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What makes SMEs more likely to collaborate? Analysing the role of regional innovation policy

Annalisa Caloffi, Federica Rossi**, Margherita Russo****

* *Corresponding author. Department of Economics and Business, University of Padua, Italy, via del Santo 33, Padova 35123, Italy. Telephone n. +390498274067. E-mail: annalisa.caloffi@unipd.it*

** *School of Business, Economics and Informatics, Birkbeck, University of London, Malet Street, Bloomsbury, London WC1E 7HX, UK. Telephone n. +44 207 0790685. E-mail: f.rossi@bbk.ac.uk*

*** *Department of Economics, University of Modena and Reggio Emilia, viale Berengario 51, 41121 Modena, Italy. Telephone n. +390592056877. E-mail: margherita.russo@unimore.it*

Abstract

The last twenty years have witnessed the diffusion of regional innovation policies supporting networks of innovators. The underlying aim of these policies is to encourage firms, particularly SMEs, to undertake collaborations with organisations possessing complementary knowledge. Focusing on a set of SMEs that have participated, over time, in several innovation networks funded by the same regional

government, the paper investigates how their relationships have evolved with respect to the following aspects: (i) reiteration of pre-existing relationships as opposed to experimentation of new relationships; (ii) collaboration with organisations possessing complementary rather than similar knowledge and competencies; (iii) creation of local relationships rather than experimentation of extra-local collaborations; (iv) reliance upon intermediaries to connect with other organisations. Our findings reveal that the involvement in these policy-supported networks changed the firms' relational patterns, leading them to collaborate with a wider variety of agents than those with whom they were linked before the policies. Sectoral heterogeneity had a negative effect on the probability to collaborate, while co-localisation increased the likelihood to collaborate. Mutual involvement with intermediaries also had a positive effect. However, in the case of firm-to-university relationships only specialized intermediaries were likely to perform a positive role and, therefore, encourage networking.

Key words: innovation policy, innovation networks, dyadic relationships, regional policy.

JEL classification: D85, H43, L52, O32

1. Introduction

The last twenty years have witnessed the diffusion of regional innovation policies that support networking among heterogeneous organisations (e.g.: firms and universities; small and large firms). Examples include policies inspired by the concepts of regional innovation system or innovation cluster (Asheim et al. 2003; Cooke et al., 2004; OECD 2007, 2010, 2011; Asheim et al., 2011; Lagendijk, 2011) and, in recent times, the smart specialization strategies launched by the European Union (Foray et al., 2012).

In these contexts, networks among heterogeneous organisations are seen as tools to enhance and exploit the complementarities between agents with different knowledge and competencies (Hagedoorn, 1993), between different sources of knowledge and skills in the region (Cooke and Morgan, 1998; Cooke, 2007; Lazzeretti et al., 2010; Asheim et al., 2011; Boschma and Frenken, 2011; Foray et al., 2012) or between local and extra-local knowledge (Trippl et al., 2009; Dettman et al., 2012).

The implicit assumption is that policies are needed to stimulate interactions that would not occur spontaneously, but whose presence would be desirable (Carlsson and Jacobsson, 1997; Klein Woolthuis et al., 2005). Interactions between SMEs and universities are a typical example, but there are many other cases of collaborations between firms that could be mutually beneficial, but are not easily realized. SMEs, which are equipped with relatively low internal resources, are most likely to benefit from collaborations with external agents. However, as in the "innovation paradox" defined by Oughton et al. (2002), SMEs are often the most reluctant to build relationships with universities or other agents. This creates a problem for policymakers who want to stimulate innovation and the upgrading of SMEs' skills, especially those which are lagging behind. The problem for the policymaker can be

summarized as follows. First, the basic issue is how to induce the targeted organisations to participate in policies aimed at supporting networking. In fact, the same reasons that may prevent firms, particularly SMEs, from innovating or that leave them in a competence lock-in trap, may also constitute barriers to their participation in the policies (Kleinknecht and Reijnen, 1991). Second, once firms have been involved in these networks, they may only perform a peripheral role, failing to achieve more than temporary benefits from the experience. In fact, the collaborative behaviour can be changed only if the organisations involved have the time to get to know the different partners and to learn how to work together. Third, even if they decide to play an active role, firms could simply use the public grant to fund the activities carried out with their already tried and tested partners, and in this way fail to benefit from the many learning opportunities offered by the policy intervention, when it provides incentives to experiment with new forms of collaboration.

What can be done to overcome these problems? Since it would not be possible, nor appropriate, to identify the specific partners with whom an organisation should collaborate, what policies can do is provide incentives in order to encourage collaboration among heterogeneous organisations (also through the use of "intermediaries", see Howells, 2006), establish a general framework of rules and then leave the participants free to organise their innovative activity. However, the presence of general and flexible incentives does not ensure that undesirable behaviours (such as peripheral involvement of firms, limited heterogeneity of collaborations or repeated interactions among the same organisations and closure to outsiders) are not adopted anyway.

Our study explores how these issues have played out within a set of policy interventions promoting innovative projects carried out by networks of heterogeneous organisations, which have been implemented by the regional government of Tuscany (Italy) in the programming period 2000-2006.

In particular, we focus on the set of SMEs that have displayed repeated involvement in these policy-funded networks, and we investigate how their relationships have evolved according to several aspects: (i) reiteration of pre-existing linkages as opposed to experimentation of new relationships (*stability*); (ii) collaboration with agents possessing complementary rather than similar knowledge and competencies or abilities (*degree of heterogeneity among agents*); (iii) development of intra-cluster relationships rather than creation of extra-local collaborations (*local relations*); (iv) reliance upon intermediaries in order to connect with other agents (*intermediaries*).

