Networking System and Innovation Outputs: The Role of Science and Technology Parks

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Abstract

During recent years, research has, provided evidence that increasing interorganizational collaborations (networking) play a central role in determining firms innovation by demonstrating that the locus of innovation is an interorganizational system of actors.

Both the relationship between networking and innovation and the role of science partners in interorganizational relationships and R&D networking have been given a great deal of attention. The interest is stimulated by the contribution to economic development, competitive advantage creation, firms performance, expecially in high-tech industry.

The main purpose of this study is to explore the dynamic of the relationship between networking and innovation and science parks' role in providing the linkages to all firms and agents in interorganizational system of innovation.

The empirical evidence of the paper consists of a survey of 15 Italian Science Parks and show networking process facilitate the innovation projects but it will not necessarily lead to innovation success.

Keywords: Networking, Innovation outputs, R&D, Science Parks

1. Introduction

In the last two decades management literature has shown that the innovation is a complex and interactive process that involves variety of actors. The driving force of innovation is learning, both organizational and intellectual human capital(Zucker et al. 1998). Accordingly, as Powell et al. (1996) suggest, the locus of innovation may be found rather in interorganizational collaboration than in firms.

The research demonstrated that the increasing costs of R&D in combination with a shortening of product and technology lifecycles and blurring industry boundaries in a dynamic technological environment have made it almost impossible to develop innovation and technology on a stand-alone basis. Actors engage these collaborations to reduce costs of R&D, to transfer technology in order to improve innovative performance, to reduce time-to-market or to search for new technological opportunities (Note 1). In addition, they are also considered to be efficient vehicles for external strategic knowledge acquisition.

On this *open innovation* perspective, the view that the locus of innovation is in networks of interorganizational relationships (networking) (Powell et al., 1996) places source of innovation outside the firm.

Networks are a source of external knowledge and competitive advantage of the firm. Embeddeness of the firm in a system of innovation is an important capability that influences the firm's innovative capacity.

The concept of embeddedness is important for R&D operators and young technology-based firms, for example small dedicated biotechnology firms. The reason is that a dominant number of such actors are small. It is likely for the small companies to have a quite limited resource base and being to the certain degree resource dependent on the other actors; especially other science agents driving to know-how and technology.

Duysters 2007 explains: Interdependence and complementarities have been addressed here as the most common motivations for actors forming inter-organizational ties.

These resource dependency perspective posits that external resource scarcity is the most relevant reason for engaging in collaborative agreements.

In *research-driven* organizations, then, technological spillovers and inter-dependence appear to be more frequent. They take place both inside the relationship between firms and public research centres, or in localised networks of actors, or again, in global international networks of agents (Owen-Smith and Powell, 2004).

This can be shown also in science clusters (or technological districts) like in the area of Cambridge and Oxford in the UK, or in Boston and Minneapolis in the US, or in Balden Waden-Wuttemberg in Germany or in the scientific parks, like Sophia Antipolis, in France.

A sector that exemplifies the positive relationship between networking activity and innovation among a variety of organizations is the biotechnology sector.

The value of relational alliances for innovation is widely documented in different industries such us biotechnology industry. The other main features of biotechnology industry are uncertainty and complexity, hypercompetition, modularity of the innovation, dependence on intellectual resources and therefore emphasis on the protection of intellectual property as well as dependence on networks and linkages as sources of knowledge (Liebeskind & al., 1996).

The biotech industry illustrates the importance of networking for innovation but the result can be generalizable on the majority of sectors, no research-driven too.

Thus, networking behaviour was identified as significantly boosting the innovation output and competitiveness of firms and partners in a diverse range of industries (Ahuja, 2000; Powell, Koput and Smith-Doerr, 1996). Industries where networking has had an impact on innovation included: service industries, primary industries, manufacturing industries and high-tech industries.

In the Italian furniture industry the international competitiveness of the industry is largely down to continuous improvements and product differentiation which has been supported by the presence of industrial districts consisting of a network of small loosely organised (family) firms which are geographically clustered.

