includes the year of the constitution of the district and four years afterwards. Therefore, the estimates are carried out over 6 years. The sample only includes firms present in the dataset over the entire examined period. The estimated model is the following:

$$(1) \quad y_{it} = \alpha + \beta_1(DIST_i) + \beta_2(POST) + \beta_3(DIST_i*POST) + \sum_s (\gamma_{1s} SECTOR_s) + \sum_s (\gamma_{2s} SECTOR_s* POST) + \sum_r (\gamma_{3r} REG_r) + \sum_t (\gamma_{4t} YEAR_t) + \varepsilon_{it}$$

[12] The impossibility of defining an appropriate control group for some district firms led us to exclude the largest ones (14 firms with sales of more than 1 billion euros). We also decided to exclude 15 firms with headquarters in regions that are not the region of establishment of the district, in order to get more homogeneous firm comparisons (this led to the exclusion of all the firms for which balance sheet information was available in the Puglia high tech district).

y_{it} is the outcome variable with which we evaluate firms' performance. $DIST_i$ is a dummy equal to 1 if firm *i* participates in a district and 0 otherwise; t=1,2 is a time index. POST is a dummy equal to 1 over the post-policy period and 0 otherwise. REG, SECTOR and YEAR are dummies for the region of localization of the district, the 3-digit sector of the firm and the years, in order to control for common regional, sectorial and time shocks. The interaction among sector-dummies (SECTOR) and the post-policy dummy (POST) controls for potentially different time trends across sectors after the policy; ε_{it} is a stochastic error with the usual properties. The baseline regressions are carried out considering the average of every variable of interest over the 5 post-policy years (the year of the creation of the district and the following 4 years) for the post-policy period and the year before the creation of the TDs for the pre-policy period. The coefficient β_3 measures to what extent the performance of district firms changed after the creation of the district with respect to that of the control group. Robust standard errors reported in the tables are clustered at the firm level.

As mentioned above, in order to measure the firm's performance we use the following as outcome variables: assets, sales and added value as proxies of firm size; ROA and gross operating margin over assets as indexes of total and operating firm profitability; net total investments and the investment rate scaled by the pre-policy fixed assets to measure the accumulation of tangible and intangible assets and, finally, leverage to assess changes in the financial structure.[13]

Since firms of various sizes might have benefitted in varying degrees from participation in the district – e.g. small firms might have received a larger amount of public funds or services than large firms or might have benefitted more from the linkages created by the policy – we also report the results by splitting the sample between small and large firms to ascertain potential heterogeneities in the performance of firms according to their size. We separated the former from the latter according to the median value of their sales the year before the birth of the district.

In Table 8 we display the results for the total sample of firms over the whole post-program period, with all the fixed effects used as controls: we find a positive and significant coefficient for the total profitability (ROA) but not for the operating profitability. This means that after the creation of the district, firms that participated in the policy improved their performance in terms of overall profitability with respect to the control group of non-district firms, although such an effect is not driven by the operating profitability measured by the EBIT over assets, but rather by the non-operating revenues. (We repeated the exercise on each single balance sheet item of the total income – ROA: we found positive effects, even if not statistically significant, for all the considered items. This would probably mean that the positive effect of the adhesion to a district on the total profitability is the result of some

[13] Investments are calculated by the Cerved dataset as the yearly difference in tangible and intangible assets over consecutive years. For the investment rate they are scaled by the average value of the total assets of two years before the creation of the districts.

cumulative effect on each item – depreciation and amortisation, financial revenues and expenses, other costs and incomes – rather than a significant effect on a single item). By splitting the firm sample by size we find that this overall effect is driven by large firms, whereas there is no effect for small ones. This suggests how the benefits of the policy might have mainly benefitted large district firms that, for example, have been able to reduce their financial costs or expand their financial revenues arguably thanks to the financial aids linked to their participation in the district. As regards the other balance sheet variables examined we do not find any significant difference in the performance among district and non-district firms. We also estimated the model for each year of the post-policy period but we do not find any evident trend in the coefficients; moreover, they turn out to be almost never statistically significant.

We break down the sample into the main four geographical areas to verify the potential heterogeneity of performance according to the location of the districts. We find that the positive effect on the large firms' total profitability is due to the north-western districts. Moreover, we also find that district firms of the Centre outperform non-district firms in the same area in terms of investment rate; in such a case the results are driven by small firms but not by large ones (Tables 8-9). As regards the other variables we do not find any statistically significant changes.[14]

4.1 Productivity and innovation capabilities

In this section we extend the analysis to labour productivity and innovation capabilities which are studied separately from the previous ones because they come from different firms' samples.

As regards productivity, since the number of employees is only available for a very limited subsample of larger firms, we estimated the model (1) over a reduced sample that includes 430 district firms and 379 matched non-district firms of the control group. The results are shown in Table 8. We

[14] In order to verify the robustness of our results, we carry out the regression considering 3 and 4 years after the birth of the district as the post-policy period (instead of 5): the results are consistent with those of the baseline exercise. Next, we test a different treatment of the outliers, only excluding the observations exceeding the 1st and 99th percentile instead of the correspondent firms (in that case we gain in the number of observations). Also in this last case the results do not differ significantly from the baseline (for the sake of synthesis they are not shown but are available upon request). Finally, we also check if firms belonging to the control group had already taken advantage of other similar instruments of policy, such as science and technology parks, which could have influenced their performance (and the results of our analysis). Thanks to the information drawn from Liberati et al. (2015), whom we wish to thank for having shared their dataset, we were able to exclude this hypothesis, given that just one firm of our sample also belonged to a science and technology park.

