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The core in the periphery? The cluster organisation as the central node in the Apulian aerospace district

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Abstract

Cluster policy is often ineffective in peripheral regions with weak institutions and significant barriers to knowledge production and exchange. Nonetheless, many peripheral regions have pursued such policies in recent years, an example being technology districts in Southern Italy. This paper examines one such district, the aerospace district in Apulia, where policy has focused on indirect support for networking through coordination. This has led to a substantial increase in knowledge exchange within the district, but also to a heavy dependence on the cluster organization itself as the key actor in the knowledge exchange network.

KEYWORDS: Clusters, Technology districts, Policy evaluation, Innovation networks, Knowledge exchange, Social network analysis

1. Introduction

The fame of Silicon Valley and Boston's Route 128 made clusters fashionable among policymakers attempting to create flourishing entrepreneurial environments, new jobs and wealthy regions (Feldman et al., 2005). However, despite efforts to replicate these success stories, many clusters remain mere co-locations of firms and organisations without significant knowledge creation, exchange and diffusion. This issue is particularly acute in peripheral regions with weak socioeconomic and institutional structures (Kasabov, 2011), where there is often insufficient local knowledge production and poor conditions for knowledge exchange. Although many clusters have arisen in peripheral regions, the literature has tended mainly to consider core regions. Consequently, we know relatively little about how clusters and, more specifically, cluster policies work in peripheral regions. Furthermore, despite the growth of relational economic geography (Balland et al., 2013), the structural properties of networks created by organisations in clusters are often neglected. Net changes in collaboration levels may reflect higher knowledge exchange in general or be driven by the positions of a few organisations in the cluster. More research is therefore needed into how cluster policies affect knowledge exchange dynamics.

This paper addresses both these limitations by analysing how the knowledge exchange network developed when a peripheral region implemented a cluster initiative. We examine the Apulian Aerospace District (Distretto Aerospaziale Pugliese, DAP), established in 2007, with the Aerospace Technology District (Distretto Technologico Aerospaziale, DTA) as its "operational arm" founded in 2009[1]. The DTA aims to strengthen intra-district relationships through a coordination/networking activity facilitating DAP members' participation in joint research projects and programmes (i.e. partnerships). The establishment of a specific cluster organisation aiming to foster knowledge flows within the district may affect knowledge exchange dynamics in the cluster. Hence, the paper addresses the following research questions: Did the establishment of the DTA lead to higher levels

of collaboration and more innovation in the Apulian Aerospace District? More generally, how does the implementation of cluster policy affect knowledge exchange and innovation in peripheral regions?

The paper is organised as follows: Section 2 below gives a brief overview of previous literature on clusters and cluster policy. Section 3 presents the geographical context and the methodology used for this study. Section 4 discusses the main features of the DAP on the basis of a survey previously designed by Trippl et al. (2009) and specifically adapted for the present case study. Section 5 investigates the network structure of knowledge exchange in the DAP, in particular examining changes over time. Finally, Section 6 provides concluding remarks and future research directions.

2. Clusters, industrial districts and Italian technology districts

Scholars have invented various neologisms for groups of interconnected organisations located in given places. Two concepts became more popular in economic geography: clusters (Porter, 1990) and industrial districts (Becattini, 1990). Industrial districts, in particular in their best-known Italian version, share some features with Porterian clusters, but differ in many others. Although both models go beyond the sector as unit of analysis, Porterian clusters refer to a set of interrelated sectors or a geographically concentrated group of interrelated companies (Sforzi, 2014), whereas industrial districts foregrounds the importance of the local community. Industrial districts are not merely agglomerations of firms, but organisms in which a local community "mirrors an industrial specialisation and the way it (the community) is organising the production" (Sforzi, 2014: 333).

The Italian industrial districts are linked to the "Third Italy", an economic development model mainly found in central and northeastern Italy. It differs from the so-called "First Italy" (the most advanced northern industrial regions) and "Second Italy" (the lagging southern regions). The "Third Italy" attracted scholarly attention as a model of industrial development "based on dense networks of flexible, strongly related, mostly small and medium-sized firms in craft-based industries" (Boschma,

1998: 3). These networks are organised in specialised industrial districts where the interplay between local communities, trust, and social capital plays an essential role (Sforzi, 2014).

Piccaluga (2003) describes the attempt to revitalise industrial districts by combining the term with the adjective "technology" in a new policy to foster "technology districts". However, if traditional industrial districts arose spontaneously in local communities, technology districts are conversely policy-driven regional inter-firm strategic alliances and university-industry ties. Italian policymakers have been inspired by theories of regional innovation systems (Cooke et al., 1997) and the Triple Helix model of innovation (Etzkowitz and Leydesdorff, 2000) in designing the policy (Bertamino et al., 2014). Technology districts represent a policy tool for structural change in regions with a critical mass of innovative actors and specific competencies (Bellandi and Caloffi, 2013). In this sense, they resemble science and technology parks (see IASP, 2017).

Scholars in evolutionary economic geography have analysed at length the dynamics leading to cluster formation and evolution. Feldman et al. (2005) argue that entrepreneurs and, more generally, a latent entrepreneurial environment are at the core of cluster formation, although the policy question is how to translate these local factors into active entrepreneurship. Moreover, product and industry life cycle approaches emphasise either the stage of a product cycle or firm entry and exit to provide insights into cluster emergence and evolution (see Frenken et al., 2015).

Many studies have focused on the origins of cluster formation, primarily considering cluster emergence as a spontaneous phenomenon fostered by a vibrant entrepreneurial and socioeconomic landscape (Owen-Smith and Powell, 2006). Others have examined policy-driven clusters (Martin et al., 2011; Aranguren et al., 2014; Authors, 2017). According to Su and Hung (2009), the birth of "spontaneous clusters" can be ascribed to historical circumstances, prior existence of supplier industries, resourceful entrepreneurs, entrepreneurial environments, or even serendipitous events and chance. Conversely, a "policy-driven cluster" is deliberately implemented to react to an industrial crisis or foster a specific sector (Huang et al., 2012). However, the literature also tends "to confuse cases of spontaneous or organic cluster emergence with organized efforts to stimulate and manage

clusters" (Uyarra and Ramlogan, 2017:40). Among other things, public policies not expressly addressing clusters (e.g. infrastructure, research, education and training) can indirectly influence the emergence of so-called spontaneous clusters. Conversely, policy-driven clusters rarely emerge from nowhere, but build on pre-existing industries and capabilities.

Keeping this in mind, this paper analyses a peripheral Italian technology district where the regional government implemented a specific policy tool to foster a cluster. The policy aims at enhancing networking, innovation outputs and socioeconomic outcomes in regions with specific characteristics (MIUR, 2017). Technology districts are formalised institutions grouping co-located research establishments and firms in a given technological field (e.g. aerospace, ICT, electronics, creative activities, etc.).

Although previous studies have extensively analysed social and relational drivers of innovation (e.g. Morrison, 2008; Cohendet et al. 2014), further analyses to provide appropriate policy guidance are still needed. Literature on territorial innovation models have studied the underpinnings of regional innovation since the 1990s (e.g. Saxenian, 1994; Braczyk et al., 1998), but have dealt less with the structural properties of clusters and their influence on innovation dynamics (see Giuliani, 2007, 2013; Balland et al., 2016; Authors, 2017). Moreover, the analysis of clusters remains biased towards successful locations (Kasabov, 2011). This paper contributes to the cluster policy evaluation literature by analysing the relational dynamics of an innovative aerospace district in a lagging peripheral region (SVIMEZ, 2015).

In such regions, previous literature highlights the difficulty of generating meaningful knowledge exchange and innovation through traditional science and technology policy (Rodríguez-Pose and Di Cataldo, 2015). This is related partly to peripheral regions' lack of capacities to benefit from these investments (e.g. weak human capital and firm absorptive capacity) and partly to their often weak institutions, resulting in clientelism and rent-seeking (Farole et al., 2011). However, policies relying on indirect support for knowledge exchange rather than direct funding may escape some of these

weaknesses, in particular if coupled with active knowledge exchange activities with partners outside the region (Rodríguez-Pose and Fitjar, 2013).