Finally: the innovation benefits of networking and collaborative agreements identified by the research include: *risk sharing; obtaining access to new markets and technologies (Grandori and Soda, 1995); "speeding products to market; pooling complementary skills" (Hagedoorn and Duysters, 2002); safeguarding property rights*(Liebeskind, Porter, Zucker and Brewer, 1996); acting as a new method for obtaining access to external knowledge (Powell, Koput, and Smith-Doerr, 1996;); Patent and R&D interorganizational project among science partners and other actors(Phillmore 1999)

Finally, with regard to the relationship between networking and innovations, the majority of research defines the role and the importance of R&D networking. Howevew, while the utility of networks for enhancing the development of innovations and innovation diffusion is well-established there appears to be a need for more focussed research on the impact of networking on the development and diffusion of different forms of innovation (e.g. product, innovation processes and organisational innovations).

The evidence shows a number of key points:

1) The nature of networking, different kinds of linkages and its utility for innovation and competitiveness depends on the strategic requirements of individual actors (Powell et al. 1996);

2) Network formation often differs between different forms of innovation required by actors; networks for product innovation are quite different from networks for process innovations;

3) The sustance of a firms' R&D alliance network during formation can have important ramifications for future innovation results (Baum, Calabrese and Silverman, 2000);

4) All types of networking constantly change and adapt depending on the requirements and ties of partners and the context within which the network operates.

5) Both in R&D networking and business networking science partner play a role of interface for innovations diffusion. However, findigs appear to be mixed with some evidence for against their capacity to promote networking success. (Phillmore 1999)

2. Causal relationship on the dynamic between networking and innovation

In the last decade researchers have examined the relationship between networking and innovations demonstrating how formalized alliances influence the frequency of innovation output (R&D projects, patent, R&D contracts, products, technology spin-off)

The empirical evidences indicate a positive relationship between interorganizational collaborations and innovation, within as diverse industries as chemicals, biotechnology, telecommunications, semiconductors, colleges, and across industries.

This positive relationship also holds when the alliances are formed, not with other firms, but with universities and Science partner.

The relationship between alliances and innovation is moderated by several variables. Research has shown that the network structure (i.e. whether a firms relationships are characterized by structural holes verses redundant ties) (Ahuja 2000), the absorptive capacity.

The types of the knowledge involve in the exchange relationship, and the trust between the partnering firms play a central role in enhancing the innovative peformance. Traditional control variables like age, size and R&D expenditures have an increased positive effect on innovation.

Research has shown that centrality within the larger network of alliances also facilitates innovations (Powell & al. 1999). Firms centrally positioned in a network have more access to new informations, than do firms in a more peripheral position.

The content of the ties that firms form also facilitates innovation. Firms can form collaborative agreements for different business activities, such as, licensing, financing, marketing, manufacturing, supply/distribution or investment. Research within the biotechnology industry shows that diversity in the type of alliance positively affects modular and complementary innovation process (Baum, Calabrese & Silverman 2000; Powell & al. 1999).

Diverse ties provide firms with access to diverse information, which makes the recombination of information more probable.

The firms experience managing alliances is another factor that explains how strategic collaborations affect innovation. Network experience has a positive influence on patenting and other innovation outputs even though the rate of increase diminishes with increased experience.

Powell & al. 1999 suggest that firms eventually exploit the most opportunities to learn, which makes further learning harder.

In general, the effects of diversity of ties and network experience are smaller than that of centrality, which might be related to the status advantages gained form being centrally located within a network.

A number of studies offer evidence other causal relationships.

Powell, Koput, and Smith-Doerr in 1996 show that R&D alliances between biotechnology and science partners facilitate the construction of non-R&D ties , and increase a firms centrality within the network.

George, Zahra et al. (2002) further find that firms with science partners and university alliances tend to form more alliances than firms that do not have university links.

Powell, Koput, and Smith-Doerr (1996) also show that forming more non-R&D ties lead to an increased tie diversity and increased network experience. A diversity of ties also results in firms becoming more central within the network The final element in the dynamic is that centrality within the network facilitates the establishment of R&D collaborations.

To summarise, Grodal 2004 explains: “not only does the formation of collaborative R&D increase innovation, which again increases the formation of collaborative R&D, but collaborative R&D also leads to increased diversity, experience and centrality within the network, all of which increases innovation. Simultaneously centrality within the network facilitates the formation of collaborative R&D”

Fig. 1 - Causal relationships on networking for innovation output.