In order to check for possible heterogeneous effects across TDs according to the features of the district we carry out a couple of further exercises. First, we check whether the change in firms' performance in large and small TDs has been different. The rationale is that districts with more firms might enhance technology transfer and firm performance more than the others, owing to stronger agglomeration economies. Therefore, we distinguish between small districts (those with a number of firms below the median value for Italy) and large districts (the others), and repeat the estimates, breaking down the firm sample into the two categories. Again, we do not find any remarkable effect on the outcome variables, either for large or for small TDs.

Second, we verify another type of heterogeneity distinguishing the TDs specialized in the same sector of specialization of the region by the others. We take advantage of the taxonomy provided by Miceli (2010) who addressed this issue by using a cluster analysis. The motivation is that the creation of the TD could have stronger positive effects if the sector of specialization of the TD reflects that of the area where the TD is localized. In this circumstance, the district can take advantage of localized knowledge and exploit stronger agglomeration externalities. From an empirical point of view we carry out separate estimates for regions specialized in the TD sectors, on one side, and regions not specialized in the TD sectors on the other. Again, the results of this exercise do not differ significantly between the two groups of regions. These results are not shown but are available upon request.

did not find any significant difference between the performance of district and non-district firms after the birth of the TDs, either for Italy or for the other sub-samples in which we have broken down the results (geographical areas and size). In order to overcome the loss of observations due to the use of an indicator scaled by the number of employees, we also tried to carry out the same analysis using the added value scaled over the labour cost as proxy for productivity and we did not find significant results (Table 8).

Next, we assess whether participation in a TD has enhanced the innovation propensity of the firms, measured by the number of patent applications presented at the European Patent Office and the probability of applying for a patent. Both are calculated over a 5-year period, before or after the creation of the TD. Information on patent applications comes from the merging of the PATSTAT dataset and the AIDA balance sheet dataset at the firm level carried out by Lotti and Marin (2013).

Overall, before the creation of the districts, the patent propensity of district firms was considerably higher than that of non-district firms located in the same region and belonging to the same 4-digit sector. The number of patent applications by firm, and the share of firms that applied for at least one patent were much larger in the district firms than in non-district firms (Table 10). However the difference in the number of patent applications depends on a very small number of district firms that have applied for a high number of patents. If we exclude the three highest patenting district firms, the two groups turned out to be very similar in terms of number of patent applications. In the five years before the birth of the TDs the average number of patent applications by 100 firms is 15.1 for district firms (it was 26.4 before the cut of the sample) against 14.6 of non-district firms.

After having balanced the samples (excluding those three firms), the next step was to estimate the equation (1) on the new firm samples. However, now the outcome variable y_{it} is the sum of the patent applications presented to the European Patent Office by firm i over the 5 years before the start-up of the policy (pre-policy period) and the 5 years after (the year of the start-up included). Over the whole 10-year period, 159 district firms and 71 non-district firms have applied for a patent. Since there are several firms with zero patent applications, we cannot exclude that the error term does not have a normal distribution. Therefore, we estimated the model both by OLS and by maximum likelihood, assuming that the error term has a Poisson distribution (a standard practice for the empirical studies on patents). As robustness checks, we have used 4-digit sector dummies and excluded the regional dummies, without appreciable differences in the results (they are not shown but are available upon request).

The main findings, in line with those previously obtained, are reported in Table 10. We see that the differences in the number of patent applications between district and non-district firms do not change after the start-up of the TDs. The estimates of the coefficient β_3 are never statistically significant.[15]

Finally, we also verify whether a firm's probability of patenting could have changed after the establishment of the district for the same samples. We estimated the equation by using a probit model after having changed the outcome variable y_{it} in the probability of patenting, i.e. $y_{it}=1$ if firm i applied for at least one patent in period t and zero otherwise. In line with previous results we did not find any significant change in the probability of patenting of district firms with respect to that of the control group after they had joined the district (see Table 10, the last column).[16]

5. Conclusions

In this paper we have examined Italy's technology districts, a policy instrument implemented in order to stimulate the creation and development of local innovative systems. The focus of our paper is on district firms' characteristics and their performances.

Our analysis shows that technology districts are very heterogeneous, in terms of innovative activities, number of firms, and distribution throughout Italy. In southern Italy there are more TDs which, however, are much smaller in size than the districts in the other geographical areas; southern TDs are also poorly diversified sectorially and more distant from the economic structure of the area. These characteristics might limit the synergies among firms and the economies of scale and scope that the policy would implicitly like to trigger. On the contrary, in the Centre and North the districts are bigger and more diversified in term of sectors, however only in the north-eastern regions do they closely mirror the sectorial specialization of the area.

