Public and private entities and their role in knowledge diffusion

Tulio Chiarini[1]

***Abstract**: This review article has the objective to analyze, in a very theoretical way, the effectiveness of private organizations and public institutions and the ways in which they interact in the production, and distribution of economically relevant knowledge, that is flows of knowledge which here are understood as creation, use and transfer of knowledge.*

***Keywords:** National Innovation System; Knowledge-based economy; knowledge flow.*

Entidades públicas e privadas e seus papéis na difusão de conhecimento

Resumo: Esta revisão tem o objetivo de analisar, de uma maneira teórica, a eficácia das organizações privadas e instituições públicas e as maneiras pelas quais elas se interagem na produção e distribuição de conhecimento economicamente relevante, isto é, fluxos de conhecimento que aqui são compreendidos como criação, utilização e transferência de conhecimento.

Palavras-chave: Sistema Nacional de Inovação; economia baseada em conhecimento; fluxo de conhecimento.

JEL: O290, O330, O390

> "Knowledge is abundant but the ability to use it is scarce" Bengt-Åke & Johnson (1994:25).

[1] MPhil in Economia do Desenvolvimento at PPGE/UFRGS, Brazil, and MPhil in Management, innovazione e ingegneria dei servizi at Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento (MAINS/SSSP), Pisa, Italy. E-mail: tuliochiarini@yahoo.com.br. I would like to thank Laura Pereira for her suggestions in reviewing the manuscript.

Introduction

Investments in knowledge such as in research and development, education and training are considered key to capital accumulation, economic growth, technological know-how and economic development and the European Commission has already acknowledged this. In knowledge-based economies, the creation, diffusion and use of knowledge is extraordinarily important in understanding the innovation process and its outcomes. Notwithstanding this, the system of distribution and access to knowledge play a crucial role in terms of efficiency and it is an indispensable prerequisite for increasing the amount of innovative opportunities which in turn may lead to improvements of competitive performance. So the links among people, enterprises and institutions should be strengthened to generate benefits to all the society. That is the reason why, for instance, the European Union supports a wide range of research and development which is carried out in support of knowledge, to make Europe the most dynamic competitive knowledge-based economy in the world.

The knowledge triangle (research, education and innovation) is understood as the key element for the players (government, universities, research institutes, financial institutions, industries, regulatory bodies, etc); they are 'connected' to each other and the main focus is on flows of knowledge, that is, its creation, its utilization and finally its diffusion.

The key elements of the link mentioned above are knowledge, financial capital and human resource, thus the abovementioned players are 'connected' to each other through these elements and the main focus should be on flows of knowledge; its creation, its utilization and finally its diffusion. A difficulty emerges when we take into consideration some elements of knowledge as public/private and tacit/codified aspects. The more private and tacit knowledge is, the harder it is to have a successful flow from one party to another. That's why there should be incentives for a tight relation among parties in order to generate benefits for both and for the society as a whole as there are positive externalities with this linkage.

Besides being helpful to those interested in studying the dynamics of innovation, this review paper's objective is to discuss, in a theoretical way, the effectiveness of private organizations and public institutions and the ways in which they interact in the production, and distribution of economically relevant knowledge, i.e. flows of knowledge which here are understood as the creation, use and transfer of knowledge. Much of this discussion was inspired by projects financed by the European Commission such as the BELIEF Project[2]. The discussion presented in this review paper brings up

[2] BELIEF, Bringing Europe's eLectronic Infrastructures to Expanding Frontiers, aims at leveraging on all European e-Infrastructure-based initiatives, to develop a denser network through which to achieve further international outreach and industry engagement.

the concept of the National Innovation System as it would be impossible to discuss knowledge, the interaction among parties and the benefits it generates without appropriating of concepts established by this approach.

Section 1 presents the concept of the National Innovation System Approach (subsequently abbreviated as NIS), which highlights that knowledge diffusion matters. In a NIS both the interactions between different parties and the coordination among them are predicted to be translated into innovation performance and development. Section 2 is in turn divided in various items. In 2.1 I discuss knowledge, presenting a conceptual framework to analyze it through basic concepts in order to understand a knowledge-based economy, which is the second central point. In order to do so, it is mandatory to differentiate public versus private knowledge and codified versus tacit knowledge. It demonstrates that knowledge is a multifaceted concept and can be divided into four different kinds, following the suggestion of Foray and Lundvall (1998): 'know-what'; 'know-why'; 'know-how' and 'know-who'. Each one of them differs in their level of 'publicness' and 'tacitness' as it will be argued in the subsequent sections. Item 2.4 addresses a discussion on knowledge production and finally section 2.5 defends the idea that the most important notion of National Innovation Systems is the

1. National Innovation System

There is no single accepted definition in the literature of a National Innovation System but there is an agreement that the interactions between different agents and institutions are of great value in understanding innovation performance and also the coordination among those institutions. Thus "the National Innovation Systems approach stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process" (OECD, 1997:07). Christopher Freeman was the pioneer when it came to introducing the concept of national innovation system (Lundvall 2008) and his idea was that national innovation system, according to Lundvall (1992:02) is:

> the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (...) (Freeman, 1987, *apud* OECD, 1997:10) and (...) it is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge.