Our analysis does not take into account the period after the end of the policy, nor the behaviour of any counterfactual sample of firms. Therefore, it cannot be considered a program evaluation exercise. Instead, we seek to contribute to the analysis of innovation policies, and to the study of the behaviour of policy-supported networks over time. This literature has often focused on the analysis of large-scale projects (e.g. the European Union's Framework Programmes) and it has often taken either the individual firm or the entire network as its unit of analysis (Breschi and Cusmano, 2004; Wagner and Leydesdorff, 2005; Barber et al., 2006; Cassi et al., 2008). Our analysis focuses instead on small-scale policies that target SMEs, and takes the dyad (firm-to-firm, firm-to-university or firm-to-other agents) as the basic unit of analysis. By adopting this quite original perspective, we try to shed some light on the "black box" of the relational behaviour of agents *within* a policy.

The paper is structured as follows. Section 2 briefly reviews the empirical literature on firms' relational patterns in the context of policy-supported innovation networks, highlighting the four key aspects that are further investigated in this study. Section 3 describes the set of interventions implemented by Tuscany's regional government, presenting the main features of the policy programmes and their objectives in the broader context of the region's innovation policies. Section 4 introduces the data and methodology. In section 5, we investigate empirically how firms' participation in early-stage policy programmes affected their relational patterns in later programmes. Section 6 concludes by drawing some general implications for more effectively implementing, monitoring and evaluating policies in support of innovation networks.

2. Relational patterns in the context of policy-supported innovation networks: four key aspects emerging from the literature

In recent years, several empirical contributions have explored the issue of publicly-funded collaborations for innovation (consortia, JVs, innovation networks). However, only a few of them have focused on the interactions among agents within policy-supported networks in order to assess how these collaborations form and evolve, and what are their main drivers. These analyses are consistent with a behavioural additionality approach to policy analysis and evaluation (Buisseret et al, 1995), which focuses on the learning effects of a policy on the participants' behaviour during and/or after the project's implementation (Clarysse et al, 2009).

Among the different aspects of agents' relational behaviour that may be affected by network-based policies, several key themes have emerged as being particularly

worthy of attention: the stability of relations, the agents' heterogeneity, the local dimension of relations, and the reliance upon intermediaries in order to connect with other organisations. According to an extensive literature on innovation, these four characteristics influence the innovative potential of interactions among organisations in a network. Moreover, as we will discuss more extensively in the next sections, these four aspects characterized the policies that we studied. In fact, the policies implemented in Tuscany in 2000-2006 displayed the following four features: i) the participants could develop repeated relationships; ii) the participants were required to set up heterogeneous partnerships; iii) the creation of extra-local (extra-cluster) relationships was encouraged, but only within the boundaries of the region; iv) intermediaries were involved in order to facilitate the creation of linkages between different partners.

In the following we briefly review some theoretical and empirical contributions highlighting the relevance of these four themes.

(i) *Stability*. Several contributions have stressed that in order to acquire and manipulate existing knowledge, as well as to produce new knowledge, the networked organisations should develop specific standards, skills and competencies, whose creation, in turn, requires non-transitory collaborations among the agents involved (Gulati, 1995; Powell et al., 1996; Nooteboom, 2000). At the same time, such collaborations should not become too stable, in order to avoid the risk of lock-ins (Lane and Maxfield, 1997; Nooteboom et al., 2007). For this reason, some authors have stressed that temporary networks, such as those emerging from the realization of a collaborative research project, are important in order to bring in new knowledge (Asheim, 2002; Grabher 2004). The empirical literature on policy-supported networks tells us that long-term policies, which allow repeated participations, may lead to the

formation of an oligarchic core of relatively stable collaborations, surrounded by a number of peripheral organisations. This has been observed by Breschi and Cusmano (2004) and Barber et al. (2006) in the case of the European Union's Framework Programmes, as well as by Russo and Rossi (2009) and Bellandi and Caloffi (2010) in the case of regional innovation policies. However, the existing contributions do not investigate to what extent this stability is the result of the innovative strategy of the agents involved. In addition, very few contributions explore whether those collaborations are created by the policies or are pre-existing. Among the few exceptions, we find Fier et al. (2006) who, in their analysis of an R&D collaboration programme implemented in Germany, showed that public policies stimulated agents to form brand new types of collaborations. Drawing on empirical results from Spain, Chávez (2011) found that regional policies were more effective than national ones in stimulating firms not previously engaged in R&D collaborations to establish new linkages with universities or technology centres.

(ii) *Degree of heterogeneity among agents*. Networks among agents that differ in nature, knowledge and competencies lead to various benefits in terms of information diffusion, resource sharing, access to specialized assets and inter-organisational learning (Arora and Gambardella, 1990; Powell and Grodal, 2006). This is particularly important in highly innovative and technology intensive industries, where agents need to complement their internal resources and competencies with specialized knowledge, technologies and know-how (Ahuja, 2000). However, a high degree of heterogeneity may hamper mutual understanding or may not be effective in focusing agents' interests and objectives (Lane and Maxfield, 1997; Sampson, 2007). As mentioned before, many innovation policy interventions around the world try to support the emergence of these complementarities. In their analysis of the European

Union's Framework Programmes, Wagner and Leydesdorff's (2005) found that these programmes have been successful in facilitating the creation of partnership among agents that belonged to different sectors.