The empirical evidence shows that firms that joined a TD were, before the creation of the district, larger, more innovative, and also more profitable than non-district firms belonging to the same sectors and located in the same geographical areas. Moreover, after the start-up of the district, district firms did not perform significantly better than similar non-district firms, except in terms of total profitability. This result is driven by large district firms in the North-West, plausibly also thanks to public financial aid, but it does not apply to small district firms. Our findings also show that small firms in the districts of the Centre outperform non-district firms – after the birth of the district – in terms of investment rates. However, this result must be taken cautiously because of the limited size of that specific sub-

[15] We also obtain qualitatively similar results when we break down the sample between small and large districts and separate the regions between those that are specialized in the same sector of the districts and the others.

[16] Table 10 shows the results of the model estimated without regional and sector fixed effects because, due to no variability of the dependent variable within some sectors and regions, some observations would have been dropped in the Probit model. However, the results are similar if we include fixed effects and estimate the Probit model over the smaller sample that excludes such observations.

sample.[17] Overall, some suggestive evidence seems to emerge that a firm's performance is weakly correlated to the participation in a district. Nevertheless, we would like to stress that an evaluation of the effectiveness of the programme is a goal beyond the scope of the present paper.

This analysis is a further step to a deeper understanding of a widespread policy instrument for innovation. However, it has some limitations that need to be borne in mind. Since the evaluation of firms' performance is focused on enterprises present in the dataset before the creation of the TDs, the results cannot be extended to the start-ups established at the same time as the TDs or to the smallest (non-limited) companies, for which balance sheet data are not available. It is possible that these categories of firms, i.e. younger and smaller, could have benefitted more from the policy, as found by Lach (2002) and Bronzini and Piselli (2016) among others. The investigation of start-ups or the smallest firms' performance would be extremely interesting, especially in our context, but it requires information that is not available so far. Second, to evaluate the effectiveness of the policy, consistently with the theoretical approach on which the TDs were based, it would be essential to evaluate the performance of all the actors and geographical areas targeted by the policy. These are challenging avenues open for future research.

[17] Excluding the outliers, in the Centre there were, respectively, 98 district firms and 70 non-district small firms.

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Table. 1

Characteristics of the technology districts by region

Region - Geographical area	Number of districts	Year of establishment	Activities	Number of district firms	Average number of firms by district	Number of district firms stored in Cerved
Piedmont (NW)	1	2003	ICT-Wireless	439	439	201
Lombardy (NW)	3	2004 2004 2004	ICT Biotechnologies Advanced materials	89 154 164	136	333
Liguria (NW)	1	2005	Intelligent integrated systems	26	26	22
Trentino Alto Adige (NE)	1	2006	Sustainable technologies for building	171	171	109
Veneto (NE)	1	2004	Nanotechnologies	16	16	15
Friuli Venezia Giulia (NE)	1	2004	Molecular biotechnologies	14	14	5
Emilia Romagna (NE)	2	2004 n.a. (1)	Advanced mechanics Biomedical equipment	89 40	65	29
Tuscany (CE)	1	2006	Mechatronics	175	175	64
Umbria (CE)	1	2006	Mechatronics	59	59	28
Lazio (CE)	3	2004 2008 2008	Aerospace Biosciences Cultural activities	221 80 90	130	226
Abruzzo (SO)	1	2005	Agri-bio-food	25	25	17
Molise (SO)	1	2006	Agri-bio-food	23	23	2
Campania (SO)	1	2005	Polymeric materials	15	15	10
Puglia (SO)	4	2005 2005 2008 2005	Mechatronics Nanotechnologies and ICT Energy Agri-bio-food	9 10 31 101	38	82
Basilicata (SO)	1	2005	Hydrogeological and sismic risks	4	4	2
Calabria (SO)	2	2005 2005	Logistics and transports Cultural activities	26 18	22	23
Sicily (SO)	3	2005 2005 2005	Micro and nanosystems ICT and microelectronics Agri-bio-food	12 136 10	53	54
Sardinia (SO)	1	2005	Wealth technologies	51	51	14
North West - NW	5	-	-	872	174	556
North East - NE	5	-	-	330	66	158
Centre - CE	5	-	-	625	125	318
South - SO	14	-	-	471	34	204
Italy	**29**	-	-	**2,298**	**79**	**1,236**

Data refer to 2012 (latest available year). District firms also include those whose headquarters are in another region.
(1) The year of establishment of the “Biomedical equipment” district is not available.

Table. 2

Number of firms and number of districts by economic activity – Year 2012

Economic activities	Number of districts	Number of district firms	Average number of firms per district
Agriculture, forestry and fishing	2	10	5.0
Food	5	78	15.6
Textile and clothing	4	4	1.0
Wood and furniture	3	9	3.0
Paper and publishing	2	2	1.0
Chemical and pharmaceutics	15	86	5.7
Rubber and plastic products	9	68	7.6
Metallurgy	9	59	6.6
Electronics products	22	151	6.9
Machinery	14	62	4.4
Means of transport	8	21	2.6
Other industries	12	60	5.0
Electricity, power, gas, etc.	7	23	3.3
Building	11	69	6.3
Trade	13	66	5.1
Information and communications	14	259	18.5
Professional activities	26	175	6.7
Other services	21	24	1.6
Industry	25	600	24.0
Building	11	69	6.3
Services	27	534	19.8
Other activities	9	33	3.7
Total	**29**	**1,236**	**42.6**

Data refer to 2012 (latest available year). Each district can include more than a single economic activity.