According to Freeman (1995), a NIS should have a qualitative character, limiting itself to the institutional design that can contribute to the capacity of innovation and imitation, that is, a synergy among parties is essential to fostering development. However, there is not an ideal model which can explain the institutional arrangement for all the regions, all the time, as the generation

of knowledge is locally and temporally bounded. There is no magic recipe that can be universally distributed elsewhere as a normative guide to development, as path dependence influences the process of generating knowledge and innovation. What is well known is the fact that knowledge creation can generate continuous innovation which in turn generates competitive advantages in 'knowledge-based economies' (Nonaka; Takeuchi, 1995).

In NIS the key elements of interactions are knowledge, financial capital and human resources, thus all the actors are linked to each other through these elements mentioned creating a network, as it is depicted in Figure 1. The main focus is on flows of knowledge; its creation, its utilization and finally its diffusion. Notwithstanding this, the flows of financial capital and human resource are also significant and should not be neglected, but they will not be discussed here as it is not within the scope of this study.

> The study of national innovation systems focuses on flows of knowledge. Analysis is increasingly directed to improving performance in knowledge based economies – economies which are directly based on the production, distribution and use of knowledge and information (OECD, 1997:11).

> (...) NIS operation depends on stimulating the creativity of the agents through, simultaneously, improving the depth and quality of the connections. The different elements that constitute the system make complementary contributions to the innovation process by informal and formal relationships that facilitate knowledge flows (Martinez; Piccaluga, 2000:04-05).

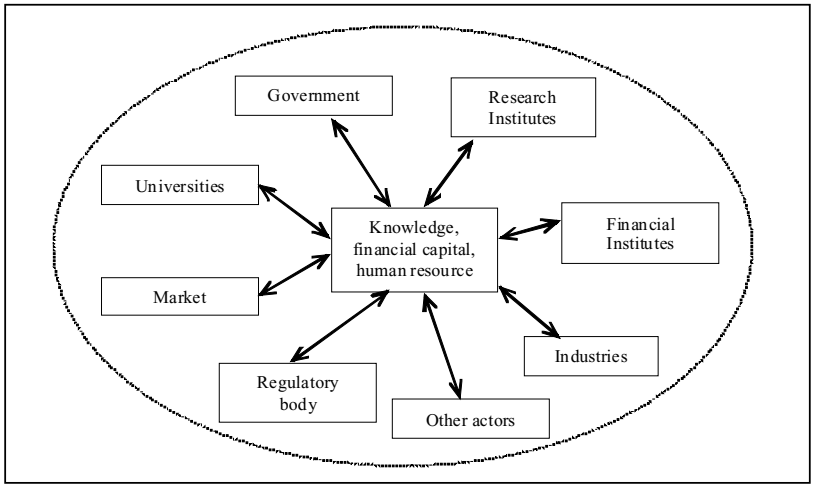
The importance of this approach is that it emphasizes that in 'knowledge-based economies' investment in knowledge is vital. So if links among people, enterprises and institutions are strengthened, the transfer of technology and knowledge can be enhanced and even accelerated, leading to improvements of innovative and competitive performance (Mowery; Sampat, 2008).

> Economic activities are becoming more and more knowledge-intensive as seen in the growth in high-technology industries and the increasing demand for highly skilled people. Investments in knowledge, such as in research and development, education and training, and innovative work approaches are considered key to economic growth (OECD, 1997:11).

The complex set of relationships among the actors shown in Figure 1, producing, distributing and applying various kinds of relations, has resulted in innovation and technical progresses. That is why the innovative performance depends largely on how tight the relations among actors are as well as the technologies they use (OECD, 1997). "Innovation is thus the result of a complex interaction between various actors and institutions" (OECD, 1997:12) and cooperation and trust are key factors in understanding the existence of

consistent and solid network across time between economic actors (Cimoli; Constantino, 2000).

FIGURE 1 – NATIONAL INNOVATION SYSTEM REPRESENTATION



Source: adapted from Yim (2006:04).