(iii) *Local relations*. A wide literature on clusters and on innovation has shown that the local environment may be home to important interactions for the generation of innovations, particularly in cases where tacit knowledge is relevant and in industries in which the knowledge base is mostly synthetic or symbolic (Asheim et al., 2007). However, the same literature has warned against the risks of localism, which can lead to cognitive lock-ins. Precisely for this reason, many policies around the world have sought to encourage firms in lagging-behind regions to break the circuit of local knowledge they are embedded in (Hassink, 2005; Tödtling and Trippl, 2005). The few empirical contributions addressing this issue show that regional innovation policies have been successful in stimulating the formation of extra-regional interactions (Antonioli et al., 2013).

(iv) *Intermediaries*. The presence of intermediaries may be required to ensure interaction and communication among heterogeneous participants (and groups of participants), which differ in knowledge, language, systems of incentives and objectives, etc. (Hassink, 1996, 1997; Howells, 2006). Intermediaries can have different nature. They may be specialized in technology transfer (from academia to industry), or they can play a wider range of functions, ranging from information diffusion to networking support and (indirect) technology transfer (Hassink, 1996). Obviously, the most dynamic firms that are able to have a direct relationship with the university will also be able to link to the former type of intermediaries (which are often directly participated by the university). On the contrary, lagging-behind firms may find it difficult to set up relationships even with the technology transfer centers

(see Hassink, 1996, 1997). This is why some policies, such as those that we analyse in this study, envision a role for the latter type of intermediaries. Previous empirical evidence on innovation networks funded within some European Union programmes found that the former type of intermediaries (including innovative firms) are able to bridge research and diffusion networks, while other types of intermediaries are able to connect peripheral agents with those at the center of the network (Cassi et al., 2008).

The analyses we have mentioned so far have focused either on the whole network of relationships between the organisations involved in the policy interventions, or on the individual organisations that participated in them, or both. In what follows we consider instead dyadic relationships between participants as the main unit of analysis. We try to identify which pairs of organisations, one of which is a firm, are more likely to form a relationship in the context of a policy programme in support of innovation networks, having already participated in the same kind of policy programmes in the past. This allows us to identify what aspects of firms' involvement in policy-funded networks makes them more likely to collaborate in subsequent networks.

3. Tuscany's regional policy in support of innovation networks

3.1 General features of programmes and participants

Our analysis focuses on a set of policies supporting networks of innovators implemented by the regional government of Tuscany, mostly in the context of the regional Single Programming Document 2000-2006 (hereafter: SPD). Tuscany's regional government has been one of the most active promoters of innovation network policies in Italy, with a succession of tenders supported by the European Regional

Development Fund (ERDF) since the early 2000s (Russo and Rossi, 2009; Bellandi and Caloffi, 2010). In particular, in the programming period 2000-2006 it promoted a set of nine programmes aimed at supporting innovative projects carried out by networks of heterogeneous economic agents[1]. These policies were addressed to a regional economic context characterized by a prevalence of SMEs that did not perform R&D activity; many of these firms operated in low or medium technology sectors affected by harsh international competition. Spontaneous networking among local firms was limited to those active in the industrial clusters of the region (Becattini, 2003; Dei Ottati, 2004), and networking among firms (SMEs in particular) and universities or public research centres was particularly weak (Caloffi and Mariani, 2011). In order to support the upgrading of these firms' innovation skills, the regional government funded collaborative innovation projects – that is, innovation networks – among micro enterprises, SMEs, large firms, universities, research centres, business services providers and other organisations acting as intermediaries.

Although funded with resources from the 2000-2006 programming period, the programmes actually ran between 2002 and 2008. In particular, the set of policy programmes can be divided into two main periods. The first period ran from 2002 to 2005 and included six programmes: a Regional Programme of Innovative Actions launched in 2002 ("Technological Innovation in Tuscany") and five programmes funded by two lines of the regional SPD (lines 171 and 172) launched in 2002, 2004 and in 2005. In the policymakers' intentions, these programmes would have led to the development and strengthening of innovation networks composed of SMEs and large companies working together with universities, innovation service providers and other organisations supporting innovation and local development (we call this the "network formation" stage). Strongly inspired by the regional innovation system framework,

the regional policymaker considered the emergence of such clusters as the first step towards the formation of Tuscany's innovation system. The programmes in the first period imposed a number of constraints in terms of size and composition of the project partnership, which will be described in detail in the following section 3.2.

The second period started in 2006, and ended with the last intervention implemented in 2008. It included three programmes: a second RPIA, launched in 2006 ("Virtual Innovation and Cooperative Integration"), and two waves of the SPD, line 171, launched in 2007 and 2008. Interestingly, the interventions implemented in the second period (almost 65% of the overall budget) had not been planned at the beginning of the programming period[2]. Rather, they were launched thanks to the availability of residual funds and premiums allocated by the European Union to the region. Since the policymaker's goal with these additional programmes was to consolidate the networks formed in the previous period, we call this the "network consolidation" stage. In this stage, all the constraints that were previously imposed on the size and composition of the project partnerships were removed.

Through the nine programmes, Tuscany's regional government funded 168 innovation networks (79 in the first and 89 in the second period), corresponding to an overall funding allocation of almost € 37 million (this amounted to around 40% of the total funds spent on innovation policies in the region in the observed programming period). In our analysis we shall consider only these funded networks.

The total amount of different organisations involved in the nine programmes was 1,127, a subset of which (205) had taken part in projects in both periods[3]. Instead, 651 organisations only participated in networks in the first period and 271 only participated in the second (table 1). Firms represented 35.6% of the organisations involved in both periods, but much higher shares of the organisations involved in only

one period. That is: most of the firms exhibited a transitory participation in the policy programmes (one year and one network on average).