Table. 3

Distribution of firms by sector and diversity index

	Shares (Percentages calculated on the number of firms)										Diversity index (1)				
	North West		North East		Centre		South		Italy		North West	North East	Centre	South	Italy
	TOT	D	TOT	D	TOT	D	TOT	D	TOT	D					
Agriculture, forestry and fishing	0.2	0.2	0.0	0.0	0.0	0.0	3.9	8.4	0.7	1.2	0.0	0.0	0.0	4.5	0.5
Food	2.3	9.0	0.0	0.0	0.0	0.4	3.3	20.6	1.6	7.4	6.7	0.0	0.4	17.3	5.8
Textiles and clothing	1.7	0.2	0.0	1.0	0.1	0.4	0.0	0.0	0.8	0.3	-1.5	1.0	0.3	0.0	-0.5
Wood and furniture	0.2	0.4	3.0	6.9	0.1	0.4	0.0	0.0	0.2	1.0	0.2	3.9	0.3	0.0	0.8
Paper and publishing	1.9	0.2	0.0	0.0	1.2	0.0	0.1	0.8	1.3	0.2	-1.7	0.0	-1.2	0.7	-1.1
Chemical and pharmaceutics	2.7	12.0	3.1	2.9	1.1	3.6	0.4	2.3	1.7	7.6	9.3	-0.1	2.6	1.9	5.9
Rubber and plastic products	5.5	13.8	1.1	3.9	0.4	0.8	0.4	0.8	2.7	7.7	8.3	2.9	0.5	0.3	5.0
Metallurgy	14.4	5.5	3.6	5.9	1.5	7.3	1.6	1.5	7.3	5.5	-8.9	2.3	5.8	0.0	-1.9
Electronics products	8.7	17.3	6.9	5.9	2.7	16.5	1.3	4.6	5.3	14.2	8.6	-1.0	13.8	3.3	8.9
Machinery	11.1	6.1	5.5	4.9	0.6	6.5	0.5	3.1	5.5	5.7	-5.0	-0.6	5.8	2.6	0.2
Means of transport	1.3	1.0	2.1	1.0	0.6	5.2	0.5	1.5	0.9	2.2	-0.3	-1.2	4.7	1.0	1.2
Other industries	4.9	6.9	0.9	0.0	1.9	2.8	1.2	4.6	3.1	4.8	2.0	-0.9	0.9	3.4	1.7
Electricity, power, gas, etc.	0.3	0.4	5.6	9.8	0.4	0.0	1.0	3.1	0.7	1.6	0.1	4.2	-0.4	2.0	1.0
Building	4.7	0.8	30.9	31.4	12.1	4.0	38.4	6.9	13.9	5.7	-3.9	0.4	-8.1	-31.5	-8.2
Trade	8.1	3.9	10.5	3.9	12.0	4.4	14.1	11.5	10.5	5.0	-4.2	-6.6	-7.5	-2.6	-5.5
Transport services	0.1	0.2	0.0	0.0	0.3	1.2	0.5	4.6	0.2	1.0	0.1	0.0	0.9	4.0	0.8
Accommodation and food services	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.8	0.1	0.1	-0.2	0.0	0.0	0.6	0.0
Information and communications	17.1	17.1	4.8	5.9	24.7	30.2	7.9	4.6	17.7	17.6	0.0	1.1	5.6	-3.3	-0.1
Real estate services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Professional services	11.9	4.3	18.6	14.7	21.2	13.3	17.4	19.1	16.3	9.7	-7.7	-3.9	-7.8	1.7	-6.6
Rental services	0.0	0.0	1.5	1.0	7.3	0.8	2.0	0.0	2.9	0.3	0.0	-0.5	-6.5	-2.0	-2.6
Other services	0.2	0.6	1.9	1.0	3.4	2.0	2.3	1.5	1.7	1.1	0.5	-1.0	-1.4	-0.7	-0.6
Mean (on absolute values)	4.4	4.5	4.5	4.5	4.2	4.5	4.4	4.5	4.3	4.5	3.1	1.4	3.4	3.8	2.7
Median (on absolute values)	2.1	0.9	2.0	2.0	0.8	1.6	1.1	2.7	1.7	3.5	1.6	0.9	1.3	2.0	1.1
Industry	54.6	72.5	26.2	32.4	10.0	44.0	9.3	39.7	30.4	56.6	17.9	6.2	33.9	30.4	26.1
Building	37.6	26.1	37.3	26.5	68.8	52.0	44.4	42.0	49.6	34.9	-11.5	-10.8	-16.8	-2.4	-14.7
Services	4.7	0.8	30.9	31.4	12.1	4.0	38.4	6.9	13.9	5.7	-3.9	0.4	-8.1	-31.5	-8.2
Other activities	3.1	0.6	5.6	9.8	9.1	0.0	7.9	11.5	6.1	2.9	-2.5	4.2	-9.1	3.6	-3.2
Total	100	100	100	100	100	100	100	100	100	100	0.0	0.0	0.0	0.0	0.0
Total number of firms	38,400	491	3,305	102	29,966	248	14,291	131	85,962	972					

(1) The diversity index is calculated as follows: ((number of district firms in sector *j*-area *i*) / (total number of districts firms in area *i*)) - ((number of firms in sector *j*- area *i*) / (total number of firms in area *i*)). For each area, values greater than zero mean that district firms are more specialized in sector *j* compared to the total firms of the area; values near zero mean that district firms are as specialized in the sector *j* as the total firms of the area; values smaller than zero mean that district firms are less specialized in sector *j* compared to the total firms of the area.