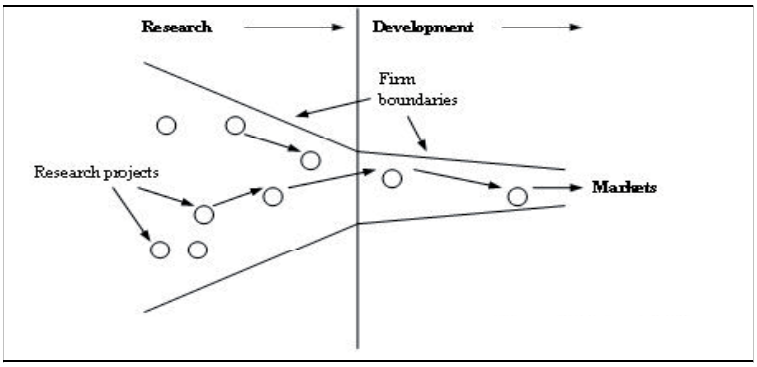
Note: Instead of using 'Financial Capital' and 'Human Resources', Yim (2006) refers to 'Money' and 'People'. Here, Financial Capital and Human Resources seem more appropriate terms.

Networks, however, as suggest Boekema *et al.* (2000) do not automatically meliorate learning, thus bringing forth innovation and competitive advantage. A high degree of trust and commitment among actors is essential.

The importance of the relation among actors has been highlighted by Chesbrough (2003) who shows the necessity of using both internal and external ideas to advance in technology. According to his findings, this 'open innovation idea' implies that agents have been relying increasingly more and more on external sources of innovation in order to leverage their internal research and development. That is, there is an increase in knowledge sharing. Thus innovation requires the mobilization of both internal and external resources, and external ones are mobilized through network relations (Boekema *et al.*, 2000).

So, that 'old idea' that agents relied on the assumption that innovation processes needed to be controlled by them is no longer valid. That approach affirmed that internal Research and Development (R&D) was a key strategic asset for innovation success. The agents and institutions worked separately and were not willing to contribute to knowledge spill-over and the research was focused on projects that had no interaction with other's projects, as it is shown in Figure 2 presented below.

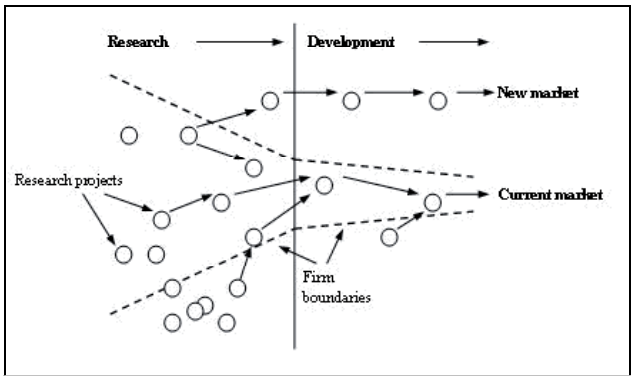
FIGURE 2 - REPRESENTATION OF THE CLOSED-INNOVATION APPROACH



Source: Chesbrough (2003).

The open innovation idea questions whether R&D is a core competency that agents need to possess (Fredberg *et al.*, 2008). It gives emphasis to the fact that ideas cannot be kept in secret and do not belong to one party, rather knowledge should float freely from one party to another, which is the same concept proposed by the NIS. The knowledge produced in a party may be put together with that created by others and generate new technologies. Figure 3 exemplifies this approach.

FIGURE 3 - REPRESENTATION OF THE OPEN-INNOVATION APPROACH



Source: Chesbrough (2003).

Even though Chesbrough has been claimed to be a visionary by many managers, Dahlander and Gann (2007) show that the idea of exploiting the external environment is not new. The first elements of this approach were found in Marshall's 1919 book, the same inspirational source for the NIS researchers.

So, the idea that the parties were very 'closed' is a myth, that is, the idea that a sequential and linear process of innovation was created in a closed lab and that there was no interaction with external actors has to be analyzed with caution because R&D labs were not "castles on the hill" (Dahlnder; Gann, 2007:09).

At this very point we can come to the conclusion that the creation, diffusion and use of knowledge is extremely important in understanding the innovation process and its results. The way knowledge is distributed and used is a central characteristic of a NIS. Therefore "an efficient system of distribution and access to knowledge is a *sine qua non* condition for increasing the amount of innovative opportunities. Knowledge distribution is the crucial issue" (David; Foray, 1995:40 *apud* Godin, 2007:08). That is the reason why the following sections will focus on knowledge in order to understand the importance of the institutions.

2. Discussing knowledge

This section presents a conceptual framework to analyze knowledge through basic principles related to it in order to understand a knowledge-based economy whose economic improvement is related to both efficacy and efficiency of using, producing and transferring knowledge. The term knowledge-based economy is coined to demonstrate that knowledge is central to economic development (OECD, 1996; OECD, 1997; Foray; Lundvall, 1998; Cimoli; Constantino, 2000; Boekema; *et al.*, 2000; Foray, 2004; Lundvall, 2008a; Lundvall, 2008b). Many authors do believe that "today, the world economy is more strongly dependent on the production, distribution and use of knowledge than ever before" (Cimoli; Constantino, 2000:58) and many competitive advantages have emerged because knowledge and technologies on which they were based are now available on a global scale (Boekema *et al.*, 2000).

