Knowledge spillovers in the process of formation of the economic clusters

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Abstract

Knowledge creation and innovation represent the result of an interactive process of collaboration between various actors that come together to solve the problems they face. However, due to the complexity of the knowledge dimension, the creation and exchange of information don't occur automatically, it requires a special environment that could facilitate these processes. Spatial clustering of economic activity proved to be an efficient way to organize interactive learning processes, offering the perfect infrastructure for fostering that collaboration between its participants, from which all of them can grasp advantages in terms of acquiring new technical, organizational, commercial or intellectual competences.

Keywords: *economic clusters, triple helix cluster model, knowledge-spillovers, innovation, entrepreneurial university*
JEL Code: O3, O25, O40

1. Introduction

As a result of the transition from the *Industrial Societies* to the *Knowledge-Based Societies*, a stronger focus is put on technology and innovation as a source of sustainable economic growth. In this respect, both industries and policy-makers began to be more concerned about finding the best solutions that could facilitate knowledge creation and its diffusion across the whole economy. Because knowledge represents a complex dimension, and not all types of information can be freely exchanged and communicated around without friction, it requires special channels and conditions for the display of its positive externalities. The empirical evidence proves that economic agglomeration, though offering proximities, can create a favorable environment for the diffusion and absorption of new formats of knowledge. Activating within a cluster, the economic actors can benefit from advantages of co-location, in terms of better access to information that arise from continuous monitoring, comparing and interaction process.

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The main objective of this paper is to clarify the mechanism of knowledge spillovers' diffusion within the process of formation of the economic clusters, normally offering multiple kinds of proximities. In particular, the paper outlines the process of knowledge creation and diffusion in the context of *the triple helix cluster model*. To reach the objectives, we use the methodology of analysis and synthesis of the literature in the field, also providing examples from empirical studies.

2. Main findings

Nowadays innovation is recognized to be a crucial factor toward increasing productivity in the economy. The OECD (2005) defines innovation as "implementation of a new or significantly improved product (good or service), or process, a new marketing method or a new organizational method in business practices, workplace organization or external relations". Innovation and learning represent the result of interactive processes, emphasizing the important role played by *the networks* established between firms that decide to collaborate in order to find solutions to concrete problems. Moreover, the collaboration does not limit just to business actors, being also extended to universities, which are a driving force of innovation, and to government - an actor that can stimulate university-industry linkages. Therefore, it can be inherited that for achieving innovation, and benefiting from knowledge spillovers, the formation of clusters represents a sustainable solution.

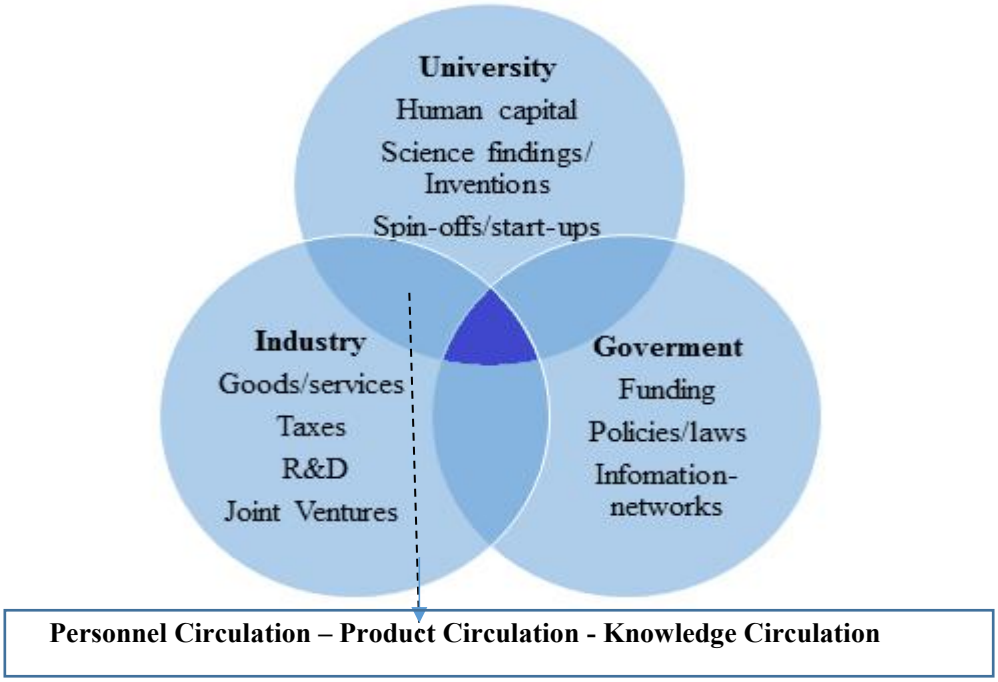
In particular, *the triple helix cluster model* developed for the first time by Etzkowitz (1993) refers to a network established between three main actors: universities – enterprises – and government, that aim to collaborate for ensuring knowledge spillovers, fostering the process of innovation and achieving, as a common goal, the economic development. The interrelations between firms, public agencies and universities create perfect channels for circulation of personnel, of products and knowledge (Figure 1), having a positive implication for the development trajectories of each member.