Table 1. Participants by type of organisation

Type of organisation	Only 2002-5		Only 2006-8		Both periods	
	n.	%	n.	%	n.	%
Firm	417	64.1%	190	70.1%	73	35.6%
University	44	6.8%	21	7.7%	28	13.7%
Private research company	12	1.8%	6	2.2%	4	2.0%
Service centre	14	2.2%	3	1.1%	18	8.8%
Business service provider	42	6.5%	23	8.5%	21	10.2%
Local government	49	7.5%	10	3.7%	18	8.8%
Local association	51	7.8%	10	3.7%	24	11.7%
Chamber of commerce	0	0.0%	1	0.4%	10	4.9%
Other public body	22	3.4%	7	2.6%	9	4.4%
Total	651	100.0%	271	100.0%	205	100.0%

Note to table 1: The category "firms" include manufacturing firms and software developers. The category "university" includes universities and public research centres, while the third category includes private research companies. Service centres are publicly funded (or funded via public-private partnerships) agents providing a wide range of innovation-related services, while business service providers are private companies providing design, marketing, business consultancy and other services to firms included in the first category. Local associations are business associations and other types of association among firms. The last category, "other public bodies" includes other public agents such as, for instance, hospitals and medical clinics.

3.2. The main policy requirements

The policy programmes were characterized by some particular features, some of which were binding in nature:

i) *Stability*: Repeated participation was admitted across the various programmes. It was seen as a means to facilitate the formation of relatively stable networks that could become the core of a future regional innovation system.

ii) *Heterogeneity*: Programmes launched between 2002 and 2005 required the inolvement of a minimum number of specific kinds of organisations (firms and/or universities, service centers, local governments or other agents). In addition to imposing constraints, policymakers encouraged the formation of heterogeneous

partnerships through a number of "softer" activities, such as giving public speeches or circulating policy documents that highlighted the need to re-combine different knowledge and skills of regional agents in order to promote innovation. Networks were seen as powerful tools to promote the rebalancing of the disparities among regional organisations having different innovation propensity and different capabilities to invest in R&D, or organisations operating in different sectors or in different geographical areas of the region.

iii) *Local relations*: the programmes encouraged the development of extra-cluster and intra-regional relationships. Agents localised outside the region could participate in the programmes, but they were not eligible for funding.

iv) *Presence of intermediaries*: This was required in many programmes as a fundamental component of the networks. Such agents (not only KIBS, but also Chambers of Commerce and local business associations) were intended to play a bridging role among organisations endowed with different knowledge, skills and abilities, and to facilitate learning and innovation processes within the innovation networks.

The interventions were characterized by a strong potential for learning on the part of the participating organisations. Particularly until 2006, participants to funded networks were regularly invited to present their progress in programme meetings. In addition to monitoring the networks' progress, and to teach the policy participants how to manage the different aspects of the projects, these meetings served to strengthen networking and facilitate the circulation of information. In fact, the regular meetings (approximately one every four months) were used to exchange information on the innovative skills possessed by the various participants, the technologies developed and used in the projects, the sector of application of such technologies. The

participation of all the network participants – not just the leader – was highly recommended. Moreover, in order to maximize the diffusion of information, the regional government funded the publication of the final reports of the activities of each innovation network, to be distributed to participants in the various programmes and in public events.

4. Data and methodology

In order to build the database of dyadic relationships we have adopted the following procedure. First, we have selected the pairs of organisations participating in the same programmes (not simply in the same network) both in the network formation and in the network consolidation stages. Then, we have mapped both the "actual" and the "potential" relationships developing among them, keeping only the firm-to-firm, firm-to-university, or firm-to-other organisation (local governments, other public bodies, business associations, etc) dyads. As for actual relationships, we have considered the co-participations in the same innovation network. The potential relationships are those that could have developed among organisations that had participated in the same programme, but that did not realize because they participated in different networks[4]. In so doing, we obtained a database made of 6,391 dyads composed of organisations that had at least a potential relationships both in the network formation and in the network consolidation stage. Each record of our database is a dyad that includes a firm (always the first node of the dyad) and another organisation (including firms)[5]. As we see from table 2, 378 out of the 6,391 dyads actually occurred in the second period, while the remaining were only-potential relationships (i.e. relationships that did not realize). Table 3 provides some details on the 73 firms (manufacturing firms and software developers) and 131 other

organisations involved in the 6,391 dyads[6]. Almost all the observed firms were SMEs (70 out of 73).

Table 2 – The actual and only potential dyads

		Network consolidation (time t)		
		Actual	**Only potential**	**Total**
Network formation (time t-1)	**Actual**	229	353	582
	Only potential	149	5,660	5,809
	Total	378	6,013	**6,391**

Table 3 – The participants in the dyads

Type of activity	N. of organisations
Manufacture of textiles, clothing and footwear	8
Other "made in Italy" goods: furniture, jewellery, food	4
Manufacture of chemical, rubber and plastic products	7
Manufacture of other non-metallic mineral products	9
Manufacture of fabricated metal products	6
Manufacture of machinery and equipment	6
Manufacture of medical devices	6
Manufacture of motor vehicles and other transport equipment	3
Manufacture of electrical equipment	3
Other manufacturing firms	4
Software developers & other activities related to informatics	17
R&D services	14
Professional, scientific and technical services	57
Public administration	18
Activities of membership organisations	12
Cultural activities	3
University departments	18
Education and training	7
Other	2
TOTAL	204

Note to table 3: In the category "firm" that we have used to build the dyads, we have included the 73 agents that belong to the first 11 rows of the table (that is from manufacture of textiles to software developers).