2.1. Cluster policy evaluation

Determining the effectiveness of cluster policy is a critical and challenging issue. Many factors affect the success of clusters, including policy in other areas, natural industry growth, and industry and cluster life-cycles. Hence, assessing the additionality of policy initiatives is often impossible. This is also a somewhat underexplored issue (e.g. Martin et al., 2011; Aranguren et al., 2014). Studies assessing the effectiveness of policy measures have mainly focused on direct R&D support programmes (see Cunningham and Gök, 2012), while neglecting indirect policy measures. Only recently, Nishimura and Okamuro (2011) compared the impact of direct R&D and indirect networking/coordination policy in Japanese clusters. They revealed a stronger and more extensive impact of indirect networking programmes on innovation outcomes.

In a related prior study, we analysed the effectiveness of an indirect policy measure aiming to stimulate cooperation in a mechatronics district in southern Italy (Authors 2017). The positive effects of this action were materialised in a substantial increase of ties established through partnerships, suggesting widespread knowledge exchange among co-located organisations. In contrast, Aranguren et al. (2014) did not find a clear relationship between cluster policy and firm productivity in the Basque country. In Maffioli et al. (2016), various authors analysed the impact of policy measures in clusters. Among others, Giuliani et al. (2016) revealed the positive effects of a coordination action in an electronics cluster in Córdoba (Argentina) to stimulate local, regional and national networking.

Finally, the connections based on joint research projects of 40 organisations involved in the Apulian aerospace system were mapped in a broader report recently issued by the Agenzia Regionale per la Tecnologia e l'Innovazione (Regional Agency for Technology and Innovation; ARTI). The findings of this analysis show similar results to those of the present case study (ARTI, 2015).

Cluster policy initiatives can take different forms, from direct financial R&D support to "soft" actions such as coordination activities to enhance cooperation and networking. Davis (2011) argues that "physical proximity does not necessarily or automatically induce relational proximity (cooperative behaviour) among firms in a cluster". Consequently, policy measures often aim at enhancing collaborations among firms and other organisations in clusters.

Confirming the assertion of Martin et al. (2011) and Aranguren et al. (2014) that few studies have considered indirect cluster policies, Uyarra and Ramlogan (2012) surveyed a limited number of studies of indirect policy measures in their broad review of the cluster policy evaluation literature. Studies of clusters' impact have adopted various methodological approaches, including econometric studies of patent and R&D data (e.g. Beaudry and Breschi, 2003; Falck et al., 2010; Viladecans-Marsal and Arauzo-Carod, 2011). However, Uyarra and Ramlogan (2012) stressed that most studies of "soft" (indirect) policy measures aiming to foster collaboration have relied on qualitative interviews with stakeholders (e.g. Staehler et al., 2006; Cooke et al., 2010).

Choosing the appropriate method for a specific evaluation is a hard task for policy evaluators (Schmiedeberg, 2010). Although this is true for all policy evaluation, the complexity of an indirect policy measure makes the task of the evaluator even more difficult and requires adequate analytical methods. Social Network Analysis (SNA) is a promising tool for evaluating interactions, and related knowledge exchange, in regions and clusters (Ter Wal & Boschma, 2007; Schmiedeberg, 2010). Despite the growth of relational economic geography, few studies have explored the changing nature of networks (Balland et al., 2013). There is thus a need for further studies analysing network structures and their evolution over time in clusters. In this respect, quantitative SNA allows for investigation of inter-organisational interactions and more formally addressing relational processes in network evolution (Balland et al., 2016).

3. Methodology

3.1. The context: Apulia and the regional aerospace district

To address the issue of how cluster policy affects network dynamics in peripheral regions, we study a cluster initiative in one such region, Apulia in Southern Italy. Long-lasting socioeconomic disparities characterise the Italian context. For instance, the unemployment rate in southern Italy region is significantly higher than the national average (20.2% vs. 12.1%), especially among the young (e.g. 31.2% in the South and 12.9% in the Centre-North for the 25-34 age group; SVIMEZ, 2015). This is related to lacking public and foreign direct investments, low competitiveness and emigration of skilled people (e.g. SVIMEZ, 2015). According to the EU Regional Innovation Monitor, Apulia is one of the most dynamic regions in Southern Italy. Despite regional R&D investment below the national average, regional authorities have recently implemented several initiatives to strengthen innovation activity. The creation of technology districts is among the most important of these (EUROPEAN UNION, 2017).

In a recent comparative study, Cersosimo & Viesti (2012) included the DAP among the six most notable, differentiated and dense technology districts in southern Italy. The DAP was established by the Apulia Region in a regional law in 2007 (REGIONE PUGLIA, 2007). It consists of about 70 organisations (firms, universities, research centres, local and regional authorities, trade unions, and various other associations). The DAP aims to support the competitiveness of the Apulian aerospace industry by fostering integration and cooperation between large companies and SMEs through joint participation in regional, national and international projects and programmes (Cersosimo & Viesti, 2012). The DAP website describes the district as an integrated system of firms, universities and research centres characterised by technological skills and scientific competencies at the forefront in the aerospace sector. The DAP carries out integration and cooperation policies between large companies and SMEs by promoting their joint participation in regional, national and European

programmes and supporting specific innovation projects aiming to strengthen the competitiveness of the Apulian aerospace industry (DAP, 2017).

Since 2009, the DAP is supported by a new "operational arm", the DTA. The DTA was established with the primary objective of enhancing knowledge transfer, industrial research and human capital among the organisations involved (Coniglio, 2012). The DTA is a non-profit organisation to promote projects and attract funds and investments in high-technology production sectors, contribute to developing the technical and scientific knowledge of its associates, and strengthen the Apulian research system (DTA, 2017). This paper examines an indirect policy measure to support networking among its members. However, the district promotes many other initiatives (e.g. support for entrepreneurial activities, encouraging Apulian technicians and researchers to return home, training projects, etc.; DTA, 2017).

The aerospace industry is characterised by high technology intensity and complexity, a global value chain and frequent market distortions, the latter mainly caused by commercial policies at the national level. Furthermore, high barriers to entry, preferential long-term collaborations, top-down business relationships and a high degree of vertical integration tend to reduce the number of nodes in the supply chain networks of the aerospace industry. However, recent trends include the entrance of new players strongly supported by their governments (e.g. in China, Russia, India, Brazil). This challenges the traditional worldwide aerospace system, so far characterised by the duopoly Boeing-Airbus, and creates interesting opportunities for the large networks of subcontractors (Coniglio, 2012). Moreover, transactions in the aerospace supply chain are primarily regulated by vertical contractual agreements, even though two-way knowledge flows based especially on risk partnerships are becoming increasingly important (Figueiredo, 2009).

In this fast-changing context, the DTA's main challenge is to strengthen both intra-district relationships and linkages with other aerospace clusters in Italy. It aims to create an interregional

meta-district and enhance interactions with related industries that could bring positive externalities (Coniglio 2012). This paper focuses on intra-district relationships to assess the effectiveness of a policy measure implemented by the administration of the DTA in its early phases to enhance knowledge transfer among its members through their participation in joint research projects and programmes (partnerships). To date, a large number of studies and reports on innovation dynamics in Southern Italy have addressed this topic mainly in a static way (e.g. BANCA D'ITALIA, 2010; Cersosimo and Viesti, 2012; CONFINDUSTRIA, 2016). These studies have provided detailed territorial description, but have neglected dynamic and/or relational aspects.

The purposes of this paper are: 1) to identify the evolution of the within-DAP relations; 2) to evaluate the effectiveness of a policy measure adopted by the DTA to stimulate the density and strength of relations inside the district through partnerships; 3) to assess the innovation capacity of firms in the DAP. In line with the DTA's objectives, we hypothesise that the action will be associated with a growth in partnerships between the DAP organisations. We apply SNA methods and techniques to examine the evolution of the knowledge exchange network. Following Authors (2017), we examine various relational indicators pertaining to different channels for knowledge exchange and adopt a longitudinal approach to examine the evolution of the network following the implementation of the policy. In addition, a separate survey analyses the innovation output and extra-regional knowledge exchange linkages of DAP firms.