To understand exactly why economic clusters, create favorable conditions for knowledge spillovers, it is important to address the concept of *proximity.*

An economic cluster is firstly about *geographical proximity*. We can find evidence of additional benefits of the firms as result of the geographical concentration of their production factors, going back to the roots of the cluster concept in the *Principles of Economics* of Alfred Marshall. By developing the notion of *external economies of scale*, Marshall argued that the source of firms' productivity lies outside the individual firms. In such a way *spatial proximity* can generate benefits for producers through sharing the fixed cost of common resources, skilled labor pools, the knowledge base. Moreover, investigating the industrial districts, Marshall showed that they are rational solutions for rescuing Britain's economic growth. He argued this by underlying the *positive externalities* created by geographical concentration: (i) it brings closer manufactures and necessary resources, leading to specialization of providers (ii) specialization of the labor force (iii) widespread knowledge and information that are "in the air". Marshall (1920, p. 84) considered "Capital consists in a great part of

knowledge and organization (…). Knowledge is our most powerful engine of production; it enables us to subdue Nature and force her to satisfy our wants". This approach to knowledge remains valid nowadays. The *knowledge atmosphere* that is *flying* within a cluster, motivates firms to concentrate and to take advantage of them.

Figure 1. Interactions provided by the triple helix cluster model.



Source: adapted by authors according to Etzkowitz (2008)

Later, Michael Porter developed influential concepts regarding advantages offered by acting within a cluster, claiming that "commonalities and complementarities created by the geographical concentration of interconnected firms make a positive contribution to the competitive advantage and performance of its participants". (Porter 2003)

A strong evidence confirming the importance of geographical proximity for knowledge spillovers was brought by Anselin et al. (1997, 2000) and Acs et al. (2002) who found that in the USA the significant effects of university R&D on innovation output of private firms are limited to about 120 km. The analysis of spatial dimensions of public research' spillovers in France made by Autant-Bernard (2001) outlines that scientific papers publicized outside the geographical zone where the firms are located, tend to have a weak impact on their innovation output. According to Beise and Stahl (1999), in Germany the impact of a public research institution on firms' innovation output is also in direct correlation to the geographical proximity of the source. Thus, most enterprises that had applied for university-based knowledge are located at about 100 km from the university. The innovation survey carried in some European Union

regions (Fritsch, 2003, 2005) states that majority of business partners of universities are located near them.

Also, Maskell (2001) supports the idea of an effective learning while interacting within a geographical cluster, stating that creation of knowledge takes place as result of *labor division and variation*. At the horizontal level, the competition between similar companies stimulates new experiments, from which can benefit the rest of economic agents, provided the cluster is characterized by transparency. At the vertical level, interactions between buyers and suppliers stimulate the inter-firm learning as the result of lowering coordination costs.

The question that may arise here is why the geographical concentration still can matter in the era of globalization when knowledge diffusion seems to be so fast?

The answer is quite simple - the geographical concentration can generate other forms of proximities that are very important for knowledge creation. There are no doubts that technological progress improved the process of information spread around the world, reducing in such a way the role of physical proximity. However, there are *costs of frictions* that make some knowledge not so easy tradable among regions. In this respect, clusters provide other forms of proximity that can facilitate the process of learning.