Our dataset is based primarily on the administrative records held by the regional government that implemented the programme. In addition, we have performed a number of direct interviews to the policy participants during the intermediate or final evaluations of some of the observed programmes[7].

The following table 4 provides some descriptive statistics and a detailed description of the variables included in the database. The variable *relation*, measured on the total of 6,391 observed dyads, is a dummy variable taking value 1 when the relationship between the two agents realized during the second stage of network consolidation, and zero otherwise.

The first group of independent variables provides some evidence on the history of collaborations between the members of the dyad, that is, on the stability of the dyad over time. The variable *previous* takes value 1 if the dyad co-participated to the same innovation network during the network formation stage (and zero if the relationship was only potential). The intensity of the previous relationship is measured by the variable *multiple*, which takes value 1 when the relationship was repeated more than once during the network formation stage (in different programmes, or in more projects of the same programme, when allowed by the policy). We also include some information referring to the period before the organisations took part in the policies: the variable *prior* takes the value 1 when the partners of the dyad had had a relationship before their participation to the policies[8]. Like for the other variables, a relationship exists when the two organisations co-participated in an innovation activity, whether spontaneously or thanks to policy incentives. The degree of heterogeneity between organisations is captured by a set of variables measuring the differences between them with respect to several criteria: i) the sectors in which they operate (*sector_het*); ii) their centrality in the network formation stage (*power*); iii)

their ability to lead a network (*leader*); iv) their ability to collect funds (*funds*) in the network formation stage.

The first variable (*sector_het*) is a simple measure of sectoral heterogeneity. As described in table 4 below, we consider three degrees of sectoral heterogeneity: low, medium and high. Heterogeneity is low when the two organisations in the dyad belong to the same 3 digit Nace sector; it is medium when the two organisations operate in different 3 digit Nace sectors that are included in the same 2 digit Nace sector; it is high when the two organisations operate in different 2 digit Nace sectors.

The variable *power* borrows some concepts from social network analysis, and in particular that of Bonacich centrality. To calculate the variable, we proceeded in the following way. First, considering the first period 2002-2005, we built a network in which two organisations are linked if they participated in the same innovation network(s). Then, we calculated the Bonacich centrality index at individual level, such that an agent is more central the higher the centrality indices of the agents in its neighbourhood (Bonacich, 1987). Finally, we defined the variable *power* as the difference (in absolute values) between the centrality indices of the two organisations in the dyad.

The variable *leader* captures the organisations' heterogeneity with respect to their skills in managing relationships, proxied by their capacity to be project leaders (the policy programmes required that each innovation network had a project leader): it is a dummy that takes value one when only one of the two organisations in the dyad had been project leader in at least one network in the first period.

Finally the variable *funds* captures the organisations' heterogeneity in their ability to successfully compete for public funds. It measures the difference (in absolute

values) in the amount of public funds received by the two organisations in the first period.

The geographical dimension of the relationships is detected by a dummy variable, *local*, which takes value one when the dyad includes organisations that are localised in the same province, and zero otherwise.

The presence of intermediaries is captured by a dummy variable (*intermediaries*) taking value one when the observed participants are indirectly linked through an intermediary, that is through an organisation which could be expected to perform an intermediation role (innovation centres and similar, private services providers, business associations and chamber of commerce). The two subsequent variables displayed in table 4 detail the nature of intermediaries. The variable *sc* focuses on innovation centres and similar organisations (incubators, technology parks and other service providers, often involving both public and private agents), that is on particular types of intermediaries that are supposed to play a prominent role in the context of innovation, while the variable *other_int* considers all the other types of intermediaries.

All the independent variables mentioned so far are measured with respect to the network formation stage (at time t-1).

The dataset also includes some control variables such as the specific policy programme in which the relationship formed or could have formed, given that both organisations participated in that programme. Moreover, since larger companies have generally a higher propensity to R&D collaboration (Hagedoorn, 2002; Belderbos et al, 2004), we have included a dummy that takes into account whether the dyad includes a large firm.

Table 4. Descriptive statistics on the potential and actual dyads linking organisations participating both in network formation and in network consolidation stages

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Dependent variables						
relation	Dependent variable in model 1. Dummy variable taking value 1 when the relationship between the two organisations realizes during the consolidation stage (time t).	6391	0.059	0.236	0	1
Stability						
previous	Dummy variable taking value 1 when the two organisations have had at least one relationship in t-1	6391	0.091	0.288	0	1
multiple	Dummy variable taking value 1 when the two organisations have had multiple relationships in t-1	6391	0.009	0.096	0	1
prior	Dummy variable taking value 1 when the two organisations have collaborated in an innovation activity before the beginning of the observed policies	5903	0.006	0.081	0	1
Heterogeneity						
sector_het	Categorical variable measuring sectoral heterogeneity among the two organisations:					
	sector_het=LOW identifies the relationship linking two organisations operating in the same 3 digit Nace Rev.2	6391	0.012	0.110	0	1
	sector_het=MEDIUM identifies the relationship linking two organisations operating in different 3 digit belonging to the same 2 digit Nace sector	6391	0.01	0.1	0	1
	sector_het=HIGH identifies the relationship linking two organisations operating in different 2 digit Nace sectors	6391	0.976	0.154	0	1
power	Difference (in absolute value) between the Bonacich centrality indices of the two organisations, calculated in period t-1	6391	41155.8	95037.85	.004	1749261
leader	Dummy variable taking value 1 when only one of the organisations has been leading partner of at least one project in period t-1	6391	0.274	0.446	0	1
funds	Difference (in absolute value) between the amount of funds that have been collected by the two organisations in period t-1	6391	51844.79	78275.26	0	391158
	Local dimension					
local	Dummy variable taking value 1 when the two organisations are localised in the same province	6391	0.173	0.378	0	1
	Intermediaries					
intermediaries	Dummy variable taking value 1 when at t-1 the two organisations were indirectly connected through an intermediary (innovation centre, private services provider, business association or chamber of commerce)	6391	0.484	0.5	0	1

