

**TECHNOLOGICAL COOPERATION:
A NEW TYPE OF RELATIONS IN THE PROGRESS OF
NATIONAL INNOVATION SYSTEMS**

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Abstract

This paper analyzes the cooperative model as a trend towards new types or relations within National Innovation Systems. Based on the review of the evolution of the national innovations systems and the analysis of the meaning of cooperation in the technological field, we expose that a cooperative innovation system model fulfill the ultimate objective of satisfying the technological requirements of companies so that they may face up to the demand of present and future markets with greater chances of success.

Keywords: National Innovation Systems, Technology, R & D, Cooperation.

Introduction

On the twenty-first century, it is a well-known fact that the acquisition and development of technologies constitutes a fundamental part of the generation of resources for the improvement of business competitiveness, and that technological dynamism does not appear in the economy if we do not have the infrastructures and capacities necessary for supporting the innovative activity of companies and allowing the spread of new technologies.

The evolution of the traditional Science and Technology System towards a National Innovation System integrated into socioeconomic life has highlighted the growing need to encourage and develop the interactions among those participating in the innovation process. In this respect, current policies relating to innovation and the transfer and spreading of technology are placing increasing importance on *cooperation mechanisms* as a means of enabling effective interaction to take place among science, technology, production and the market.

On the basis of the review of the national innovation systems and the analysis of the meaning of cooperation in the technological field, we study the cooperative model as a trend towards new types of relations within the national innovation systems. This progress allows greater interaction among the participating agents, especially in the case of the member nations of the European Union, whose project of integration in the technological sphere superimposes different levels of action linked to the principle of subsidiary.

As a conclusion, we propose the modelling of a *Cooperative Innovation System*, taking into account the principles for its functioning and the different areas of interaction, which would fulfil the ultimate objective of satisfying the technological requirements of companies so that they may face up to the demand of present and future markets with greater chances of success (Martin, 2005).

The evolution of National Innovation Systems

The importance of linking the scientific and technological activity of universities and research centres more closely with industry is considered to be a key element for the economic and technological growth of countries. The technology policy constitutes the axis around which the scientific, technological and innovation activities are structured, activities which help to bring about technological advances as an indispensable public asset for growth.

In an initial stage, the technology policy was manifested in what were known as science and technology systems, whose main objective consisted in developing policies geared towards creating, mainly, research infrastructures. In this model, the interactions among the universities, the government and the business world were characterized by the existence of a reduced flow of ideas from the universities and research centres to the companies, the State acting as an intermediary in the allocation of resources -originating from the payment of taxes on the part of the companies- in order to finance the research activity.

The evolution towards a model in which there is greater interaction among the universities and public research centres, the companies and the government is regarded as a necessity for satisfying the requirements of services, research and development, as well as continuous training, over a period of years in which the speed of innovation has meant that it takes very little time for a new product to reach the market after it has been designed in a research laboratory, and in which the new technologies -in the sphere of acquisition and processing of information, in telecommunications and materials- have opened up possibilities for rapid technological progress in the most diverse fields of knowledge.

The concept of National Innovation System (NIS) has been introduced into the literature in order to designate the existence of certain organizational and operating mechanisms which enable *interaction* among science, technology, production and the market (Hagedoorn *et al.* 2000). The National Innovation System -or science-technology-industry system- is an institutional organization scheme which encompasses different capacities (information, knowledge, financial resources, etc.) from different origins (public laboratories, university research centres, engineering firms, information centres, users, etc.) which make the innovation processes possible within an economy.

Therefore, we can define the national innovation systems as being those which bring together all the economic and social agents that intervene in any of the phases of the innovation process. Specifically speaking: the companies, the public R&D system (which includes the universities and public research centres), the government services which carry out policies relating to technology and the promotion of innovation, the innovation support infrastructures and other agents or related subsystems (the education system, the capital markets, etc.).

Alongside this evolution, the approach to technological innovation and development systems has also changed, not only with regard to the stages involved in the process, but also in relation to the way in which these processes are carried out by the companies.

The concept of innovation proposed by Schumpeter (1980) and its division into different stages led to the first analyses identifying as characteristics of the process the *linearity* between invention and innovation, and sequentially, i.e. the different stages in the process formed part of a chain, based on a gradual and systematic development of knowledge, whose culmination would be the marketing of new and improved products or services. This division of activities helped enormously to create policies which treat technological innovation and development as a process open to fragmented support -the traditional science and technology systems already been referred to-. However, the limitations of this approach, which does not take into account the interaction among activities and among the different agents, and the fact that the analysis of the innovation processes requires the consideration of numerous factors, both internal (multiplicity of agents involved and interaction mechanisms) and external (set of policies and factors of competitiveness which determine the environment in which the companies operate) has made it necessary to study it through models which consider an *interactive, systemic and international approach*.