In 1990-ies a great contribution to the scientific literature on innovation was brought by French School of Proximity Dynamics, which underlines that proximity can be described not just in terms of spatial distance between economic actors but can go far beyond it, encompassing forms of relations, interactions, and coordination established between them.

Therefore, alongside with geographical proximity, these *other forms of proximities* remain decisive while firms decide to work in cluster (Boschma, 2005):

(i) *cognitive proximity* assumes that "knowledge and innovations" are often cumulative and localized outcomes of search processes within firms with a high degree of tacit knowledge;

(ii) *organizational proximity* is associated with the closeness of actors in organizational terms (organizational practices and interdependencies, that play an important role in interactive learning);

(iii) *social proximity* is defined in terms of social relations between agents at the micro-level, that involve trust biased on friendship, expertise, regarded also as a prerequisite of interactive learning;

(iv) *institutional proximity* refers to institutional proximity at the macro-level, regarding such as "a common language, shared habits, a law system securing ownership and intellectual property rights, etc." that provide the support for economic coordination.

When activating within a cluster, the actors can benefit from the created proximities and enjoy positive externalities of discoveries, innovation strategies, findings that were created outside their own firms. Because innovative activities are localized and territorially embedded, the dimension of proximity plays an important role when deciding where to establish a firm. The existence of the above-mentioned

proximities generates positive externalities that enhance knowledge transfer via limitation of uncertainty, reduced transaction costs and common understanding of technological aspect. Additionally, because not all kind of information can be transmitted in the same way, proximity creates the perfect environment for diffusion of *tacit knowledge*. While *codified information* can be easily transferred outside boundaries, *tacit knowledge* tends to be geographically concentrated. Since not all the information is completely codifiable, some specific features mainly referring to strategic information, require face-to-face interaction. This suggests that proximity facilitates the faster diffusion of tacit knowledge, mainly due to stronger personal relationships established between various actors. According to Baptista and Swann (1998), "so long as technological knowledge has a tacit nature which cannot be codified through plans, instructions or scientific articles, it seems reasonable to expect a greater geographic concentration of innovators".

Alongside with proximities, the mechanism of knowledge spillovers in economy is influenced by additional factors such as: *(i) the absorption capacity of firms* - knowledge capabilities of firms tend to improve their capacity of assimilating external knowledge *(ii) firms 'connections with the open science communities*, which according to Cockburn and Henderson (1998) are able to increase the absorbing capacity as to the knowledge spillovers. Thus, firms establishing networks with universities, taking part in common research projects and being involved in scientific work have an increased chance to benefit from external knowledge.