sc	Dummy variable equal to 1 when the two organisations at t-1 were indirectly connected through an innovation centre	6391	0.215	0.411	0	1
other_interm	Dummy variable equal to 1 when the two organisations at t-1 were indirectly connected through an intermediary that was not an innovation centre	6391	0.183	0.386	0	1
Controls						
large_firm	Dummy variable taking value 1 when the dyad includes (at least) one large firm	6391	0.040	0.197	0	1
2006_VIN	Programme into which the two agents (might) have met: Programme: 2006_VIN	6391	0.038	0.191	0	1
2007_171	Programme: 2007_171	6391	0.577	0.494	0	1
2008_171	Programme: 2008_171	6391	0.563	0.496	0	1

We define a model that seeks to determine whether and to what extent the presence of previous relationships, the degree of heterogeneity, the local scale of the relationships, and the mutual connection to the same intermediaries in the first period are associated with a greater likelihood that, in the network consolidation stage, the organisations actually established a relationship. The dependent variable is the binary variable *relation* that takes value one when the members of the dyad had a relationship in the consolidation stage, and zero otherwise. The independent variables are as described above. After having checked that correlations among variables are sufficiently low, we run a logit regression model on the total number of dyads. In addition to this first model, we present other three models, which are run on different types of subpopulations. In particular, we disaggregate the analysis for different types of dyads, considering: i) firm-to-firm dyads; ii) firm-to-university dyads; iii) firm-to-other organisation dyads[9]. In addition to presenting a more detailed analysis for the type of organisations involved in the relationship, the models two to four differ from the first also because they discriminate between the types of intermediaries that indirectly linked the two organisations. We argue that while intermediaries having a broad and "political" mission (such as business associations or chambers of

commerce) can play an important role in creating connections between firms, more specialized organisations (such as innovation or service centres) may be more effective in creating connections between firms and universities.

We hypothesize that, net of what we measure with the aforementioned covariates, the observed dyads are independent. However, as each organisation included in the database can be repeated several times, we adopt a specification of both models that uses the Huber-White sandwich estimators of the standard errors[10].

5. Results

The following table 5 illustrates our results. The first model (table 5, column 2) explores the determinants of the likelihood to form a relationship in the network consolidation stage (*relation*). The results of the logistic regression suggest that the presence of a previous relationship in the network formation stage has a positive impact on the probability to form a new relationship in the network consolidation stage (*previous*), and this is particularly true when the previous relationship was strong (*multiple*). On the contrary, the presence of a relationship formed before the participation to the observed policies (*prior*) does not have any impact on the likelihood of collaborating in the network consolidation stage.

In general, heterogeneity seems to play a negative role in fostering the formation of relationships during the consolidation stage. As for the sectoral heterogeneity, we observe that the probability to form a relationship in the network consolidation stage decreases as the distance among organisations increases. In fact, the coefficient associated with the maximum sectoral heterogeneity of the dyads – which is expressed in terms of the log odds – tells us that a one unit increase in sectoral heterogeneity results in a -1.9 unit change in the log of the odds. Also when measured

in terms of leadership capabilities, heterogeneity proves to have a negative impact on the probability to form a relationship in the second stage. On the contrary, the relationships formed in the second period are more likely to involve dyads that are heterogeneous in terms of funds collected. Here heterogeneity seems to play a positive role: the variable *funds* tells us that the probability to form a relationship in the network consolidation stage increases as the differences in the organisations' success in collecting funds increases.

The variable *local*, identifying relationships developing at local level (very often intra-cluster relationships), has a positive influence on the probability to form a relationship in the second stage. Given that the observed region has a dense fabric of industrial clusters (Dei Ottati, 2004), it is not surprising to find that the local dimension of the relationships is important.

The presence of intermediaries brokering the relationship at time t-1 has a positive influence on the formation of a new relationship in the stage of network consolidation.

Table 5. Regressions results

	Model 1 - all dyads		Model 2 - firm-to-firm dyads		Model 3 - firm-to-university dyads		Model 4 - firm-to-other agent dyads	
	obs=5903		obs=1121		obs=1085		obs=3697	
Variables	Coef. (s.e.)		Coef. (s.e.)		Coef. (s.e.)		Coef. (s.e.)	
y=relation								
cons	-2.7586	***	-3.3579	***	-3.6896	***	-5.4583	***
	(0.3873)		(0.6638)		(0.4436)		(0.3906)	
previous	2.7235	***	3.4663	***	3.4060	***	3.0425	***
	(0.1620)		(0.5543)		(0.4981)		(0.3087)	
multiple	3.5325	***	n.i.		n.i.		2.6548	***
	(0.6765)						(0.7483)	
prior	0.2553		-0.6236		0.0645		1.1789	
	(0.5043)		(1.0662)		(0.7680)		(0.8077)	