3.2. Data collection and methods

Data were collected in 2014 through interviews using two different questionnaires. Both questionnaires were administered in person by one of the authors. A list containing the name, address and contact details of the 58 organisations making up the DAP was provided by the administrators of the DTA. This included 6 large companies, 39 SMEs, 3 universities, 4 research centres and 5 associations.

Questionnaire 1 was based on Trippl et al. (2009), who examined the nature and geography of knowledge linkages in Vienna's software cluster. The questionnaire was slightly adapted for the specific case study to obtain information on the characteristics of the DAP organisations. This questionnaire was developed specifically for private firms and was not administered to other actors such as universities, research centres and various associations. Twenty-five out of the 45 firms in the district (55% of the total) were interviewed.

Questionnaire 2 was used to collect network data on a variety of relationships between all organisations of the DAP in two distinct periods: 2008-2010 and 2011-2013. The first period starts the year after the creation of the district and corresponds to its very early phase, while the second period represents a more mature phase during which the policy action should have started to work. The hypothesis is that increased knowledge exchange will mainly be reflected in a higher number and density of partnerships – the type of relationship specifically promoted by the policy. As explained above, DTA's objective is to coordinate activities among its members to enhance participation in joint research projects and programmes (partnerships) and consequently foster knowledge exchange. The term 'partnerships' refers to participation in joint research projects launched with national and EU funding bodies, short-term research arrangements, consortia, etc. Four other relational indicators (non-research contracts, research contracts, co-publications and informal contacts) were used primarily as a baseline for assessing the changes observed in the network of partnerships. Although we cannot exclude that the policy implemented by the DTA could have an effect on these other channels, we expect only minor changes in these since they were only indirectly affected by the policy. It is almost impossible to control completely for confounding external factors (e.g. influence of other regional policy measures, natural evolution of the network, etc.) without identifying a control group of non-beneficiaries, and in most cases – including this – it is impossible to find a set of similar firms against which the development of the treated firms can be compared. A number of regional policies besides explicit cluster policy can influence cluster development (see Uyarra and Ramlogan, 2017). Similarly, phenomena such as natural growth and cluster life-cycles are independent from the

policy measure implemented and can potentially influence network dynamics. However, by comparing changes in partnerships to other knowledge exchange channels that were not specifically targeted by the policy, we hope to get some indication of its effects (on this aspect, see Authors, 2017).

To minimise the potential problems of low response rates and/or unreliable responses, we designed a structured questionnaire for the assessment of various networks, building on the roster-recall method (Ter Wal & Boschma, 2009; Giuliani & Pietrobelli, 2011). Respondents indicated with whom their organisation had formal and informal contacts in the two time periods from a predefined list including the surveyed firms belonging to the DAP. They were also asked to indicate the strength (frequency or intensity) of each tie by marking the cell in the appropriate range (see Table 3). We verified the entire networks by comparing responses of both partners. The response rate for questionnaire 2 was about 65%. Although this is a good response rate for a survey, SNA is sensitive to missing data, and missing ties may impact the overall understanding of the social network. However, the characteristics of the knowledge flows considered in this study (mutual exchange) allow us to capture both sides of the relationships inasmuch as ties are reciprocated: the solution for handling missing data thus was their replacement with symmetric ties (see Authors, 2017).

4. Innovation activities and sources of knowledge

Online Appendix Table 1 shows various distributions from Questionnaire 1. The survey identified a relatively high share of innovative firms in the district, with 36% of firms reporting new-to-market and another 24% reporting new-to-firm innovation. On this basis, the DAP is a highly innovative district, in particular in the Southern Italian context. Following the scheme used by Trippl et al. (2009) with regard to innovation activities, 76% of businesses are focused on the production of new goods and services, with a high share simultaneously involved in other innovation activities, such as development (52%), applied research (44%), and design (44%), although only a few entities engaged in basic research (20%) [2]. The overall share of annual turnover invested in R&D is 14%

(UNIONCAMERE, 2013, similarly reported 12-13%). The share increased in 2011-2013 compared to 2008-2010 for 78% of the surveyed firms. Exports of the DAP's firms were 20% over the entire period. For most firms (62.5%), sales abroad remained constant during the most recent years considered (2011-2013).

Most respondents (60%) consider R&D partnerships an important channel for exchanging knowledge, indicating that firms value this mechanism. Furthermore, 52% consider informal contacts an important channel. DAP members collaborated mainly on applied research (56%), development (56%) and prototyping and testing (48%). This could be attributed to their knowledge base (primarily engineering-based; see Broekel and Boschma, 2011). The objectives of such R&D collaborations are mainly product/process innovation activities (new-to-firm, 64%, and new-to-market, 52%), entering new technical fields (52%), and improving existing products or services (48%). Thus, the firms clearly see a link between partnerships and their innovation processes.

Partners at the national level are substantial sources for novel knowledge, while regional or European organisations are generally perceived as less important in knowledge exchange processes, with the exception of regional universities and research centres (48%). Outside the EU (rest of the world), clients are considered to be the most significant sources of new knowledge (40%, higher than regional or EU clients), reflecting the location of the major aircraft manufacturers.

However, actual R&D collaborations involve especially regional enterprises (48%), regional and national university/research centres (48% for both) and clients at the national level (40%). Other sources scored much lower, regardless of their geographical location (see Online Appendix Table 2).

Overall, the results reveal a strong national orientation of the district for knowledge exchanges, and a lower level of involvement in more localised or international flows. Finally, respondents expressed appreciation for the DTA's activities for strengthening relationships and enhancing knowledge exchange among the DAP members (mean: 7.4 on a 1-10 scale, with a mode of 8.0).

5. Knowledge exchange in a dynamic perspective

In the next sub-sections, the relational networks of the DAP's organisations in two distinct periods (2008-2010 and 2011-2013) are examined to assess the knowledge exchange dynamics among the organisations in the district. The two periods reflect the establishment of the DTA in 2009, to assess the effectiveness of its initiatives to support the formation of partnerships. We use the aforementioned relational indicators and apply several SNA techniques (overall density, degree, block and cutpoints, fragmentation, Quadratic Assignment Procedure - QAP) to analyse the networks.

5.1. Density and centrality

The overall density shows significant differences both between the different channels used for exchanging knowledge and between the two periods. Table 1 shows how especially the co-publications and research contracts networks were less dense than the other networks, with only negligible differences between the two periods. The network of non-research contracts is only slightly denser and also does not change much between the two periods. Conversely, the informal contacts and partnerships networks are denser and change more between the two periods. With regard to informal contacts, more than 17% of pairs were connected in 2008-2010 and about 22% in 2011-2013. This was the most frequently used knowledge exchange channel in both periods. However, partnerships network changed most between the two periods, increasing from 3.3% of pairs connected in 2008-2010 to more than 11% in 2011-2013 (+7.9%-points).

[Table 1 about here]

Online Appendix Table 3 shows the five organisations with the highest degrees in each network. The presence of large companies is limited in all networks with the exception of contracts, which is dominated by SMEs and large companies. Similarly, the presence of SMEs is substantial in research contracts, where they were the most active organisations together with universities. One university is particularly active in co-publishing (its degree was 10.00 in 2008-2010 and 15.00 in 2011-2013), exceeding by far all the other organisations involved.

Major changes and a more diverse composition were observed in the two remaining networks. With regard to informal contacts, the major difference both between the two periods and in comparison with the other networks analysed so far is a greater diversity of higher degree organisations. Moreover, the ability of the DTA to establish informal contacts both in the first period (e.g. within one year of its foundation) and in the second period is evident. Several changes also occur in the network of partnerships. Firstly, the degree centrality of the top five organisations increases significantly. Secondly, the centrality of the DTA grows remarkably, from 3.00 in 2008-2010 to 50.00 in 2011-2013. Together with the growth in the density measure, this preliminarily suggests the positive effects of the DTA on the density of partnerships. However, the analysis also reveals the crucial role of the DTA itself in the network, as a large number of the new partnerships involve the DTA as one of the partners (47 new connections in the 2011-2013 period). Hence, the increase in partnerships between district members other than the DTA itself is somewhat more limited than suggested by overall density, even if many other organisations are also increasing the number of partnerships.