Table. 4

Heterogeneity by district in terms of sector of economic activity

Districts	Sector of specialization	Number of sectors by district	First most important sector	First most important sector (percentage)	Three most important sectors (percentage)
Piedmont (NW)	ICT-Wireless	14	Information and communications	43.0	70.2
Trentino Alto Adige (NE)	Sustainable technologies for building	14	Building	35.2	61.5
Lombardy (NW)	ICT	7	Electronics products	65.9	86.6
Lombardy (NW)	Biotechnologies	10	Chemicals and pharmaceutics	44.4	88.7
Lombardy (NW)	Advanced materials	10	Rubber and plastic products	59.4	85.8
Liguria (NW)	Intelligent integrated systems	4	Information and communications	63.2	89.5
Tuscany (CE)	Mechatronics	8	Information and communications	46.7	77.8
Veneto (NE)	Nanotechnologies	4	Metallurgy	37.5	87.5
Friuli Venezia Giulia (NE)	Molecular biotechnologies	2	Chemicals and pharmaceutics	66.7	100.0
Lazio (CE)	Aerospace	15	Information and communications	34.3	64.3
Lazio (CE)	Biosciences	9	Electronics products	31.3	62.5
Lazio (CE)	Cultural activities	4	Information and communications	28.6	85.7
Umbria (CE)	Mechatronics	7	Machinery	37.8	81.1
Abruzzo (SO)	Agri-bio-food	5	Food	42.9	85.7
Molise (SO)	Agri-bio-food	1	Building	100.0	100.0
Basilicata (SO)	Hydrogeological and sismic risks	1	Professional services	100.0	100.0
Campania (SO)	Polymeric materials	2	Professional services	75.0	100.0
Puglia (SO)	Mechatronics	4	Professional services	42.9	85.7
Puglia (SO)	Energy	6	Electricity, power, gas, etc.	27.3	72.7
Puglia (SO)	Agri-bio-food	9	Food	45.5	79.5
Calabria (SO)	Logistics and transports	7	Transport services	42.9	71.4
Calabria (SO)	Cultural activities	1	Professional services	100.0	100.0
Sicily (SO)	Micro and nanosystems	3	Chemicals and pharmaceutics	33.3	100.0
Sicily (SO)	ICT and microelectronics	8	Trade	26.1	56.5
Sicily (SO)	Agri-bio-food	2	Professional services	66.7	100.0
Sardinia (SO)	Wealth technologies	4	Other industries	40.0	80.0

Data refer to the year before the establishment of the districts. Firms with sales of over 1 billion euros have been excluded.