sector_het=MED	-0.5287		-0.7664		n.i.		n.i.	
	(0.5088)		(0.5828)					
sector_het=HIGH	-1.8723	***	-1.5705	***	n.i.		n.i.	
	(0.3295)		(0.3836)					
power	0.0000		0.0000		0.0000		0.0000	
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
funds	0.0000	**	0.0000		0.0000		0.0000	**
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
leader	-0.5895	**	0.1798		-0.4338		-0.5479	**
	(0.1874)		(0.8403)		(0.3673)		(0.2414)	
local	0.8209	***	1.5544	***	0.2677		0.8931	***
	(0.1454)		(0.3225)		(0.2742)		(0.2070)	
intermediaries	0.3672	**	n.i.		n.i.		n.i.	
	(0.1845)							
cs	n.i.		0.5940		0.9991	*	0.3173	
			(0.5417)		(0.5373)		(0.3622)	
other_interm	n.i.		0.1594		-0.9665	*	0.5438	
			(0.5182)		(0.5090)		(0.3633)	
2006_VIN	0.5274		n.i.		n.i.		1.4558	
	(0.3974)						(0.4811)	
2007_171	0.3276	*	0.5827		0.2582		0.6320	
	(0.1891)		(0.4557)		(0.3168)		(0.2668)	
2008_171	0.6267	***	0.8444	*	1.0325	**	0.6186	
	(0.1898)		(0.4774)		(0.3311)		(0.2594)	
large_firm	0.3009		-0.3541		0.1542		0.6682	
	(0.3966)		(0.6635)		(0.7470)		(0.6884)	

Note to table 5: Robust standard errors are in brackets. Significance levels: *** = 1%; ** = 5%; * = 10%.
Model 1: Log pseudolikelihood = -872.8719; Wald Chi-Square test(14) = 647.58; pseudo R2 = 0.3274; n.i. stands for variable not included in the model.
Model 2: Log pseudolikelihood = -187.66398; Wald Chi-Square test (13) = 211.42; pseudo R2 = 0.3603.
Model 3: Log pseudolikelihood = -239.89318; Wald Chi-Square test (11) = 135.83; pseudo R2 = 0.2206.
Model 4: Log pseudolikelihood = - -432.87431; Wald Chi-Square test (13) = 501.18; pseudo R2 = 0.3666.
The variables *multiple* and 2006_VIN are excluded in models 2and 3 because they predict failures /successes perfectly. Models 3 and 4 do not include the categorical variable measuring sectoral heterogeneity, because the latter largely overlaps with the definition of the nature of the agents involved. N.i. stands for variable not included in the model.

In the second to fourth models (table 5, columns 3-5) we disaggregate the analysis, considering firm-to-firm, firm-to-university and firm-to-others dyads (*relation_D*). The dependent variable is always the presence (absence) of a relationship linking two organisations in the network consolidation stage.

As in model 1, relationships that occurred before the beginning of the observed policies (*prior*) do not have any influence on the formation of subsequent

relationships in the network consolidation stage, while having had a relationship in the network formation stage has a positive effect on the probability to form a new relationship in the network consolidation stage, and this happens for all the observed types of dyads. Organisations that collaborate in more than one project during the network formation stage are likely to continue their collaboration also in the second stage[11].

The observation of firm-to-firm dyads confirms that sectoral heterogeneity plays a negative role. In fact, in the second period firms are more likely to collaborate with other firms in the same 3-digit sector, which means partners who can be considered quite similar to them. The categorical variable measuring sectoral heterogeneity is not included in models three and four because it largely overlaps with the definition of the nature of the agents involved in the dyads. As for the other types of heterogeneity, we observe that in the case of relationships between firms and other agents, heterogeneity – as measured by differences in capabilities for network management (*leader*) reduces the chances to form a new relationship in the consolidation stage. On the contrary, the difference in funds collected has a positive impact on the likelihood to form a relationship in the second period. The second aspect is easily understood if we consider that many of the firms that we observe are small. On average, incubators, technology parks, but also chambers of commerce and local governments (that are included in the category "other agents") have participated in a larger number of networks and have collected a larger amount of funds than these SMEs. As for the first aspect, it is not surprising that firms with higher networking and leadership skills can be better able to establish connections with other agents. Therefore, relationships between firms and other agents that develop in the second period are likely to involve

agents that are heterogeneous in terms of funds collected, but which have similar leadership and networking capabilities.

In general, co-location in the same province (often in the same cluster), has a positive impact on the possibility to form a new relationship in the second period. This does not apply in the case of university-industry collaborations, where geographical proximity may be less relevant than in other types of relationships, especially when it is measured at the level of individual province (see also Laursen et al, 2011).

The presence of intermediaries brokering the relationship is of particular importance in the case of firm-to-university dyads. However, it is the brokering activity of a specialized intermediary (e.g. an innovation centre) that increases the probability to form a relationship in the network consolidation stage, while other "broader" intermediaries such as business associations or chambers of commerce (included in the variable *other_interm*) seem to play a negative role. This is possibly due to the fact that different types of intermediaries perform different types of tasks and pursue different goals. As discussed by Hassink (1996, 1997) specialized intermediaries may be effective in connecting firms to research centers because this is the specific task they focus on. Often, this task is facilitated by the fact that this type of intermediaries is controlled or participated by research centers. In contrast, intermediaries having a broader mission may not be useful for the purpose, because their resources are dispersed on many activities and on incouraging networking with a wide variety of agents[12].

Summarizing, the analysis shows that participation in the policy programmes considered somehow changed the firms' relational patterns. In fact, having collaborated before the participation in the policy programmes did not affect the probability of having subsequent (policy-funded) collaborations. On the contrary,

having collaborated within the network formation stage did have a positive effect on the probability of new collaborations, and this is particularly true when the relationship was strong. This result seems to suggest that the observed policy programmes affected how firms chose their partners in innovative projects. At the same time, the programmes offered firms the opportunity to strengthen relationships over time.