5.2. Cohesion and separability

We analyse cohesion by adopting a measure of fragmentation, i.e. the proportion of pairs that cannot reach each other (Hanneman and Riddle, 2005). This index ranges from 0 (each node is reachable by all others) to 1 (all nodes are isolated). This helps to assess whether all organisations are part of the

same knowledge exchange network or whether there are various sub-networks of different organisations. The networks of co-publications and research contracts show a high degree of fragmentation in both periods, whereas the network of contracts without research content is characterised by a moderate degree of fragmentation (i.e. about a half of nodes are reachable by all the other nodes in 2008-2010 and 2011-2013). Conversely, the figures related to the network of informal contacts reveal that almost all of the nodes are reachable (i.e. 0.036 in 2008-2010 and 0.034 in 2011-2013). The results of the network of partnerships demonstrate that the higher density in 2011-2013 than the previous period (see Section 5.1) led to a similarly higher degree of cohesion. The fragmentation index dropped from 0.764 (similar to research contracts) in 2008-2010 to 0.198 in 2011-2013. This means that the network of partnerships exhibited the highest increase from the first to the second period in terms of cohesion (see Table 2).

[Table 2 about here]

An additional analysis of blocks and cutpoints is needed in order to examine the potential separability of each network. Blocks and cutpoints identify nodes (actors) which are necessary for connecting different blocks of actors. These nodes have a privileged position in the network and act as gatekeepers in knowledge exchange dynamics (Giuliani and Pietrobelli, 2011). Most networks showed a high degree of separability, except for the network of informal contacts where three cutpoints (the DTA and two associations) were found in 2008-2010, and two cutpoints (the DTA and one research centre) and only four blocks were found in 2011-2013. Furthermore, the blocks and cutpoints analysis revealed a peculiar situation with regard to partnerships. The connectivity of this network was already weak and in line with the other less cohesive networks in 2008-2010 because of the significant number of blocks (10) in relation to the number of organisations actually involved in the network. However, its level of separability increased further in the following period in conjunction

with the massive presence of the DTA: in fact, there are 23 blocks, of which 22 involve the DTA and only one other organisation.

The presence of this considerable number of dyads is undoubtedly symptomatic of the ability of the DTA to strengthen the presence of its organisation in partnerships. In many cases, the knowledge exchange did not involve a broad range of the districts' organisations tightly connected to each other, but rather partnerships between each organisation and the DTA itself. Figure 1 displays these findings graphically. The node size corresponds to each organisation's degree, and the white nodes show the cutpoints. The network of partnerships in 2011-2013 had many new organisations (with a higher overall degree), although in most cases they were connected only to the DTA and not to other organisations in the network. This makes the network strongly dependent on the DTA and subject to a high level of separability.

[Figure 1 about here]

5.3. Relationship between networks

To examine the correlation between the two periods, as well as between the knowledge exchange channels, we use QAP with simple matching coefficient (see Hanneman and Riddle, 2005). QAP measures whether network structures of different networks tend to overlap, i.e. whether the same nodes are connected in various networks. The analysis (see Online Appendix Tables 4 and 5) shows high correlation between the connected nodes in 2008-2010 and 2011-2013 for all networks. The network of partnerships in 2011-2013 is highly correlated with the other knowledge exchange channels. Specifically, the QAP correlation reveals a 90% probability that links established in the partnerships network in 2011-2013 are also present in each of the other networks in both 2008-2010

and 2011-2013. This implies that the organisations involved in partnerships tend to establish recurring relationships also in other channels, and vice versa.

5.4. Intensity of ties

The measures used so far analyse whether there is a relationship between two organisations, but does not consider its strength or whether it changes over time. Therefore, the ties on each relational indicator were also weighted according to Table 3. Using this scheme, the overall tie intensity was calculated for each knowledge exchange channel and each period.

In the research contracts and informal contacts networks, most ties were strong in both periods. In the remaining networks, tie strength changed considerably. Most ties in the network of non-research contracts were moderate (39%) in 2008-2010 and weak (38%) in 2011-2013, even though the share of strong ties increased (from 24% to 35%). Similarly, most ties in the co-publications network were strong (44%) in 2008-2010 and moderate in 2011-2013 (42%), with an increase of weak ties (from 17% to 21%). Finally, the intensity of ties decreased on average also in the partnerships network. Most ties were moderate (42%) in 2008-2010 and only weak in 2011-2013 (40%). The entry of new organisations in the network, as shown above, can explain this. These most likely had not developed strong collaborations so far.

[Figure 2 about here]

After calculating the overall tie strength for each knowledge exchange channel, we also calculate changes in tie strength over time. We assign values from 0 to 3 to the categories no ties, weak, average, and strong ties, and calculate the difference between the two periods. The average score is then divided by 3 to generate an index from -1 to +1 (see Authors, 2017).

In all networks, ties were stronger in the second period, but only slightly so in most networks. The networks of contracts without research content (0.065) and research contracts (0.121) changed the least, whereas the networks of informal contacts (0.245) and co-publications (0.275) changed moderately. The network of partnerships changed the most in absolute terms (0.490). Hence, not only the density but also the overall intensity of partnerships increased (see Table 3). The new partnerships included many new weak and moderate ties between previously unconnected pairs. As highlighted above, a large number of these new pairs involved the DTA and another organisation.

[Table 3 about here]

6. Discussion and conclusion

This paper examined knowledge exchange following the implementation of a cluster initiative in a peripheral region. Specifically, we examined the dynamics of the partnership network in the Apulian aerospace district following the establishment of the DTA, a cluster organisation. The objective was to uncover changes in the density and intensity of ties, as well as network structure and substructures, between the early and more mature phases of the cluster.

Technology policy based on direct R&D support is often ineffective in peripheral and less innovative regions (Rodríguez-Pose and Di Cataldo, 2015). Therefore, other types of indirect actions could represent an effective alternative for peripheral regions. The case study demonstrated a substantial increase in partnerships in the peripheral district under analysis. These findings provide useful information on the success of policies based on indirect action in clusters.

The analysis showed that the DAP is a dynamic and innovative district in terms of the share of innovative firms. National (extra-regional) sources of knowledge and partners are important in these innovation processes. Similarly, the surveyed firms were positive about the role of the DTA in strengthening relationships among the district's members. The effectiveness of the policy measure is confirmed also in the social network analysis, showing significant increase in terms of density, cohesion and intensity of ties in the network of partnerships compared to the other channels investigated. However, the analysis of blocks and cutpoints clearly revealed how the network of partnerships in 2011-2013 is characterised by a particularly high level of separability caused by the high number of blocks held together by only one cutpoint, the DTA.

The DTA has been essential in bringing novel knowledge into the network by means of a relevant number of new partnerships gathering together different types of organisations that would have been otherwise disconnected or completely excluded from knowledge flows. Moreover, the policy implemented by the DTA has been able to create a number of potential new connections that could be developed in the near future. However, most of the new actual and potential connections enhancing knowledge exchange primarily pass through a single organisation, i.e. the DTA itself. The relational dynamics within the DAP are still strongly dependent on the administration of the DTA in broadening the number of organisations involved in partnerships. There is less knowledge exchange between the district's other organisations. This makes the network vulnerable to changes in the policy context and indicates that the policy has not so far managed to create a self-sustaining network.