Table. 5

Economic financial indicators: district and non-district firms by regions

	Mean		Median		Standard deviation		Pctile_10		Pctile_90		Coeff. of var.	
	ND	D	ND	D	ND	D	ND	D	ND	D	ND	D
	North West (462 D; 30.666 ND)											
Assets	5,290	14,044	750	4,657	32,376	47,621	100	729	8,199	22,052	6.1	3.4
Sales	5,752	14,186	885	5,318	29,098	42,781	103	975	9,363	25,883	5.1	3.0
Added value	1,323	3,810	259	1,443	6,627	11,872	13	278	2,279	6,780	5.0	3.1
ROA	-2.3	1.0	0.4	0.4	56.6	10.1	-9.1	-2.9	9.2	8.2	24.8	9.6
EBIT/assets	10.6	11.2	10.8	10.3	56.3	13.5	-3.8	0.1	30.3	24.7	5.3	1.2
Invest. rate	59.3	12.7	-5.0	-3.0	2,738.0	84.0	-39.5	-29.2	72.3	52.5	46.2	6.6
Tot.inv./sales	-32.6	0.5	-0.5	-0.2	2,962.4	16.8	-7.7	-4.7	7.6	8.9	90.9	33.8
Leverage	39.0	50.7	41.5	56.4	589.4	35.2	0.0	0.0	93.1	89.3	15.1	0.7
	North East (93 D; 2.314 ND)											
Assets	4,538	18,261	947	6,261	17,224	47,410	107	453	9,195	40,365	3.8	2.6
Sales	4,384	13,991	861	5,807	16,659	22,079	82	530	8,869	38,114	3.8	1.6
Added value	1,016	3,813	220	1,488	3,155	6,276	7	110	2,198	8,969	3.1	1.6
ROA	-8.6	1.0	0.6	0.8	432.8	5.9	-6.9	-3.7	9.6	7.1	50.6	5.7
EBIT/assets	10.7	9.8	9.2	7.7	25.1	11.1	-3.6	0.3	28.9	20.3	2.3	1.1
Invest. rate	56.6	34.6	-3.8	-2.4	581.6	153.7	-37.6	-24.9	89.0	85.7	10.3	4.4
Tot.inv./sales	-11.5	4.4	-0.5	-0.2	548.0	25.2	-10.0	-3.7	10.7	11.0	47.7	5.7
Leverage	45.6	42.8	38.9	43.0	187.7	32.7	0.0	0.0	95.5	87.1	4.1	0.8
	Centre (224 D; 19.905 ND)											
Assets	3,269	32,058	266	2,450	112,124	146,785	47	199	2,499	35,578	34.3	4.6
Sales	2,292	18,878	286	2,373	19,945	66,397	38	260	2,480	30,061	8.7	3.5
Added value	623	7,318	74	788	7,073	33,320	2	53	634	8,720	11.4	4.6
ROA	-3.3	1.3	1	1	69.5	8.4	-11.3	-3.8	11.5	8.1	20.9	6.6
EBIT/assets	12.2	12.3	11.3	10.5	58.0	15.8	-5.8	-1.3	37.5	26.6	4.7	1.3
Invest. rate	68.3	31.9	-5.0	0.0	1,631.0	166.5	-47.4	-28.5	100.0	78.3	23.9	5.2
Tot.inv./sales	-6.6	2.6	-0.5	0.0	445.2	14.7	-11.4	-4.3	9.8	8.5	67.9	5.6
Leverage	34.4	40.2	11.8	46.5	175.1	44.3	0.0	0.0	90.4	84.1	5.1	1.1
	South (113 D; 9.155 ND)											
Assets	2,007	25,317	438	4,351	9,612	92,444	53	618	3,804	55,991	4.8	3.7
Sales	1,518	18,921	367	3,186	7,434	63,257	34	356	2,890	35,062	4.9	3.3
Added value	390	4,626	108	713	1,818	14,958	4	44	718	9,048	4.7	3.2
ROA	-3.9	0.5	0.5	0.2	76.6	7.4	-10.6	-3.4	9.6	7.5	-19.7	16.0
EBIT/assets	7.3	6.1	7.9	6.4	72.6	17.6	-6.2	-6.3	29.2	16.5	9.9	2.9
Invest. rate	85.6	80.6	-4.1	3.9	1,236.2	347.5	-47.1	-24.0	110.0	157.1	14.4	4.3
Tot.inv./sales	20.2	58.5	-0.4	1.7	1,158.2	412.2	-14.3	-8.0	14.0	41.3	57.3	7.0
Leverage	38.6	44.9	20.0	47.2	239.0	38.5	0.0	0.0	92.9	84.4	6.2	0.9
	Italy (892 D; 62.040 ND)											
Assets	4,129	20,435	496	4,301	67,660	89,055	67	520	5,464	30,556	16.4	4.4
Sales	3,966	15,944	530	4,485	23,833	51,078	56	499	5,745	28,679	6.0	3.2
Added value	949	4,795	149	1,252	6,226	19,626	6	112	1,456	7,532	6.6	4.1
ROA	-3.1	1.0	0.4	0.4	104.8	9.0	-9.9	-3.4	10.0	7.9	33.9	8.7
EBIT/assets	10.6	10.7	10.4	9.2	58.7	14.6	-4.7	-0.5	32.4	24.8	5.5	1.4
Invest. rate	66.0	28.4	-4.8	-1.6	2,190.3	169.4	-42.1	-27.2	90.2	69.3	33.2	6.0
Tot.inv./sales	-15.7	8.8	-0.5	0.0	2,147.3	148.3	-9.7	-4.7	9.1	11.0	137.2	16.9
Leverage	37.7	46.5	30.4	51.3	437.4	38.1	0.0	0.0	92.5	87.8	11.6	0.8

Data refer to the year before the establishment of the districts. Firms with sales of over 1 billion euros have been excluded.

Table. 6

Number of applications to the European Patent Office: district and non-district firms

Areas	Percentage of patenting firms		Average number of patents by patenting firm * 100	
	District	Non-district	District	Non-district
North West	8.8	2.0	37.1	7.4
North East	9.8	1.5	11.8	3.9
Centre	10.1	0.3	31.9	1.3
South	6.1	0.2	9.9	0.2
Italy	**8.8**	**1.1**	**29.4**	**4.0**

Data refer to a period of 5 years before the establishment of the districts. Firms with sales of over 1 billion euros have been excluded.

Table. 7

Probit – Dependent variable: probability of joining a district (robust std. error in brackets)

Variables	Probit (1)	Variables	Probit (1)
Assets	0.000202**	Added value	0.00541***
	(0.000096)		(0.000961)
ROA	1.13***	ROA	1.12***
	(0.309)		(0.306)
Leverage	0.0598**	Leverage	0.0609**
	(0.0266)		(0.0266)
Patents (2)	0.713***	Patents (2)	0.653***
	(0.0655)		(0.0691)
Obs.	61,435	Obs.	61,435

Data refer to the year before the establishment of the districts. Firms with sales of over 1 billion euros have been excluded. All coefficients and standard errors (except "patents") are multiplied by 1,000 to improve readability
(1) Probit with 2-digits sector dummies and regional dummies as controls. – (2) Patents: dummy equal to "1" if the firm has applied for at least one patent in the five years before the establishment of the district; "0" otherwise.