3. Science and Technology Parks as Networking provider

The first science park of all time, the Stanford University Science Park in California, was founded in 1950 and in 1986 had already over 80 occupant companies employing over 26000 people. Starting slowly the Park eventually drew in Eastman Kodak and Varian and accommodate new university-spawned companies such as Hewlett-

Packard and Syntex, thereby fuelling its growth from both external and internal sources.

Silicon Valley, the regional expression of the 'Stanford phenomenon', in 1986 had already more than 3000 advanced electronics companies providing over 200.000 jobs.

Research parks became more common in Europe during the 1980's. However, majority of the currently existing Science & Technology Parks in the world were created during the 1990's.

On the perspective of the American experience, during 1980's also Italian government began to emanate normative for the R&D and techology transfer activities.

According to other authors: "*looking for a uniform description of a STP it seems necessary to report some of the most considered definitions given by national and international organizations related with the parks"*.

As defined by the IASP (International Association of Science Parks) (Note 2) "a science/technology park is a property-based Initiative which:

- has operational links with Universities, Research Centres and other Institutions of Higher Education;
- is designed to encourage the formation and growth of knowledge-based industries or high value added tertiary firms, normally resident on site;
- has a steady management team actively engaged in fostering the transfer of technology and business to tenant organisations".

The Italian Association of Science and Technology Parks (APSTI) defines a STP like a "system for local development aimed at the promotion and support of:

- initiatives dedicated to scientific and technologic research;
- R&D linkages;
- new innovative firms;
- innovation and competition for those firms operating in the geographical range of action of the park."

Maki 2002 *shown: "Such wide-open definitions are the expression of a variety that roots in the fact that STPs are a relative recent phenomenon and in rapid evolution"*. Nevertheless, above all, that they are the expression of a milieu, its socio-political system, its economic and industrial development, its relationship between research and industries and its available resources (knowledge, culture, human capital, economic, infrastructure, environment).

3.1 STP: Central Actor on Innovation Process

The phenomenon science parks have been researched for almost 20 years.

The most essential research areas related to science parks are new technology based firms, academic entrepreneurship (Mitra 2002), university-industry links (Vedovello 1997), technology transfer and networks.

The effect of the business and technological strategy of Science centres have been discussed in the last two decades (see for example Massey-Quintas-Wield 1992; Maggioni e Bramanti, 2002, Autio-Klofsten 1998, Westhead-Batstone e Martin, 1998; Mäki-Sinervo 2001).

These researches have considered the subject also from a regional policy point of view. The relationships with and inside the science parks have not been widely discussed in the research related to the science parks.

In networking process or network formation process, science partners play an important role as independent provider and intermediaries within business and R&D networks.

One of the most important topic emerging from the literature on R&D networking is that while organizations can use collaborative alliances to complement their technical and managerial strengths, they cannot substitute alliances for the complete absence of specific competencies. If actors are to benefit from R&D networking to R&D consortia, for example (Note 2), they need to have sufficient absorptive capacity to take in knowledge generated and transform it into technology or knowledge relevant to their particular mission. The study by Grindley et al. (1994) of the Semiconductor Manufacturing Technology Consortium (SEMATECH) revealed that those organizations that had strong in-house expertise benefited most from the alliance.

On this *open-tchnology* perspective science partners act as, intermediaries or neutral agents within networks enabling different business systems to communicate by generating trust between different parties. The evidence demonstrates that science partners tend to be most important where the innovation is complex and involve more technologies and capabilities.

The science parks often declare that they have an important role in developing the innovation output in business networks especially for the start-up companies that are located in and outside science parks.

In case of start-ups, the development of their business network is vitally important. (Autio 1997)

Thus for the start-ups located in science parks the science park should act as an intermediator or provider of business and R&D relationships. On networking system the science parks in this context can be seen either as actor in the relationship between two or different organisations, i.e. between science park and company belonging to the science park, or science park can be seen as intermediator in relationship between University, start-up science driven and corporation to commercializating new product.

The intermediator / provider role can be even extended to a larger network of different actors: university, DTFs (Dedicated Technology firms), Corporations, Administration, other Centres of Research, other Science and Technology Parks, Venture capital Groups

Science park organisation as well as universities and R&D institutions are key *actors* on innovation perspective.

In addition, there are also some other external groups, which are not stakeholders of science parks but are linked to a science park or its firms. Such groups include for example accountants, auditors, lawyers, merchant and investment banks, business consultants and other service providers, which are located in and outside the parks or whose clients are mainly located in the parks.