This carries important policy implications also for other regions and cluster administrators. Cluster policy is often implemented through the establishment of a cluster organisation which comes to play a central role in the network. However, if all partnerships pass through the cluster organisation, the cluster becomes reliant on continued public funding and it might be difficult to develop a self-sustaining network of knowledge exchange. Cluster organisations need to be aware of the risk that

their partnerships with firms can crowd out more directly relevant firm-to-firm or firm-to-university partnerships within the region, as well as extra-regional networks that can bring new knowledge into the cluster. It is crucial to develop an exit strategy, considering how the cluster can develop into a self-sustaining network without the need for a cluster organisation. The DTA is already thinking about this, as the DAP moves into a new stage where the DTA – according to its administrators – aims to diminish its direct presence in networking activities. Success in this area will be crucial for the long-run effects of the technology district.

This paper contributes to a limited number of studies analysing at the same time structural properties and evolution of clusters (e.g. Giuliani, 2013; Balland et al., 2016; Authors, 2017). Indeed, the paper highlights the importance of such methods, as a simple study of changes in partnerships overall in the network would most likely have overlooked the DTA's crucial role as the central node in the network. This is an important part of the story and essential in evaluating the success of the policy.

However, the present analysis is not exempt of limitations that must be duly acknowledged. Future studies should examine causal connections between policy measures, degree of networking and innovation and/or economic outcomes (e.g. patenting, turnover, creation of new jobs) rather than considering only knowledge exchange dynamics. They should incorporate more fully the importance of external sources of knowledge, due to the growing importance of extra-cluster and -regional knowledge flows especially for organisations located in peripheral regions, as also reflected in the survey (e.g. Trippl et al. 2009; Fitjar and Rodríguez-Pose, 2011). Finally, we examined relational indicators which were directly and not directly affected by the policy to examine its impact. However, it remains impossible to control for potential external confounding factors without a targeted control group. A major challenges of future network studies is precisely to address this limitation.

References

Aranguren, M.J., de la Maza, X., Parrilli, M.D., Vendrell-Herrero, F., & Wilson, J.R. (2014). Nested Methodological Approaches for Cluster Policy Evaluation: An Application to the Basque Country. *Regional Studies*, 48(9), 1547-1562. doi: 10.1080/00343404.2012.750423

ARTI (2015), *L'industria aerospaziale pugliese. Occupazione, innovazione e prospettive di sviluppo (Report)*. Retrieved from http://www.arti.puglia.it/wp-content/uploads/ARTI_REPORT_AEROSPAZIO_2015_Low.pdf

BANCA D'ITALIA, (2010). *Il Mezzogiorno e la politica economica dell'Italia.* Retrieved from https://www.bancaditalia.it/dotAsset/261c5662-0cf4-47cd-9fa0-2d0162ce03ea.pdf

Balland P.A., De Vaan M., & Boschma, R. (2013), The dynamics of interfirm networks along the industry life cycle: The case of the global video game industry, 1987–2007. *Journal of Economic Geography*, 13, 741–765. doi:10.1093/jeg/lbs023

Balland, P.A., Belso-Martinez, J.A., Morrison, A. (2016). The dynamics of technical and business knowledge networks in industrial clusters: embeddedness, status or proximity?. Economic Geography, 92, 1, 35–60.

Bellandi, M., & Caloffi, A. (2013), System-based policies in Italy: From industrial districts to technological clusters. *European Review of Industrial Economics and Policy*, 4.

Bertamino F., Bronzini R., De Maggio M., Revelli D. (2014), *Local policies for innovation: the case of technology districts in Italy*. Banca d'Italia. Retrieved from https://www.bancaditalia.it/pubblicazioni/qef/2016-0313/ index.html?com.dotmarketing.htmlpage.language=1.

Beaudry, C., & Breschi, S. (2003). Are firms in clusters really more innovative?, *Economics of Innovation and New Technology*, 12, 4, 325-342. doi: 10.1080/10438590290020197

Boschma, R. (1998). *The industrial rise of the Third Italy: open window of locational opportunity?*. paper to be presented at the 38th Congress of the European Regional Science Association, 28 august - 1 september 1998, Vienna

Borgatti, S.P., Everett, M.G., & Freeman, L.C. (2002). *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies

Braczyk, H.J., Cooke, P., & Heidenreich, M. (Eds) (1998). *Regional Innovation Systems: The Role of Governance in a Globalized World*. London: UCL Press.

Broekel, T., & Boschma, R. (2011). Aviation, space or aerospace? Exploring the knowledge networks of two industries in the Netherlands. *European Planning Studies*, 19(7), 1205-1227. doi: 10.1080/09654313.2011.573133

Calignano G., Fitjar R.D. (2017), Strengthening relationships in clusters: How effective is an indirect policy measure carried out in a peripheral technology district?. *The Annals of Regional Science*, 59, 1, 139-169. doi: 10.1007/s00168-017-0821-x

Cersosimo, D., & Viesti G. (Eds). (2012), *Il Mezzogiorno tecnologico. Una ricognizione in sei distretti produttivi*. Retrieved from http://www.coesioneterritoriale.gov.it/wpcontent/uploads/2012/09/Mezzogiorno-Hi-Tech.pdf

Cohendet, P., Grandadam, D., Simon, L., & Capdevila, I. (2014), Epistemic communities, localization and the dynamics of knowledge creation. *Journal of Economic Geography*, 14(5), 929-954. doi: 10.1093/jeg/lbu018

CONFINDUSTRIA (2016), Rapporto PMI Mezzogiorno 2016. Retrieved from http://www.astrid-online.it/static/upload/repo/report-cerved-mezzogiorno-2016_web_72.pdf

Cooke, P., Gomez Uranga, M., & Etxebarria, G. (1997). Regional Systems of Innovation: An Evolutionary Perspective, *Environment and Planning A*, 30, 1563-1584. doi: 10.1080/09654310500107084

Cooke, P., Eickelpasch, A., & Ffowcs-Williams, I. (2010). From low hanging fruit to strategic growth- International evaluation of Robotdalen, Skåne Food Innovation Network and Uppsala BIO. VINNOVA - Swedish Governmental Agency for Innovation Systems / Verket för Innovationssystem. Retrieved from http://www.vinnova.se/upload/EPiStorePDF/vr-10-16.pdf

Coniglio (2012), Il sistema aerospaziale pugliese. In D., Cersosimo, & G. Viesti (Eds.), *Il Mezzogiorno tecnologico. Una ricognizione in sei distretti produttivi*. Retrieved from http://www.coesioneterritoriale.gov.it/wpcontent/uploads/2012/09/Mezzogiorno-Hi-Tech.pdf

Cunningham, P., & Gök, A. (2012). The Impact and Effectiveness of Policies to Support Collaboration for R&D and Innovation. Nesta Working Paper Series. Retrieved from http://www.nesta.org.uk/publications/impact-andeffectiveness-policies-support-collaboration-rd-and-innovation

DAP, (2017). Chi siamo. Retrieved from http://www.apulianaerospace.it/chi-siamo

DTA, (2017). Il Distretto Tecnologico Aerospaziale. Retrieved from http://www.dtascarl.it/

Davis, C.H. (2011). Media industry clusters and public policy. In Karlsson C., & Picard R.G. (Eds). Media clusters. Spatial agglomerations and content capabilities (pp. 223-250). Cheltenham/Northampton: Edward Elgar

Etzkowitz H., & Leydesdorff L. (2000). The dynamics of innovation: from National Systems and ‘‘Mode 2’’ to a Triple Helix of university–industry–government relations. *Research Policy*, 29, 109-123. doi: 10.1016/S0048-7333(99)00055-4

Falck, O., Heblich, S., & Kipar, S. (2010), Industrial innovation: Direct evidence from a cluster-oriented policy. *Regional Science and Urban Economics*, 40, 6, 574-582. doi: j.regsciurbeco.2010.03.007

Farole, T., Rodríguez-Pose, A., & Storper, M. (2011). Cohesion policy in the European Union: Growth, geography, institutions. *Journal of Common Market Studies*, 49, 1089-1111. doi: 10.1111/j.1468-5965.2010.02161.x

Feldman, M., Francis, J., & Bercovitz J. (2005) Creating a Cluster While Building a Firm: Entrepreneurs and the Formation of Industrial Clusters. *Regional Studies*, 39, 1, 129-141. doi: 10.1080/0034340052000320888