Table. 8

Diff-in-diff regression: Coefficients of DIST*POST (robust std. error in brackets)

Areas	Observations	Total assets	Sales	Added value	ROA	EBIT/assets	Total investments	Total investment rate	Leverage	Added value * 100 / labour cost	Sales per capita (1)
	Pre period:t-1; Post period: average from t to t+4 – All fixed effects (2)										
Total	2,482	606.4	45.92	-14.33	0.897**	0.0894	57.32	1.875	-1.195	2.338	-26.68
		(613.5)	(427.3)	(153.0)	(0.435)	(0.550)	(102.4)	(8.501)	(3.170)	(5.096)	(26.88)
Small	1,152	134.7	144.7*	44.61	0.529	1.282	-15.59	4.628	-5.003	1.977	7.984
		(146.5)	(85.92)	(37.33)	(0.727)	(0.954)	(29.03)	(16.37)	(5.013)	(8.978)	(25.72)
Large	1,330	389.0	-987.5	-268.8	1.003*	-0.930	70.69	3.423	3.736	3.362	-36.67
		(1,263)	(962.5)	(308.5)	(0.513)	(0.683)	(205.8)	(7.069)	(4.902)	(6.703)	(32.67)
	Pre period:t-1; Post period: average from t to t+4 – All fixed effects (2)										
North West	1,479	353.7	189.3	89.39	0.906*	0.375	36.97	-9.010	1.197	4.557	-28.92
		(761.5)	(598.5)	(204.9)	(0.547)	(0.700)	(151.3)	(10.19)	(3.042)	(5.217)	(35.90)
North East	214	4,929	724.1	-63.20	0.524	-1.106	-158.1	-3.972	0.873	5.609	-3.925
		(3,312)	(769.5)	(261.8)	(0.857)	(1.587)	(256.8)	(12.05)	(5.568)	(11.49)	(38.96)
Centre	544	255.5	-86.82	115.4	0.149	-0.665	105.1	32.72***	-5.235	-10.10	-138.4*
		(817.2)	(725.0)	(183.6)	(0.940)	(1.345)	(94.93)	(11.20)	(9.836)	(16.88)	(72.91)
South	245	-1,315	-1,213	-765.0	3.195	0.400	219.3	39.18	-16.75	17.03	-85.40
		(2,206)	(1,459)	(787.0)	(2.140)	(2.118)	(246.3)	(30.04)	(22.80)	(26.95)	(85.88)

Firms exceeding the 1st and 99th percentiles for each variable are excluded. (1) Regression on "sales per capita" has been carried on over a sub-sample of 809 firms for which the information on the number of employees was available. – (2) Regression with dummies "year", "ateco 3 digit", "(ateco 3 digit * post)", "region". Robust standard error clustered by firm. *** p<0.01; ** p<0.05; * p<0.1

Table. 9

Diff-in-diff regression: Coefficients of DIST*POST (robust std. error in brackets)

Areas	Observations	Total assets	Sales	Added value	ROA	EBIT/assets	Total investments	Total investment rate	Leverage
	Pre period:t-1; Post period: average from t to t+4 – SMALL (1)								
North West	603	108.8	125.1	58.56	0.476	1.928	-1.103	-12.21	-6.048
		(149.8)	(122.8)	(47.78)	(1.093)	(1.390)	(29.26)	(19.71)	(4.019)
North East	71	380.8	-139.7	-59.78	-3.237*	-2.735	-339.1	-8.260	-4.346
		(2,240)	(621.7)	(214.3)	(1.664)	(2.437)	(435.3)	(29.24)	(18.91)
Centre	332	26.01	168.5	48.00	-0.455	-1.207	33.19	51.31***	2.308
		(193.7)	(162.4)	(69.00)	(1.065)	(1.896)	(34.53)	(16.63)	(5.613)
South	146	246.1	93.95	-25.57	3.453	3.137	-50.48	50.55	-33.92
		(656.9)	(246.1)	(158.4)	(2.944)	(3.414)	(149.2)	(55.21)	(45.35)
	Pre period:t-1; Post period: average from t to t+4 – LARGE (1)								
North West	876	420.7	-73.24	32.29	1.049*	-0.579	50.29	3.997	9.396*
		(1,467)	(1232)	(386.0)	(0.597)	(0.809)	(274.1)	(9.000)	(5.045)
North East	143	6,102	-750.3	-517.7	1.574	-0.215	-141.1	-3.586	5.359
		(6,338)	(1,594)	(565.6)	(1.237)	(2.417)	(351.0)	(16.25)	(6.827)
Centre	212	349.9	-1,255	-132.1	2.212	1.006	368.6	8.368	-41.48
		(3,095)	(2,567)	(715.9)	(2.301)	(2.079)	(338.9)	(21.28)	(42.31)
South	99	-6,295	-5,749	-2,820	-0.132	-5.413*	326.1	11.75	-2.284
		(5,210)	(3,720)	(1,798)	(1.180)	(3.056)	(521.5)	(24.73)	(9.561)