The peculiar characteristics of these policy programmes - the fact that they encouraged interactions with many diverse organisations in the network formation stage – may help to explain why sectoral heterogeneity had a negative effect on the probability to form relationships in the network consolidation stage: once the policy constraints were removed, firms resumed to cooperate with organisations that were most similar to them. This result may still indicate that learning had taken place: firms may have learned that heterogeneous relationships imposed by the policymakers were not particularly efficient or were not fulfilling their needs, and hence when the constraints were removed they sought out more effective partnerships.

Focusing on intermediaries, we note that only some types of specialized intermediaries (innovation and technology transfer centres, incubators, science and technology parks) were able to play an effective bridging role between firms and universities.

6. Conclusions

In this study we analysed empirically under what circumstances, for firms, the experience of having engaged in relationships with external organisations in the context of policy-supported networks can increase their likelihood to collaborate in the future. We did so by investigating the case of Tuscany, which can be considered

an old industrial region (as defined by Tödtling and Trippl, 2005), with its typical problems of lock-in and the need to bring SMEs closer to the world of research and technology transfer. In such regions, policies in support of innovation networks may facilitate the reconfiguration of innovative relations of the regional agents and the search for new complementarities.

Although our dataset did not allow us to extend the analysis beyond the period of implementation of the policy interventions themselves nor to have a counterfactual analysis, we have observed the extent to which policy programmes with certain characteristics were able to promote firms' engagement in subsequent relationships.

We found that the participation in the policy programmes somehow changed the SMEs' relational patterns, pushing them to collaborate – often in a stable way – with a variety of agents. In addition, we found that SMEs' likelihood to form relationships with other organisations, including other SMEs, was influenced by certain features of their participation in the previous policy programmes: mutual involvement with certain kinds of intermediaries and previous collaborations, especially if repeated, increased the likelihood to collaborate, while heterogeneity in networking abilities had positive effects only in the case of relationships between SMEs and other agents. Sectoral heterogeneity had a negative effect on the probability to form relationships in the network consolidation stage: once the policy constraints were removed, firms resumed to cooperate with partners that were most similar to them, and who were presumably useful in achieving their innovation objectives. The results also highlight an interesting aspect of firm-university relationships, which policymakers in many European regions are very interested in supporting: only some types of intermediaries – those specialized in providing innovation-related services – were able to encourage

the development of university-industry relationships. Co-location in the same province (often in the same cluster), increased the likelihood to collaborate.

Therefore, we find that by imposing certain requirements on the characteristics of networks to be funded within a policy programme, policymakers could encourage the adoption of certain behaviours that are considered desirable, but only to a limited extent.

Although these results have interesting policy implications, they do not tell us whether the observed changes in firms' behaviour turned out to be long-lasting. It is on this last point that we want to focus our future research. Furthermore, our results can be used to design a counterfactual analysis in order to assess the policy impact of relational learning in the context of a regional innovation system.

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[1] As it will be explained later in the section, the programmes were 4 and they were articulated in 9 waves in total. However, here and in what follows we will use only the term programme both to refer to the programme and to refer to the specific wave. This choice is motivated by the fact that each of the 9 waves was not merely a replica of the general framework set out in the programme, but it had its own peculiarities.

[2] Bellandi and Caloffi (2010) included only a part of these projects, because the analysis was carried out in a period (2007) when the funds for the regional innovation policies seemed to be terminated.

[3] The data refer to definitive projects, drafted in the format scheduled in the funding specifications. Our analysis includes all the subcontractors that have been explicitly identified in the application forms.

[4] We have not considered as "potential relationships" all the relationships that might have developed between all participants in the same period (of network formation or consolidation), but we have restricted our observation to the participants in the same programme. We believe that the latter definition is the one that best fits the concept of a "truly" potential relationship, because it identifies a

relationship that involves organisations that have chosen to participate in the same period in the same policy programme (though not to the same project).

[5] Relationships are bidirectional: if firm A participates in a project with organisation B, we have a unique link connecting both A with B and B with A. Multiple relationships, which can occur when two organisations meet in more than one programme (project) at the same stage of network formation or network consolidation, are not recorded as separate relationships (we do not generate a duplication of the record-dyad). As we will discuss in the following section, we consider the repeated co-participation as a specific feature of the observed dyad.

[6] The organisations participating both in the first and in the second period are 205, but only 204 of them have at least one potential relationship with the same partner both in the first and in the second period (in other words: only 204 of them co-participate with the same organisation to the same programmes both in the first and in the second stage).

[7] The authors have taken part in the evaluation of some of the programmes, namely the RPIA implemented in 2002, the programme 171_2005, and the RPIA launched in 2006. Moreover, they have had access to all the administrative data (evaluation reports, project reports, information on participants) collected by the Region.

[8] We have obtained this information thanks to the interviews to the participants that we have performed during the evaluation of the different programmes. In particular, we have asked the participants whether the relation with each project partner was initiated thanks to the policies or was pre-existing.

[9] Out of the 5,903 dyads for which we have complete information, 1,121 are formed by pairs of firms, 1,085 are formed by pairs that include a firm and a university, while the remaining 3,697 are firm-other agents pairs.

[10] We have run some post-estimation tests that have allowed us to assess the models' goodness-of-fit, and to exclude the presence of multicollinearity.

[11] In particular, in the case of firm-to-firm and firm-to-university dyads, the organisations that have multiple relations in the network formation stage, *always* continue to collaborate in the second period. In these dyads, the variable *multiple* exactly predict success: this is why we have excluded it from the analysis, as explained in the note to table 5.

[12] Obviously, there is a wider range of variables that can have an impact on the effectiveness of intermediaries. We refer to Hassink (1996, 1997) and Howells (2006) for a more detailed discussion of this point.