As regards the way in which the companies carry out the innovation processes, the significant increase -starting from the mid-1980s- in the number of strategic alliances based on collaboration for the development of innovations highlights the fact that technological innovation is the result of a process which is carried out within a network (Hagedoorn, 1993). The network comprises not only the companies which collaborate, but also clients, supplier, sources of technological knowledge (universities, public research centres), administrators, etc., whereby a large number of interactions are generated among the various participants.

In this context, the definition of National Innovation System implicitly entails the acknowledgement of the multiplicity of factors and agents that intervene in the technological innovation process and, therefore, in the technical change. Freeman (1987), for example, by associating the substantial technological changes with the national innovation systems, defines the latter as “the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and spread new technologies”. These institutions range from the institutional and political apparatus of the State to the private individual, who will be the end consumer of the new products or services offered on the market. Along similar lines, Hauschildt (1994) also stresses the fundamental role played by interactions in the multiplication and acceleration of the technological results.

The meaning of interaction between agents

As we have seen, the interaction among organizations, due to the multiplicity of participating agents, constitutes one of the key aspects not only in the study of the innovation processes, but also in the way that these are carried out by the companies, and also within the framework of the National Innovation Systems.

Despite its importance, a review of the literature reveals the existence of a wide range of terms for referring to the relations between organizations and therefore a great diversity as regards the contents in the definition of the concept. The wide variety of

interpretations is partly due to the fact that the relations between organizations have been the subject of study and analysis by researchers belonging to different disciplines (marketing, organization theory, company economics, strategic management, etc.) and although each one of these perspectives helps to understand these relations, they generally make different assumptions about the nature of them.

In general, however, we can delimit the contents of the relation between organizations in terms of four aspects (Johanson and Mattson, 1987):

1. The orientation or common predisposition to work together, whether this may involve taking advantage of or sharing an asset (generating economies of scale) or taking advantage of complementarity.
2. Dependence, deriving from the fact of different organizations working together.
3. The link which, in some way, is a measure of connection (albeit unspecified) between the parties which interact. The links have a series of characteristics which Aldrich (1979) limits to four: formalization, intensity, reciprocity and standardization.
4. The investments made by the parties, which will determine the future obligation of the relation, and which normally materialize in the form of people and time. Iacobucci and Ostrom (1996) in this respect identify several types of investments: symmetrical, asymmetrical, competitive or hostile, social or work-related, etc.

Together with the recognition of the complexity in the definition of the relations between organizations, there are also other matters which further complicate their analysis with respect to the national innovation systems: the obligation in the relationship, the diversity of participating agents, the specific nature of the technology and ever-increasing internationalization, both in relation to generation and operation.

Moreover, according to the definition of the National Innovation Systems given in the previous section, we can delimit various levels of relations within each one of them (Edquist, 1997):

- The individual (or person) who with his or her skill, training, initiative, etc., and in interaction with other individuals, is capable of developing or using technological knowledge.
- The company, made up in turn of the set of individuals situated within a hierarchy who interact with other agents in the development of technological processes.
- The grouping or network of organizations regarded as a group -and therefore, with a collective strategy- that participate in innovation processes with the aim of gaining access to a certain technology (networks of companies which generate economies of scale, jointly acquire a technology via transfer or participate in supranational technological innovation projects, making up a network with other agents).
- On a national scale, regarded as the national innovation system in which each type of agent (technological, scientific, financial, etc.) is linked with the aim of developing, within this geographical sphere, a process of economic growth through technological progress.
- From a supranational or interaction point of view among various national innovation systems, as in the case of the member nations of the European Union.

The search for efficiency in interorganizational relations

From a purely economic perspective, we are obliged to consider efficiency in interorganizational relations (Moulin, 1995). The following example attempts to show the different situations which may arise.

Let us assume that there are two economic agents, A and B, each one of whom contributes certain economic resources in order to jointly carry out a technological innovation process. We assume that each agent has certain preferences represented by the utility function U_a and U_b .

$$\begin{aligned} F &= a^\alpha b^\beta & \alpha \text{ and } \beta &\geq 0 \\ U_a &= f(a,b) & U_b &= f(a,b) \end{aligned}$$

being F a Coob-Douglas function which represents the function of production in the innovation process.