Firms exceeding the 1st and 99th percentiles for each variable are excluded. (1) Regression with dummies “year”, “ateco 3 digit”, “(ateco 3 digit * post)”, “region”.
Robust standard error clustered by firm. *** p<0.01; ** p<0.05; * p<0.1

Table. 10

Patents: balancing properties and "diff-in-diff" regression – Coefficients of DIST*POST (robust std. error in brackets)

Firms	Share of patenting firms*100	Patents/firms*100
	Before the exclusion of the most innovative firms	
Non-district	4.1	14.6
District	7.7	26.4
Total	6.0	20.7
	After the exclusion of the most innovative firms	
Non-district	4.1	14.6
District	7.4	15.1
Total	5.8	14.9

Areas	Dependent variable: number of patents (1)			Dependent variable: probability of patenting
	Observations	Ols	Poisson	Probit
Italy	3,106	0.0133	0.0678	0.140
		(0.0859)	(0.464)	(0.105)

For each firm we considered a ten-year period: the year of establishment of the district, five years before and four years after.

District firms with sales of over 1 billion euros have been excluded. Furthermore, we decided to exclude the three highest patenting firms in order to get more comparable results. – (1) Regression includes region and 3-digit sector dummies as controls.

Robust standard error clustered by firms . *** p<0.01; ** p<0.05; * p<0.1.

Appendix

Table. a1

Balancing properties

Matching by macroregion and sector of economic activity (ateco 2 digit) with the "Mahalanobis" method

Areas	Number of matched firms		Sales				Added value				ROA				EBIT/assets			
	D	ND	Mean D	Mean ND	Diff	Std. Err.	Mean D	Mean ND	Diff	Std. Err.	Mean D	Mean ND	Diff	Std. Err.	Mean D	Mean ND	Diff	Std. Err.
Italy	766	727	10,230	9,255	975	875	2,722	2,395	326	216	1.4	1.2	0.2	0.3	11.1	11.2	-0.1	0.5
North West	435	415	10,975	10,678	296	1,239	2,734	2,595	139	255	1.6	1.3	0.3	0.4	11.7	11.6	0.1	0.6
North East	68	62	14,880	13,149	1,730	3,893	4,025	3,722	304	1,130	1.2	1.5	-0.3	0.8	9.0	9.7	-0.7	1.4
Centre	185	167	7,516	5,600	1,914	1,181	2,486	1,916	569	395	1.1	1.4	-0.3	0.6	11.5	12.6	-1.1	1.1
South	78	83	8,457	6,583	1,874	2,351	2,076	1,369	707	765	0.7	-0.4	1.1	1.1	8.9	7.9	1.0	1.8
Italy - small	361	376	1,849	1,748	101	88	713	643	70 (*)	39	1.3	0.7	0.6	0.5	12.0	12.0	0.0	0.8
Italy - large	405	351	17,699	17,296	403	1,532	4,513	4,272	241	381	1.4	1.6	-0.2	0.3	10.3	10.4	-0.1	0.6

Areas	Number of matched firms		Total investments				Total investment rate				Leverage				Added value*100/labour cost			
	D	ND	Mean D	Mean ND	Diff	Std. Err.	Mean D	Mean ND	Diff	Std. Err.	Mean D	Mean ND	Diff	Std. Err.	Mean D	Mean ND	Diff	Std. Err.
Italy	766	727	103	103	0	40	18.7	13.7	5.0	4.5	47.5	44.9	2.6	1.8	160	167	-7	5
North West	435	415	87	104	-17	27	9.6	8.9	-0.7	4.0	50.7	46.2	4.5 (**)	1.1	159	163	-4	5
North East	68	62	248	220	28	194	42.7	21.3	21.4	27.5	41.4	48.6	-7.2	5.8	162	168	-6	20
Centre	185	167	71	14	57	56	22.9	16.8	6.1	9.7	44.6	40.8	3.8	3.7	158	171	-13	11
South	78	83	141	193	-52	129	38.2	25.2	13.0	18.9	41.9	44.0	-2.1	5.3	167	183	-17	18
Italy - small	361	376	55.7	41.7	14.0	19.4	28.6	18.8	9.8	8.3	42.2	38.2	4.0	2.7	157	157	-1	7
Italy - large	405	351	145	170	-25	77	9.8	8.2	1.6	3.8	52.3	52.2	0.1	2.2	162	178	-16 (***)	5.8

Firms have been matched with reference to the year before the establishment of the districts, based on the following variables: sales, added value, EBIT/assets, total investments/sales. District firms with sales of over 1 billion euros have been excluded. Firms exceeding the 1st and 99th percentiles for each variable are excluded. – Total Investments: (Total net assets $_t$ - Total net assets $_{t-1}$). – Total Investment rate: (Total assets $_t$ - Total assets $_{t-1}$)/ Total assets $_{t-1}$. "t" is the year of establishment of the district. *** p<0.01; ** p<0.05; * p<0.1