The role of universities in the diffusion of knowledge spillovers

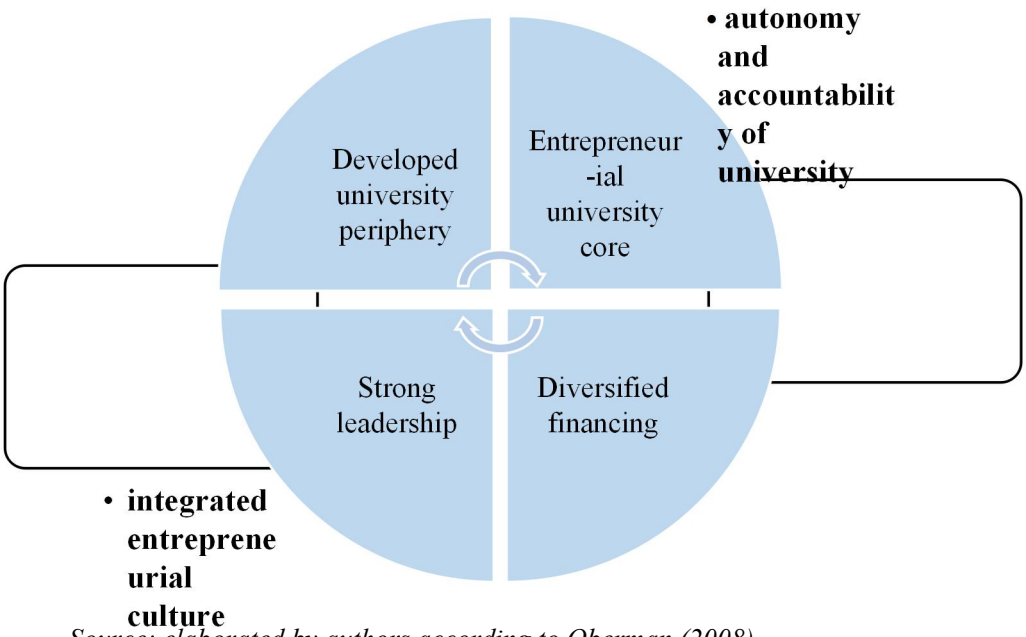
According to the endogenous growth model, alongside with capital stock and labor force, technical progress has been internally incorporated in the production function, extending its role from the residual one (as stated in the neoclassical theory) to that of an engine of the economic growth (Romer 1990, Lucas 1988). Precisely, endogenous growth theory assumes that entrepreneurs in the seeking process for the best opportunities to increase profits, agreed that best way to achieve this goal is to generate new ideas, implement innovation and attract human capital, recognizing that technological progress is both a cause and an effect of the economic growth. Per general, this means that the increase in technological knowledge relies on two main factors: (i) the labor force in the knowledge creating industry and (ii) the stock of knowledge. This implies that knowledge is the main factor influencing the output per labor ratio in the long run. Lundvall and Maskell (2000) describe information as a "key commodity and knowledge - as the critical scarce resource". Therefore, the role of universities in the economic system is seen as a central one, due to their huge potential to enhance the national and regional systems of innovation. This is to the fact that universities expended their functions over time, so along with the traditional process of teaching and research, they are more and more involved in the technological transfer, becoming better interconnected with the industry. Universities may enhance the performances of clusters by providing a new stock of knowledge. The conducted empirical studies on knowledge externalities found that it is a strong positive

correlation between knowledge source and the innovative capacities of firms located near it, rather than firm located in other parts (e.g. Jaffe et al., 1993; Audretsch and Feldman).

An important role toward emphasizing the role of universities in the process of knowledge spillovers was by introducing the term "entrepreneurial university". Etzkowitz (2008) defines it as a leading institution of putting knowledge into use and of enhancing the academic knowledge production. Clark (2001), referring to entrepreneurial universities describes them as the universities that can survive and adapt in highly complex and uncertain conditions of the environment in which they operate.

The entrepreneurial university has several basic characteristics that make it connected with the business environment.

Figure 2. Characteristics of an entrepreneurial university



Source: elaborated by authors according to Oberman (2008)

Entrepreneurial university core refers to basic university components (structure of departments, faculties) that perform the basic research and education functions.

Developed university periphery represents the channels through which is realized the transfer of knowledge to the business sector, established connection with the external environment, keeping contacts with graduates etc. This may involve: Technology Park, Centre for student career development, Centre for development of university's intellectual property, Centre for entrepreneurship.

Strong leadership characteristics refer to the abilities of the management body to ensure the continual process of university transformation and evolution, creating an environment that stimulates pro-activeness, enterprising behavior, collaboration.

Diversified financing. If universities can obtain financing from different sources like state funds, business funding, tuition fees, donation, they can act flexibly in sense of freedom to choose projects according to their own interest and priorities, rather than according to the interest imposed by the only financier, for instance, the government.
Additionally, there are two more complementary characteristics: (i) *Accountability and autonomy*, that mean that while university have the liberty in performing its own activity, they should act either for the sake of the environment, defining and implementing its projects for solving concrete problems *(ii) Integrated entrepreneurial culture* that assumes that its behavior should be focused on proactivity, innovativeness, readiness to assume risk, in order to predict possible changes in markets trends, to ensure continuous innovation through its educational programs, research topics, methods of teaching and research, but also to help and cooperate in conditions of great uncertainty.

The well-known cluster like Silicon Valley" in California and the "Cambridge Phenomenon" in England, serve good examples that prove the role of universities in their successful stories.