To summarise, the science center as Science and Technology Parks could become central actors in networking system for innovation, they could increase the number of linkages, could increase the diversity of ties and partners. Unesco-WTA 2011:" Consequently, the different kinds of collaboration and actor involve in interorganizational system could increase knowledge, critic mass, capabilities and innovation output. "

The concept of science park role in networking for innovation can be presented visually as follows.

Fig. 2. A model of Causal relationships and innovation networking.

4. Research method, findings and illustration

The data presented in this paper consists of a survey for 15 Italian Science Parks. Only the science and technology parks, APSTI (Associazione Italiana Parchi Scientifici e Tecnologici) associated. The survey data was collected by interviews in the locations. I submitted to the sample a questionnaire answers about different innovation output, university-STP relationships, different types of ties, different types of partners, size and employees STP etc.

The questionnaire consisted of structured questions in Likert Scale value and descriptive questions.

The methodology is focused on the qualitative analysis of the data. Comparative analysis of literature results in other countries evidence the role of Science Parks in different contexts: political, economic, industrial.

To sumarise, the dimension of the analysis:

Location: Italy - *Number* : 15 – Total APSTI associated 30

Types of linkages: Financing, Licensing, Commercial, R&D, Other Types.

STP Partner: University, Large diversificated Firms, dedicated Techonology Firms, Other Research Centres, Other STP, Central and local government, VC Partner, other partner.

Industry: information technology; wellness technology; other technology; technology related services, agroindustry, biotechnology.

Size: no employees

Enterprise in STP: Ict, biotechnology.

Innovation output: R&D interProject, Products, Patents, Innovation Process.

Tab. 1 – Types of ties and STP Partners

According to STP's answers the diversity of linkages are one of the most common features for science park . The frequencies are presented in the table 1.

According to other studies, the number of Research & Development linkages seem to be highest with average of 19,66, a sum of 236, a 56 maximum of and a minimum of 4.

These types of collaboration, are determinants variables in innovation output process and strategic collaborations of other substance, considering the mission of the STP and the role in networking process. The maximum value of R&D relations is attributable to the Science Area Park of Trieste, considering also the start activities.

Likewise, the collaborations with University Departments and small technology firms, are most numerous than other actors in networking (mean 13,33 - 17,16).

They are main STP's partners on perspective to planning of research & development activity for new interprojects and products.

The relations with other STP are still low (mean 7, tot. 25), greater ones are those with other Research centres (mean 9.91, tot 64).

This result puts in relief problematic the relative ones to the competition between Science partners. However during recent years has been however moderated thanks to the role of coordination of the APSTI.

At last still insufficient they turn out to be the relations financial institutions and venture capitalist (mean 2,58, tot. 5) to confirmation that still is not joints to the complete autonomy regarding the public funds of the research.

This problem is debate object on the dynamic of R&D coordination between governmental political and APSTI.

Tab. 2: Time costitution, employees, fields/areas activity.

According in table 2, the first Park has been constituted in 1982, the last one in 2003. The STP investigate incubent 72 employee in mean and second operate in average in nearly 5 fields/areas The greater employees number is imputable to Consortium 21 of Sardinia (375). The maximum number of activity fields/areas is imputable to Kilometer Rosso and Technapoli.

Tab. 3 - Innovation outputs

Zucker et al. 1997 and Landefeld in 1994 noted that more direct measures of R&D and technological development may require use of no-expenditure data such as the number of patents, patent applications, R&D Projects, R&D personnel, proxies for embodied technological change (e.g., average age of physical capital), and intellectual human capital stock estimates

Those factors are used to develop quantitative measures of innovative output and science-technology linkages.

The outputs of innovative activities can vary along a number of dimensions, such as product-process-service, firm size, technical complexity and performance.

Those innovation outputs can be modified by industry-specific versus country agents-specific factors in shaping the rate and direction of innovation. Porter (1990) and Patel and Pavitt (1994) have argued that country specific factors, such as the degree of rivalry in the domestic market and the type of financial and educational institutions are the dominant influence on innovation. Conversely, Malerba and Orsenigo (1995) suggest that sector-specific factors such as technological and market opportunities are more important.