If we consider that an interaction exists between a and b , the utility functions of each one of the agents will depend on the quantity of resources contributed by the other agent.

$$\begin{aligned} \delta U_a / \delta b &\neq 0 \\ \delta U_b / \delta a &\neq 0 \end{aligned}$$

On the basis of this approach, two efficient solutions may arise (in the Paretian sense):

a) A non-cooperative solution, which involves each agent trying to maximize its profit bearing in mind the contributions of the other —Nash-Cournot equilibrium—. Thus, in the case of agent A, in order to maximize $U_a = f(a,b)$:

$$\delta U_a / \delta a = 0 \text{ (with } b \geq 0)$$

In the same way, in the case of agent B:

$$\delta U_b / \delta b = 0 \text{ (with } a \geq 0)$$

b) The cooperative solution, which would involve:

$$\delta (U_a + U_b) / \delta a = 0$$

$$\delta (U_a + U_b) / \delta b = 0$$

Therefore, the interaction between organizations may lead to two possible solutions if the aim of the relation is to obtain economic efficiency: a non-cooperative solution, which corresponds to a Nash-Cournot equilibrium in which each agent maximizes its profit, bearing in mind the interaction between organizations; a cooperative solution, in which the joint maximization of profits is opted for.

Cooperation as a basis for technological development

Having considered the meaning of interorganizational relations and the matters relating to their efficiency, we will now focus on the analysis of interorganizational relations when the aim is to carry out technological projects.

The exchange of technology involves certain high transaction costs due to both the intrinsic characteristics of the item to be transferred and the set of exogenous -or environmental- factors which condition the transaction.

With respect to the characteristics of the technology, it should be pointed out that:

1. Technology is knowledge and not information, and therefore its reproduction and acquisition is neither easy nor free of charge. Its accumulative nature through learning and experience gives it a great specificity.
2. Its local and discriminatory nature -partly deriving from the prioritization and selection of certain courses of technological development- which means that sometimes very marked differences between sectors are generated (specificity of localization).
3. The presence of a high level of uncertainty throughout the entire process of technological development, both in the preliminary stages -with respect to the results which are going to be obtained and the periods in which they are going to be achieved- and in the final market response stage -in the selection of products deriving from a certain type of technological development-.

The difficulties in appropriation -in the case of the transfer of technology- or the need for cooperation -in the case of technological development- deriving from the different levels of technological capacity between organizations means that the relations between organizations must be very close and frequent, something which leads to an increase in the transaction costs, especially if we bear in mind globalization in both one case or the other.

We can define technological cooperation as the agreement between two or more independent agents who, by joining or sharing their skills and/or resources, develop and carry out a technological process with the aim of increasing their competitive advantages. The resulting type of agreement will depend on the contingencies of the environment, the characteristics of the item to be transferred, the qualities and behaviour of the contracting agents, etc. and therefore numerous contractual arrangements will exist (Gulati, 1998).

In the terminology of Imai and Itami (1984), the contractual forms of cooperation between organizations constitute intermediate structures between the company and the market. The forms closest to the market materialize in very simple contracts and, on the contrary, the options closest to the company involve much more complex agreements - with structures very close to internalization-, deriving, logically, from the greater involvement between the participating agents, the levels of investment required and the need to carry out a follow-up adapted to the extent of the transaction carried out.

Cooperation, as a form of interrelation between economic agents, leads on the one hand to the fulfilment of the objective of seeking economic efficiency in the transaction -as we have seen in the previous section- and, on the other, helps to reduce the transaction costs.

Cooperation also makes it possible to reach the critical threshold necessary for undertaking large-scale projects, obtain resources from public entities (Branstetter and Sakakibara 2002; Aulich, 2003), successfully introduce new technologies (Balachandra and Friar 1997), spread a new technologically more rapidly and facilitate access to new capacities on the part of the remaining participants in the cooperation agreement.

Conclusion: Towards a cooperative design of National Innovation Systems

We have already mentioned that the National Innovation Systems involve different organizational schemes and different policies which, furthermore, involve the creation of effective mechanisms of interaction among agents.

We have also highlighted how the interactions based on cooperation are very suitable in the field of technology, given that as well as representing an efficient solution, from the economic point of view, they lead to saving in transaction costs.

Furthermore, given that cooperation involves establishing a contractual relation between agents in order to jointly perform a certain business function, in order for cooperation to be established there must be an incentive and this will exist provided that the agents, upon cooperating, obtain greater profits than they would achieve individually. The synergic effects arise, therefore, when the total profit of operating together is greater than the sum of the profit of each one of the participants considered individually.