The Silicon Valley cluster has a strong association with Stanford University. This university occupying the best position in the international rankings, with notable achievements of students across various disciplines, since the creation had a core objective - to advance knowledge for the sake of knowledge. Although in the beginning, Stanford was seen by the government as the solution for development of the best electronics defense technology, in the context of Second World War, according to a lot of funding in this sense. Namely, this represented the fundamental pillar toward the creation and strengthening the university's capacity in electronics, going beyond the limit of the military domain. Moreover, the objectives set by the university itself from the beginning contributed to achieving the remarkable results we can see now. For example, in 1930, the Dean of the Stanford Engineering School, Frederick Terman focused on three main directions for the academic development strategy: (i) establishing close connections between science and engineering departments; (ii) connecting academic departments and local knowledge-based enterprises; and (iii) concentrating resources on key research areas with both theoretical and practical potential. In such a way, he contributed enormously in removing the barriers between firms and university, helping them to collaborate productively. Additionally, the creation of the Stanford Industrial park was the perfect recipe for bringing the academia and industry minds together in one space, for the sake of advancing new technological knowledge and it served as a bridge toward employment of best graduates by the private sector. Now Stanford is a core part of Silicon Valley seen as a pool of talents and a real source of innovation.

The famous Silicon Fen, also known as the Cambridge Cluster is the largest high-tech cluster in Europe, specialized in software, electronics and, biotechnology.

The epicenter point for its creation was played, undoubtedly, by Cambridge University. The establishment of Cambridge Science Park stimulated the formation of new companies. To emphasize the amplitude of these phenomena, the statistics data show that by1990, on average two companies per weak are created within the cluster. The University provides a favorable network for expanding the cluster, by training high skilled graduates, offering solutions to concrete business issues through consultancy activity and through the licensing of discoveries to new and existing companies.

Table 1. Role of University-Industry collaboration within a cluster

Universities	Industries
Identify research problems and topics that require practical solutions	Obtain access to valuable academic expertise and imperative for internal capabilities
Broaden practical experience of students and better adjustment of curricula program	Gain access to better prepared and equipped potential employees
Increase employment opportunities of graduates	Gain access to better prepared and equipped potential employees Create an innovation culture in institutions
Create an entrepreneurial culture in universities	
Contribute to regional economic development as a whole	Increase firm' s competitiveness through improving production process/product features

Source: authors' own elaboration

The channels for knowledge spillovers between universities and industrial sector:

- *Training of new generation of professionals*, providing them with the best skills and competences to meet the requirements of the labor market. Human capital represents the best resource for the economic system. On the one side, human capital influences directly the capabilities of enterprises to absorb and implement the new knowledge, while on the other side, it can represent a new source of innovation, by generating new creative ideas, that can be afterward implemented in the production process. In this sense, an empirical example that shows the magnitude of the highly skilled labor force on productivity was brought by Rauch (2003) who estimated that one additional year of schooling will lead to the 3 per cent increase of productivity in the region. Moreover, universities could encourage students to become new entrepreneurs, stimulating start-ups creation.
- *Knowledge transfer and training schemes*. This facilitates the flows of information between universities and industry, giving to the latest, access to key resources like R&D, human capital, innovation infrastructures in order to tackle the concrete problems the industrial sector faces. Although, the universities also can grasp benefits from such collaboration that gives insights on what is happening in the real sector, what are the real concerns of economic agents, allowing them to adjust curriculum programs, but also giving ideas about new topics of research.

- *Licensing of university patents*. Purchasing a license to exploit the findings / inventions of universities' research represent a solution to foster the business's innovation, creating in such a way the best channel for diffusion of the technologic knowledge to the marketplace. This also encourages universities to disclosure research results by granting them title to Intellectual Property.

Universities play a central role in the process of knowledge creation and diffusion to the real sector since spillovers stemming from knowledge production in forms of findings, academic papers, patents, and the development of human capital are assumed to be important inputs for private sector and high-innovative production (Malecki, 1997). The collaboration between universities and industries is a dual process, implying creation and efficient use of research outputs. On one side universities through research activities transfer knowledge and provide practical solutions to business environment. On the other side, industries transposing the newly created knowledge into realistic environment, create positive externalities to the whole economic system.