Figueiredo, P., Gutenberg, S., & Sbragia, R. (2009), Risk sharing partnerships with suppliers: The case of Embraer. *Journal Technology Management Innovation*, 3, 1. Retrieved from https://jotmi.org/index.php/GT/article/view/art70/436

Fitjar, R.D. & Rodríguez-Pose, A. (2011). Innovating in the Periphery: Firms, Values, and Innovation in Southwest Norway. *European Planning Studies*, 19, 4, 555-574. doi: http://dx.doi.org/10.1080/09654313.2011.548467

Giuliani, E. (2007). The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of Economic Geography*, 7, 139-168. doi:10.1093/jeg/lbl014

Giuliani, E. (2013). Network dynamics in regional clusters: evidence from Chile. *Research Policy*, 42, 8, 1406-1419. doi: 10.1016/j.respol.2013.04.002

Giuliani, E., & Pietrobelli, C. (2011). *Social Network Analysis Methodologies for the Evaluation of Cluster Development Programs*. IDB Publications 53978 Inter-American Development Bank. Retrieved from https://publications.iadb.org/handle/11319/5342?locale-attribute=en.

Giuliani, E., & Pietrobelli, C. (2016). Social Network Analysis to Evaluate Cluster Development Programs.In A., Maffioli, C., Pietrobelli, & R., Stucchi (Eds). *The Impact Evaluation of Cluster Development Programs. Methods and Practices*. Washington DC: Inter-American Development Bank.

Giuliani, E., Matta, E., Pietrobelli, C. (2016). Networks, Cluster Development Programs, and Performance: The Electronics Cluster in Córdoba, Argentina. In A., Maffioli, C., Pietrobelli, & R., Stucchi (Eds). *The Impact Evaluation of Cluster Development Programs. Methods and Practices* (pp. 37-58). Washington DC: Inter-American Development Bank

Hanneman, R.A., & Riddle, M. (2005). Introduction to social network methods. Riverside, CA: University of California, Riverside. Retrieved from http://faculty.ucr.edu/~hanneman/

Huang, K.F., Yu, C.M..J., & Seetoo, D.H. (2012). Firm innovation in policy-driven parks and spontaneous clusters: the smaller firm the better?. *Journal of Technology Transfer*, 37, 715-731. doi:10.1007/s10961-012-9248-9

IASP, (2017). Knowledge bites. Science park (IASP official definition). Retrieved from http://www.iasp.ws/knowledge-bites

Kasabov, E. (2011). Towards a Theory of Peripheral, Early-stage Clusters. *Regional Studies*, 45:6, 827-842. doi: 10.1080/00343401003724651

Maffioli A., Pietrobelli C., & Stucchi R. (Eds). (2016) *The Evaluation of Cluster Development Programs: Methods and Practice*. Washington DC: Inter-American Development Bank.

Martin, P., Mayer, T., & Mayneris, F. (2011). Public support to clusters. A firm level study of French "Local Productive Systems". *Regional Science and Urban Economics*, 41, 108-123. doi: 10.1016/j.regsciurbeco.2010.09.001

MIUR, (2009). The Italian technological districts. Retrieved from http://hubmiur.pubblica.istruzione.it/web/ricerca/ricerca-internazionale/technological-district

Morrison, A. (2008). Gatekeepers of knowledge within industrial districts: who they are, how they interact. *Regional Studies*, 42: 817–835. doi : 10.1080/00343400701654178

Nishimura N., & Okamuro, H. (2011). Subsidy and networking: the effects of direct and indirect support programs of the cluster policy. *Research Policy*, 40, 714–727. doi:10.1016/j.respol.2011.01.011

Owen-Smith, J., & Powell W.W. (2006) Accounting for emergence and novelty. In Braunerhjelm, P., & Feldman, M. (Eds). *Boston and Bay Area Biotechnology in Cluster Genesis: Technology-Based Industrial Development* (pp. 61-86). Boston MA: Harvard Business School Press

Piccaluga, A. (2003), *Il distretto tecnologico: lo strumento, le potenzialità, le esperienze*. Dipartimento per le politiche di sviluppo. Retrieved from http://www.dps.tesoro.it/documentazione/convegni/13_11_2003/Atti_23giu_piccaluga.pdf

Porter, M.E. (1990). *Competitive Advantage of Nations*. New York: Free Press.

Regione Puglia (2007), *Legge Regionale 3 Agosto 2007, n.23 – Promozione e riconoscimento dei distretti produttivi*. Retrieved from http://www.regione.puglia.it/index.php?page=burp&opz=getfile&file=s1-1.htm&anno=xxxviii&num=112

Rodríguez-Pose, A., & Fitjar, R.D. (2013). Buzz, archipelago economies and the future of intermediate and peripheral areas in a spiky world. *European Planning Studies*, 21, 355-372. doi: 10.1080/09654313.2012.716246

Rodríguez-Pose, A., & Di Cataldo, M. (2015). Quality of government and innovative performance in the regions of Europe. *Journal of Economic Geography*, 15, 673-706. doi: 10.1093/jeg/lbu023

Saxenian, A. (1994). *Regional advantage*. Cambridge: Harvard University Press.

Schmiedeberg, C. (2010). Evaluation of cluster policy: a methodological overview. *Evaluation* 16 (4), 389-412. doi:10.1177/1356389010381184

Sforzi, F. (2014). The empirical evidence of industrial districts in Italy. In Becattini, G., Bellandi, M., & De Propris, L. (Eds). *A handbook of industrial districts* (pp. 327-333)

Staehler, T., Dohse, D., & Cooke, P., 2006. *Evaluation der Fördermaßnahmen BioRegio und BioProfile*. Centre for Advanced Studies in the Social Sciences (CASS). Retrieved from http://www.e-fi.de/fileadmin/Evaluationsstudien/Evaluation_der_Foerdermassnahmen_BioRegio_und_BioProfile.pdf

Su Y.S., & Hung, L.C. (2009). Spontaneous vs. policy-driven: The origin and evolution of the biotechnology cluster. Technological Forecasting and Social Change, 76 (5), 608-619. doi: j.techfore.2008.08.008

SVIMEZ (2015). *Rapporto SVIMEZ 2015 sull'economia del Mezzogiorno*. Bologna: Il Mulino

Ter Wal, A.L.J., & Boschma R. (2009). Applying social network analysis in economic geography: framing some key analytic issues. *The Annals of Regional Science*, 43(3), 739-756. doi: 10.1007/s00168-008-0258-3

Trippl, M., Tödtling, F. & Lengauer, L. (2009). Knowledge sourcing beyond buzz and pipelines: evidence from the Vienna software sector. *Economic Geography*, 85, 443–462. doi: 10.1111/j.1944-8287.2009.01047.x

EUROPEAN UNION (2017), Puglia. Growth: Internal market, Industry, Entrepreneurship and SMEs. Retrieved from https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/puglia

UNIONCAMERE (2013), *Distretti anti-crisi. Innovazione, tradizione e reti di impresa per competere sui mercati*, Osservatorio Nazionale Distretti Italiani. Retrieved from http://www.unioncamere.gov.it/P42A1520C189S123/IV-Rapporto-dell-Osservatorio-nazionale-dei-distretti-italiani.htm

Uyarra, E., & Ramlogan, R. (2012). *The Effects of Cluster Policy on Innovation*. Nesta Working Paper No. 12/05. Retrieved from https://www.nesta.org.uk/sites/default/files/the_effects_of_cluster_policy_on_innovation.pdf

Uyarra, E., & Ramlogan, R. (2017). Cluster policy in an evolutionary world? Rationales, instruments and policy learning. In D., Fornahl & R., Hassink (Eds). The Life Cycle of Clusters (pp. 35-55). Cheltenham, UK/Northampton, MA, USA: Edward Elgar Publishing