Regarding innovation output evidence of this survey, according to the literature, one typology of innovation developped by networking process are R&D interprojects among, STP, University, Other Science Partner and Government(49%) and process innovation(34%). R&D projects regarding pre-competitive and competitive research to developping new products to the technology transfer. The purpose of this fase of innovation process is the patent.

Table 3 show that italian STPs networking system doesn't increase the number of italian patent (only 11%) of activities. This insufficient result, according to other empirical evidence may be related to low number of STP's agreements with dedicated technology firms and other science partners. Likewise, the number of products developped is still insufficient (6%) because STP's agreements with dedicated technology firms, large diversificated firms and venture capitalist partners result more low than university linkages.

However, patents represent only a portion of innovative activity and none of the latter stage investments entailed in commercializing technology. Patents are of widely varying value to firms. Motivations for patenting vary across industries and technologies; equally important, they change over time.

Likewise, the empirical evidence show that in the last 5 years (time 2002- 2008) the number of fims linkages, financials agreements, other Science Centres linkages, number of start-up innovation firms in and outside STPs and number of patents are increasing.

5. Conclusions

In high tech context, the Science Center as Science and Technology parks could become central actors in networking system for innovation, they could increase the number of linkages, could increase the diversity of ties and partner. Consequently, the different kinds of collaboration and actor involve in interorganizational system could increase knowledge, critic mass, capabilities and innovation output.

Focused on the peculiarities of one specific country, this paper has evidencied the dynamic concerning the relationship between networking and different forms of innovation, such as, process and product innovation.

Both in R&D networking and business networking science partner play a role of interface for innovations diffusion.

However, in survey results, the extent to which Science Parks promote interorganizational systems for innovation appears to be mixed with some evidence for and against their capacity to promote networking success.

Detailed evidence on how Science Parks might promote networks success also appears to be few from the literature.

According to other research, inter-firm networking can facilitate the innovation process but it will not necessarily lead to innovation success.

In facts, the evidence found shows that Italian STPs do not always contribute to networking success to increase innovation outputs. However, the number and the types of ties and the number of innovation outputs are increasing in last five years. Empirical research focused in other countries show this result findings.

This is the problem of central government coordination of research found and research programs on the new perspective of the interprojects and networking among science and business agents.

It is possible that innovation policies and regional infrastructures can assist networking activities leading to innovation, but actually their degree of effectiveness can be considered insufficient to draw any useful conclusions.

The problem with the study is, that survey does not give enough information about increasing of the different linkages of the firms and other agents (firms viewpoint) and the methodology chosen (qualitative analysis and focused in one country) could be extended in other European countries.

Future study and research can shows how do Science Parks actually provide linkages and business co-operation possibilities for all the firms embedded in interorganizational system of innovation and the role of Science Parks in European Innovation System.

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Notes

Note 1. IASP definition. (2002): “A Science Park is an organisation managed by specialised professionals, whose main aim is to increase thewealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spinoff processes; and provides other value-added services together with high quality space and facilities."

Note 2. Concerns about the appropriability of results is a major factor circumscribing the development of alliances in R&D: R&D alliances in the private sector are most appropriate for "leaky" technologies where property rights are appropriable by the inventor for only a short period of time. While concerns about appropriability of research results may be less explicit in public sector research, concerns about appropriability of credit for research developments can have the same constraining effect on the formation and functioning of an R&D networking.

Table 1. Types of ties and STP Partners

	RELR&S	RELICENS	RELCOM	RELFIN	RELOTH	RELUNI	RELLDF	RELDTF	RELSTP	RELSP	RELGOV
N	14	15	15	14	15	15	13	13	13	14	12
Mean	19,66	5,41	2,41	2,58	4,58	13,33	7,66	17,16	7,00	9,91	4,58
Median	13,00	3,50	2,50	2,00	3,50	8,00	4,50	6,50	3,00	4,50	3,00
Std. Deviation	17,32	6,40	2,11	1,72	4,23	10,00	9,34	33,84	8,31	17,64	4,90
Minimum	4,00	1,00	,00	,00	,00	3,00	,00	,00	,00	,00	,00
Maximum	56,00	24,00	6,00	5,00	14,00	31,00	35,00	121,00	25,00	64,00	18,00
TOT	236,00	65,00	29,00	31,00	55,00	160,00	92,00	206,00	84,00	119,00	55,00