Factors affecting the knowledge spillovers between research institutions and business

The interaction between business actors and academic researchers is a complex process implying collaboration between people belonging to different professions (business and research), meaning they may have differing viewpoints on the same subject. Also, it involves collaboration between people/teams rather than just organizations. Organizations create the environment and background for collaboration. Yet the results depend much more on the characteristics, abilities of the individuals involved in the process. So, the relations established at the individual level are crucial for productive results.

Considering the above mentioned, the following factors seem to matter most:

- *Knowledge bases of firms*. This refers to how the firm's characteristics can affect the formation of different types of linkages with universities. Dosi (1998 p.1126) defines the firm's knowledge base as the set of information inputs, knowledge and capabilities that inventors draw on when looking for innovative solutions. Nelson and Winter (1982) defines knowledge as residing in skilled knowledge workers in firms and as being accrued and generated through their experimentation efforts, to both exploit and explore new ways to solve problems. The researches on this subject found a positive correlation between knowledge base and formation of university-industry linkages, because strong knowledge capabilities of firms improve the assimilation capacity of external knowledge, generated by the research institutions. Moreover, studies have shown that companies with higher in-house R&D tend to have more university collaborations (Arundel and Geuna, 2004; Fontana et al., 2003; Schartinger et al., 2002).

- *Size of the firm.* Firm's size represents a variable affecting the propensity to engage in cooperation with a university. Empirical studies (Beise and Stahl, 1999, Fritsch, 200) found a direct correlation between the size of the entity and its probability

to establish partnerships with the science sector. This is explained by the fact that larger firms can cooperate more effectively with academia because have more financial and R&D capacities that facilitate this interaction.

- *Scientific quality of university departments*. Not just the capacity of firms to absorb knowledge plays an important role in the diffusion of the innovation process, but also the universities' degree of embeddedness in the local environment and their concern to research needed by economic agents. Some studies find that universities with high-quality scientific records are more likely to establish linkages with the industry.

- *Type of industry*. The empirical studies found that the role of academic research has different impact on business, depending on the type of activity they perform. There is a very strong correlation between universities and industries that are involved in hi-tech activities, while this interdependence tends to diminish in industries that require less innovation (Marsili 1999). Accordingly, university-industry linkages are:
- Very high in computers, pharmaceuticals etc.;
- High in aerospace, petroleum, motor vehicles, chemicals, telecommunications and electronics, food, electrical equipment etc.;
- Medium: Instruments, basic metals, non-electrical machinery, building materials etc.;
- Low: metal products, textiles, rubber and plastic products, paper etc.

The role of government in the stimulation of knowledge creation and diffusion

The nature of innovation is complex, and the simple presence of universities is not enough to achieve a knowledge base society. The government implication is needed to encourage the strength of relations between science and industry, but also to create favorable infrastructure: such as technology transfer offices, science parks, and business incubators, that can conduct the knowledge diffusion between the actors.

The importance attributed by the government to research and development plays a crucial role toward development of the university-industry linkages. The government, through efficient policies, can contribute to fostering the relations between business and research institutions activating within a cluster, by creating an efficient system that defines and regulates the innovation process.

The public spending aiming to fund academic researches focused on specific, strategic for real sector topics, are considered very important for adjusting research agenda to market demands. Moreover, in order to stimulate the collaboration of academia with businesses, additional criteria should be introduced in measuring university performance. Alongside with traditional criteria like the number of students, PhD graduates, the number of publications, other criteria such as the number of consulting contracts with industry, the number of start-ups created by university' s graduates, etc., should be considered.

The incentives offered to industry for in-house R&D could also play an important role. For example, in some developed countries (Netherlands, Ireland, and the UK) governments successfully tested and implemented a new instrument aiming to promote collaboration in R&D - *the innovation voucher.* This represents a credit line

offered by the government to firms for purchasing services from universities with the aim to introduce innovations in business operations of enterprises.

International experience (see Table 2) shows that *government funding for collaborative projects* between science and industry enhances networking between the two sectors, serving as a catalyst for the formation of long-term and in-depth relationships.