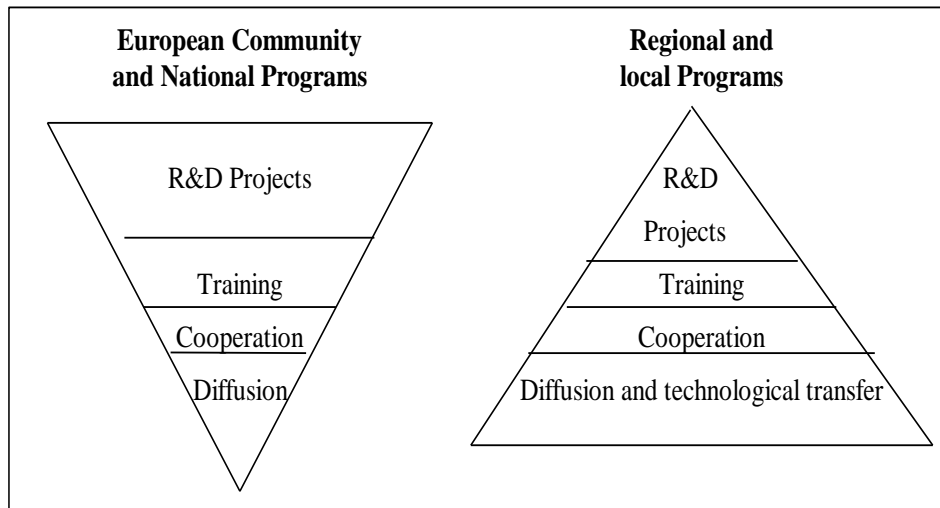
Therefore, the interactions based on cooperation within the National Innovation Systems might be the most suitable, given that they permit synergic effects, both in the performance of horizontal actions (exchange of information, linking among agents, etc.) and in the integration of vertical actions in the different levels of analysis mentioned above:

- At an individual level: since technological knowledge is tacit knowledge (learning by using, learning by doing... learning by learning) and given the difficulty involved in spreading it, it is essential to create work teams based on cooperation as a means for learning and spreading technological knowledge.
- At a company level: either by promoting cooperation among companies with the aim of generating economies of scale, or by seeking complementarity through a closer relationship between universities and public research centres by means of cooperation.
- At a regional, national or supranational level: given that individuals and companies operate in geographical spheres of different sizes in which actions which correspond to the different spheres mentioned may be coordinated through cooperation.

This proposal virtually becomes a necessity in the case of the European Union. On the one hand, at a Community level, the search for *effective coordination* among the different governments of the member nations with regard to R & D has led to the

establishment of plural-annual Framework Programmes, in which the actions of each government in this sphere must be carried out in a coordinated manner in keeping with the objectives proposed in the Programme. Ultimately, the Programmes seek to achieve synergic effects in technological matters for all the member nations of the Union.

Figure 1. Technology Policy: field of application



On the other, the principle of *subsidiary* underlies all the Community's actions. This term refers to the need to assume responsibilities in a decentralized manner through the various levels of government, as a mechanism for reinforcing the efficiency of the actions.

In short, the aim is to ensure that the *effective coordination* among the different governments is guided by efficiency criteria, and as we have seen, *cooperation involves an efficient solution* from the economic point of view.

Together with this, the dual and complementary nature of national and/or supranational actions with respect to regional actions is highlighted, and therefore efficiency, in this sense, from our point of view, comprises two aspects:

- Cooperation among regional and local organizations based on complementarily, given that the programmes they carry out -taking advantage of their proximity to the company- will focus on the areas where the economies of accumulation of knowledge are more important (the spreading of technologies and the promotion of cooperation among the economic and social agents of their environment).
- Cooperation in national and/or supranational actions based on the search for economies of scale, given that most of their resources will be devoted to the financing actions which, due to their extent require high investments (research projects, technological development and demonstrations), as well as to the training activities which help to create teams of research and innovation excellence in the European and national spheres.

In short, in the construction of National Innovation Systems based on cooperation, the Public Administration must carry out, apart from the traditional duties involving the generation of infrastructure (research centres, information systems, formation of human resources, etc.) and the promotion of innovation (by designing policies and creating institutional mechanisms aimed at completing the functioning of the market), an important task as promoter and manager of agreements with the aim of establishing a network of relations through cooperation which enables the different types of information, knowledge and skills which support the innovation processes to flow between the different economic and social agents.

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