Viladecans-Marsal, E., & Arauzo-Carod, J-M. (2012). Can a knowledge-based cluster be created? The case of the Barcelona 22@ district. *Papers in Regional Science*, 91, 2, 377-400. doi: 10.1111/j.1435-5957.2011.00383.x

TABLES

Table 1. Density and number of ties. Source: Elaboration from Questionnaire 2 with UCINET (Borgatti et al., 2002)

	2008-2010		2011-2013	
	Density	**Number of ties**	**Density**	**Number of ties**
Contracts	0.052	172	0.057	188
Research contracts	0.029	96	0.035	116
Co-publications	0.012	40	0.016	52
Partnerships	0.033	108	0.112	370
Informal contacts	0.172	568	0.223	736

Table 2. Fragmentation. Elaboration from Questionnaire 2 with UCINET (Borgatti et al., 2002)

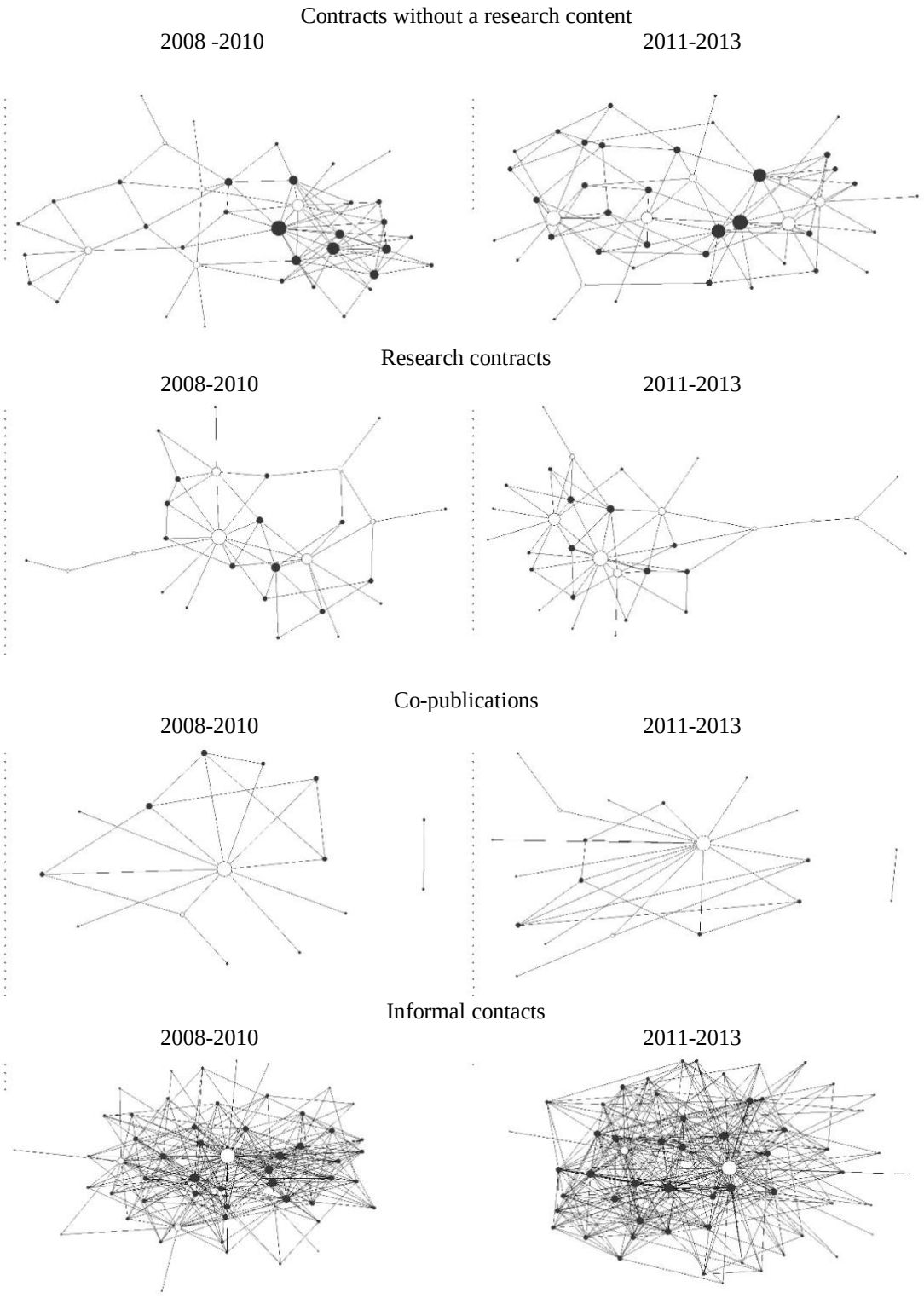
	2008-2010	**2011-2013**
Contracts without a research content	0.527	0.428
Research contracts	0.745	0.719
Co-publications	0.947	0.948
Informal contacts	0.036	0.034
Partnerships	0.764	0.198

Table 3. Types and attributes of relational data/ Variation of the intensity of ties between 2008-2010 and 2011-2013. Source: Elaboration from Questionnaire 2

Three year periods (2008-2010 and 2011-2013)					
Relational Data/Knowledge exchange channels	***Description of ties***	***Ties' strength***			***Variation Index***
		Weak	*Average*	*Strong*	
Contracts	Overall number of contracts	1-5	6-9	>9	0.065
Research contracts	Overall amount of research contracts	< 50.000	50.000- 99.000	> 99.000	0.121
Co-publications	Overall number of co-publications	1	2-5	>5	0.275
Partnerships	Overall number of partnerships	1	2-5	>5	0.490
Informal contacts	Intensity of informal contacts	Weak	Average	Strong	0.245

FIGURES

Figure 1. Network structures, 2008-2010 (left) and 2011-2013 (right). Notes: Dimension (Degree); White nodes (Cutpoints). Netdraw visualisation (Borgatti et al., 2002)