Table 2. Time constitution, employees, fields/areas activity

	Time	N- Empl	N – Research area
N	14	13	13
Mean	1995	71,72	4,75
Median	1995	25,00	3,00
Std Deviation	6,38	107,84	3,69
Minimum	1982	5,00	2,00
Maximun	2003	375,00	11,00
TOT		789,00	57,00

Table 3. Innovation outputs

INNOVATION OUTPUT	%	NETWORKING PARTNERS
R&D interProjects	**49%**	University, Other Science Partners and Government
Patents	**11%**	University, Dedicated Technology firms and Science Partners
Products	**6%**	Large Diversificated Firms, Dedicated Technology firms
Processes	**34%**	University, Other Science Partners and Government

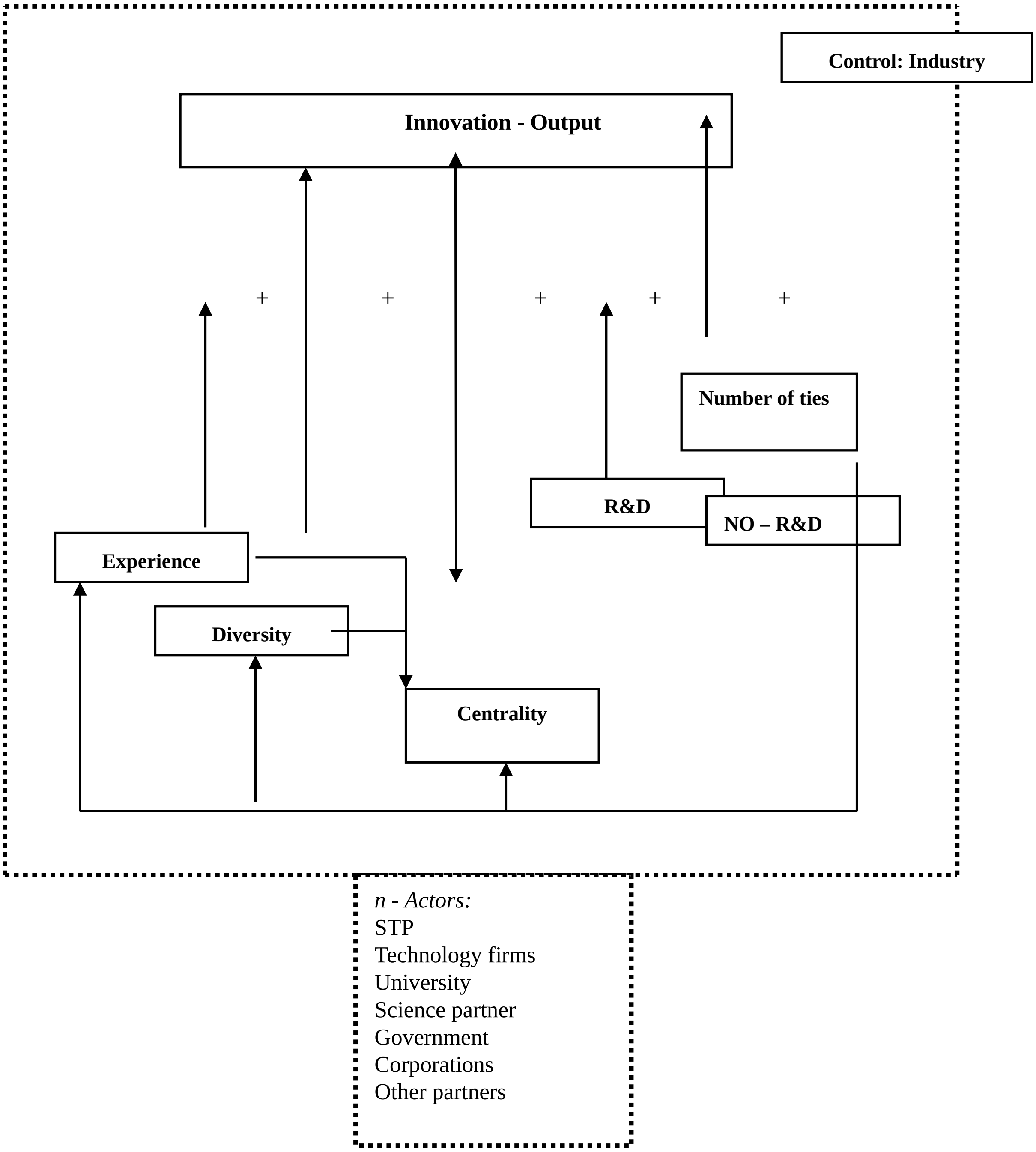

Figure 1. Causal relationships on networking for innovation output

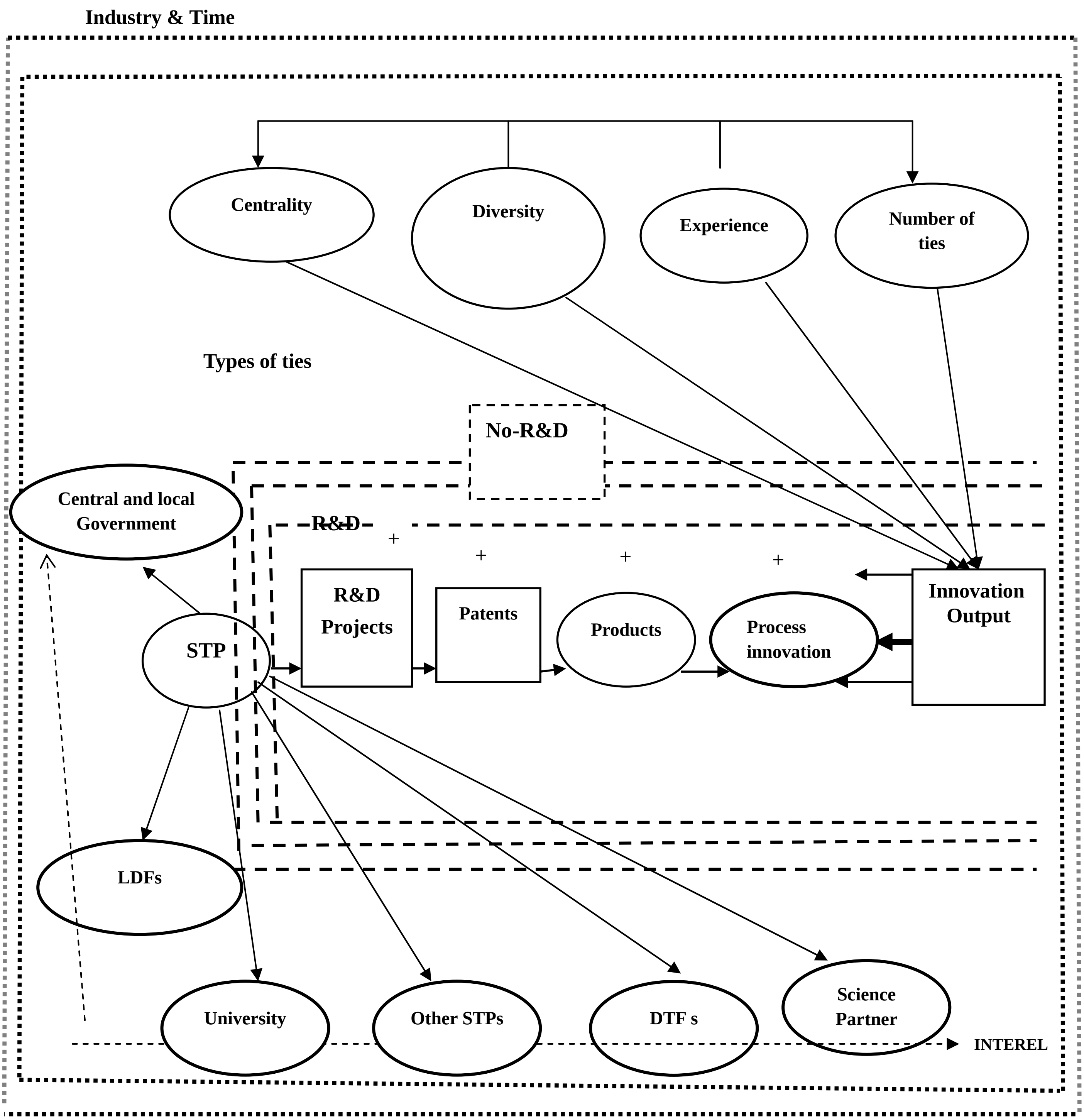

Figure 2. A model of causal relationships and innovation networking