Table 2. Types of partnership funded by the government in university-industry linkages

Type of partnership	Description	Examples
Collaborative research projects	Government offer specific grants for research projects undertaken jointly by industry and universities aiming to find solutions to real-life challenges.	Australia: *Collaborative Research Grants Scheme*
Research consortia	Government-sponsored large-scale research programs involving several parties.	European Union: *Framework Programs*
Co-operative research centers	Government-supported facilities for collaboration between science and industry research.	Sweden: *NUTEK Competence Centre Program*

Source: elaborated by authors

In order to improve collaboration within the triple helix model, it is important to increase the *permeability of universities to the environment*. Even if there are universities with a high number of publications and patent ratings, their resources may not be exploited at the full potential, because of their inappropriateness to be applied in practice. Therefore, for the knowledge-based economic development, ensuring the permeability of the science sector should be a key priority for the government initiatives. European Union can be a good example in this respect. Through *Knowledge Alliance Initiative*, it was intended to strengthen Europe's innovation capacity by creating *a knowledge alliance* between higher educational institutions and businesses. The alliances tend to create the best conditions for the development of new multidisciplinary curricula for the teaching process, to promote entrepreneurship and to facilitate the exchange of knowledge.

Additionally, the role of government must be extended to providing strong regulation on Intellectual Property Rights. While research institutions and firms are concerned to find solutions to real problems, the governmental agencies have a role to play in providing legislation on academic patenting and licensing in order to create incentives to innovate but also to grant security over the created knowledge.

3. Critics

Even if proximity is recognized to be an important factor toward innovation, motivating firms to cluster together for achieving benefits from knowledge spillovers,

some challenges could be mentioned in this regard. Too much proximity, either cognitive, social, or institutional, may be harmful to interactive learning, increasing the risk of *lock-in*. The too loyal and friendly relations established between economic actors may *lock* members, denying the acceptance to the entry of new firms that can introduce better ideas and information (Uzzi, 1997). Also, too much proximity may be a barrier when it comes to a radical innovation that requires completely new knowledge, skills, organizational structure and new institutions (Boshma, 2004)

Although many studies have proved the important role played by universities in the process of knowledge spillovers, some authors (Blumenthal et al. (1997), Louis et al. (2001), Nelson (2004) still criticize the close collaboration between universities and industries, alleging that the strong focus of universities on the enquiries coming from real sector undermines the freedom of research, implying negative long-run effects on the university creativity process. In this context, the university-industry relations are regarded as time-consuming, and too costly when universities focus on short-term consultancy research rather than on long-run fundamental investigations. In such cases, universities can lose their sight of critical thinking and become too business-oriented (Saad, 2004)

4. Conclusion

The notion of development emphasizes the improvement in capabilities of economic agents to produce, absorb and implement in production the new knowledge. This complex process can be accomplished through learning and creativity. Nowadays, due to the technological progress, innovations have become more globalized, easier to access worldwide, and this is particularly true of the formal codified knowledge. Simultaneously, innovations become more *territorially-embodied*, when referring to the tacit knowledge, that implies some untraded aspects, that are crucial for developing competitive advantages. In this regard, the logic of spatial economic agglomeration explains why firms decide to activate within a cluster, in such a way being included in the value chain of an ecosystem of tacit knowledge diffusion and knowledge spillovers. Additionally, alongside with geographical proximity, the actors in a cluster can benefit from other forms of proximities such as cognitive, social, institutional, organizational that are essential for learning and interactive collaboration.

Therefore, driven by the desire to take advantage from positive externalities of knowledge spillovers and to grasp benefits of proximities, economic agents see cluster as a sustainable option for their development. A cluster construction offers the optimal environment for knowledge diffusion, in terms of mutual trust, strong translation focus, better understanding and alignment to each members' needs and objectives. A concentrated location generates synergies between universities and production units, particularly in terms of tacit knowledge exchange through face-to-face encounters.

Also, the government can exercise a strategic role in enhancing local learning and technology transfer. Government policies providing incentives to strengthen university-industry collaboration in R&D activities, offering adequate infrastructure to allow efficient communication and a favorable economic environment are a key factor

toward stimulation of knowledge-based clusters. The above-mentioned successful example of the Stanford scientific park, confirms that government R&D policies, can become an efficient mechanism for bringing closer science sector and business environment, through connecting entrepreneurial universities with economic agents.

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