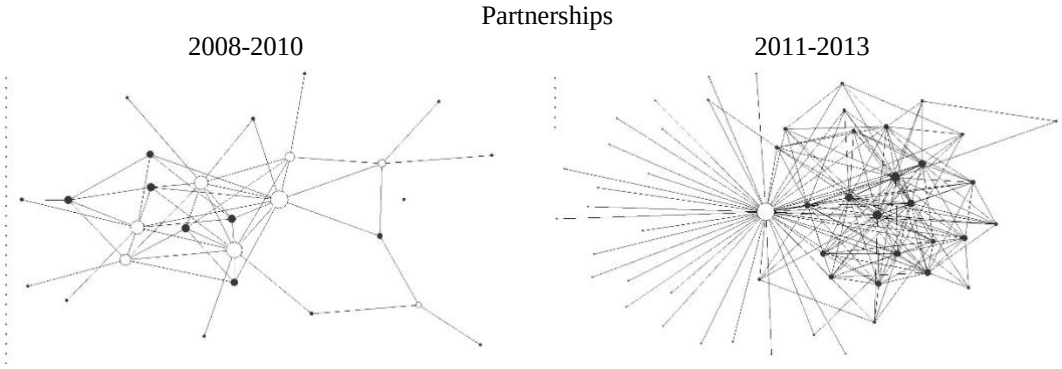
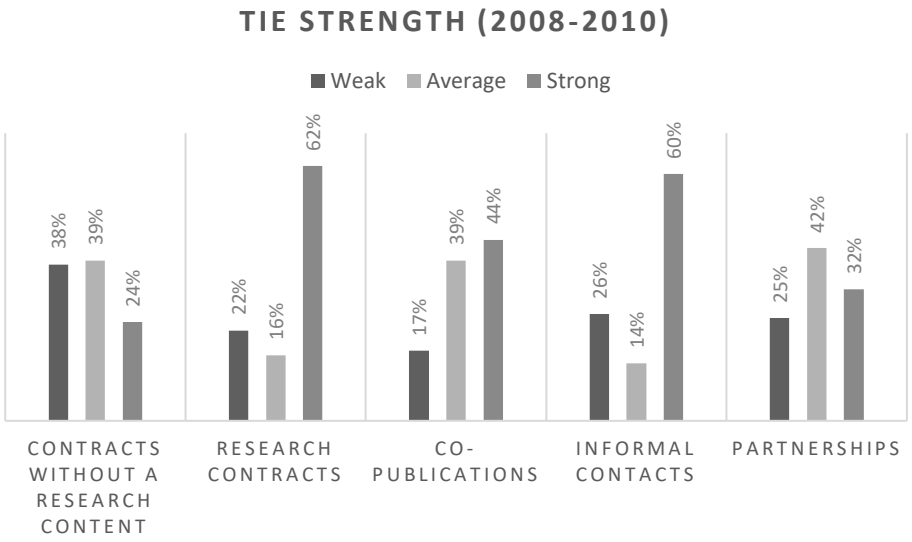
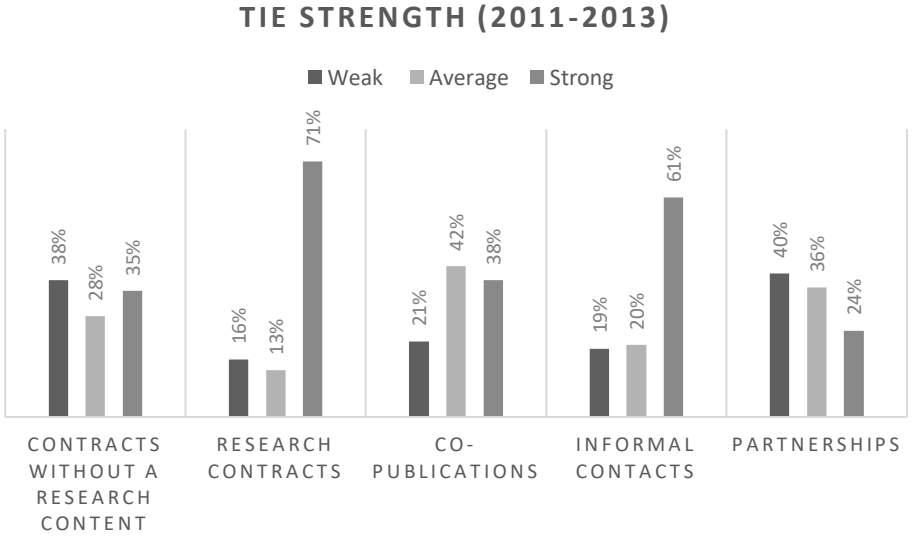


Figure 2. Tie strength – 2008-2010 (above) and 2011-2013 (below). Source: Elaboration from Questionnaire 2





APPENDIX A

Table A1. Sources of knowledge. Source: Elaboration from Questionnaire 1

	Local Area	*Italy*	*European Union*	*Rest of the world*
1. Firms (same sector)	36%	56%	40%	28%
2. Clients	32%	68%	38%	40%
3. Suppliers	32%	72%	40%	36%
4. Competitors	24%	52%	28%	28%
5. Service firms	28%	48%	8%	4%
6.R&D partners	24%	48%	28%	12%
7.Universities/ Poliytechnics /Research centres	48%	68%	16%	20%
8.High schools	24%	8%	4%	0%
9.R&D partners (Non-profit)	20%	12%	12%	4%
10. Technology transfer offices/centres	20%	16%	16%	0%

Table A2. Relationships of the DAP's members. Source: Elaboration from Questionnaire 1

	Local Area	*Italy*	*EU*	*Rest of the World*
1.Firms (same sector)	48%	28%	28%	8%
2.Clients	32%	40%	16%	8%
3.Suppliers	28%	32%	24%	12%
4.Competitors	20%	16%	12%	8%
5.Services Firms	20%	20%	8%	0%
6.R&D (commercial purposes)	24%	24%	12%	0%
7.Universities/Polytechnics/Research Centres	48%	48%	20%	0%
8.High schools	12%	8%	16%	0%
9.R&D (Non-profit)	16%	20%	4%	4%
10.Technology transfer offices/centres	16%	4%	12%	0%

Table A3. Top five degrees and types of organisations in each network. Elaboration from Questionnaire 2 with UCINET (Borgatti et al., 2002). Notes: LC (Large company), SME (SME), UNI (University), RC (Research Centre), ASS (Association), DTA (DTA)

Contracts

2008-2010			2011-2013		
Organisation Code	***Type of organisation***	***Degree***	***Organisation Code***	***Type of organisation***	***Degree***
044	SME	15.00	037	SME	12.00
041	SME	12.00	002	LC	12.00
039	SME	11.00	004	SME	11.00
002	LC	9.00	044	SME	11.00
004/009/014/016	LC/SME/SME/SME	8.00	041/057	SME/UNI	10.00

Research Contracts

2008-2010			2011-2013		
Organisation Code	***Type of organisation***	***Degree***	***Organisation Code***	***Type of organisation***	***Degree***
038	UNI	13.00	038	UNI	15.00
057	UNI	9.00	037	SME	12.00
046	SME	7.00	057	UNI	8.00
037	SME	7.00	010	SME	7.00
058	UNI	5.00	004	LC	7.00

Co-publications

2008-2010			2011-2013		
Organisation Code	***Type of organisation***	***Degree***	***Organisation Code***	***Type of organisation***	***Degree***
038	UNI	11.00	038	UNI	15.00
058	UNI	4.00	058	UNI	4.00
037	SME	4.00	048	SME	4.00
057/048/024/015	UNI/SME/RC/RC	3.00	024/047/015/057/037	RC/SME/RC/UNI/SME	3.00

Partnerships

2008-2010			2011-2013		
Organisation Code	***Type of organisation***	***Degree***	***Organisation Code***	***Type of organisation***	***Degree***
038	UNI	12.00	020	DTA	50.00
024	RC	11.00	015	RC	23.00
037	SME	9.00	057	UNI	23.00
018	RC	9.00	038	UNI	21.00
015	RC	7.00	024	RC	18.00

Informal contacts

2008-2010			2011-2013		
Organisation Code	***Type of organisation***	***Degree***	***Organisation Code***	***Type of organisation***	***Degree***
020	DTA	47.00	020	DTA	52.00
057	UNI	26.00	057	UNI	32.00
014	SME	25.00	014	SME	28.00
038	UNI	23.00	044	SME	26.00
024	RC	23.00	018	RC	26.00

Tables A4 and A5. QAP with simple matching coefficient. Elaboration from Questionnaire 2 with UCINET (Borgatti et al., 2002). Note: *Correlation is significant at the 0.05 level

		QAP Correlation - Simple matching coefficient	QAP Correlation - Simple matching coefficient (Avg)
2008-2010	**Contracts without a research content**	0.956*	0.897*
		(0.000)	(0.000)
-	**Research contracts**	0.976*	0.938*
		(0.000)	(0.000)
2011-2013	**Co-publications**	0.993*	0.972*
		(0.000)	(0.000)
	Informal contacts	0.896*	0.682*
		(0.000)	(0.000)
	Partnerships	0.912*	0.863*
		(0.000)	(0.000)

		QAP Correlation - Simple matching coefficient, 2008-2010	QAP Correlation - Simple matching coefficient (Avg), 2008-2010	QAP Correlation - Simple matching coefficient, 2011-2013	QAP Correlation - Simple matching coefficient (Avg), 2011-2013
	Contracts without a research content	0.865*	0.848*	0.868*	0.844*
		(0.006)	(0.006)	(0.000)	(0.000)
Partnerships	**Research contracts**	0.892*	0.865*	0.894*	0.861*
		(0.000)	(0.000)	(0.000)	(0.000)
2011-2013	**Co-publications**	0.899*	0.879*	0.900*	0.876*
		(0.000)	(0.000)	(0.000)	(0.000)
	Informal contacts	0.865*	0.755*	0.874*	0.715*
		(0.000)	(0.000)	(0.000)	(0.000)

[1] In the rest of the paper, DAP refers to the district as a whole and DTA to the cluster organisation.

[2] The questionnaire allowed for multiple answers