> [knowledge] is an explicit variable in an increasing number of theoretical and empirical contributions dealing with fundamental issues such as: economic growth and accumulation of human capital; education, social segmentation and income distribution; location and clustering of economic activities; R&D contracts and networks; technological choices within firms; North-South transfers of technology; fertility and population (Navaretti *et al.*, 1998:01).

It must be emphasized here that "knowledge is a multifaceted concept with multilayered meanings" (Nonaka, 1994:15) and that the objective of this section is not to present a philosophical discussion on the meaning of knowledge[3] but to introduce important attributes/elements of knowledge

[3] For an analysis of the philosophical discussion on knowledge consult MACHLUP, Fritz (1982). **Knowledge:** its creation, distribution and economic significance. Princeton: Princeton University Press.

such as public/private and codified/tacit ones which are mandatory in order to understand knowledge flows and how parties can interact to enhance this flow and generate economic development. This section also aims to show that there are differences among various sectors regarding those attributes.

2.1 Economics of knowledge

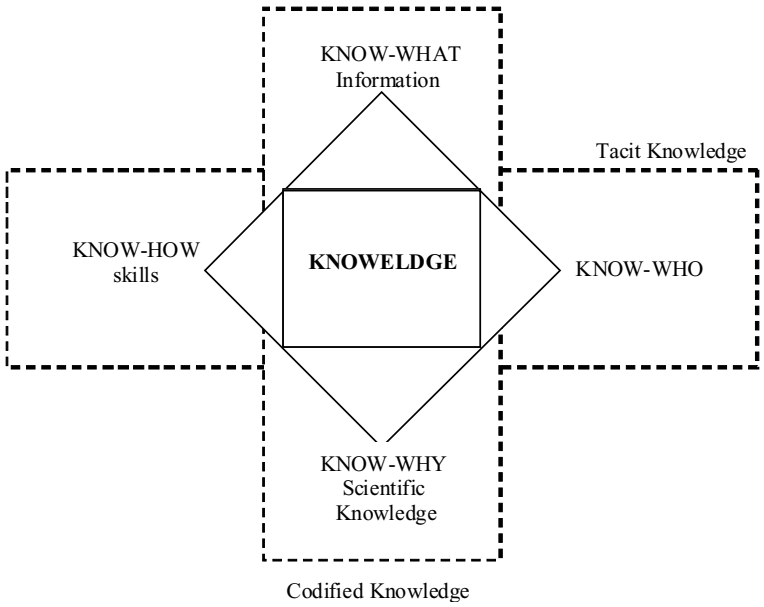
Knowledge can be understood as an economic good with properties that are different from those conventional tangible ones which are: a) non excludability, that is, it is difficult to control it privately but that does not mean it cannot be kept secret, b) non rivalry, that is, knowledge can be 'enjoyed' simultaneously, c) inexhaustibility, in other words, the use of existing knowledge by an additional agent does not limit others to have an additional 'copy of that knowledge', d) cumulativeness, that is, knowledge "is an intellectual input likely to spawn new ideas and new goods" (Foray, 2004:94); e) fragmentability, that is, knowledge is divided and dispersed over sites, territories, and the like, and f) weak persistency, that is, the stock of knowledge available at one period still remains for other periods (FORAY, 2004). It is then called a hybrid good, namely semi-public, because knowledge presents characteristics of both private and public goods as it could be demonstrated.

> If knowledge were completely public it would be meaningful to speak of one common knowledge base for the whole economy and there would be a strong need for coordinating investments in knowledge production at the global level. If, conversely, knowledge were completely individual and private there would be no common knowledge base at all and investment in knowledge production could be left to the individuals themselves. As we shall see, reality is complex and most knowledge is neither completely public nor completely private (Lundvall, 2008b:03).

Four different kinds of knowledge can be identified (Lundvall; Foray; 1998; Lundvall, 2008a; Lundvall, 2008b), as it is depicted in Figure 4: 'know-what'; 'know-why'; 'know-how' and 'know-who'. According to Lundvall (2008b) 'know-what' refers to knowledge about facts, that is, knowledge is close to what is usually called information; 'know-why' refers to "scientific knowledge of principles and laws of motion in nature, in the human mind, and in society (...) [and] it has been extremely important for technological development in certain science-based areas, as chemical and electric-electronic industries" (Lundvall; Foray, 1998:116). 'Know-how' refers to the ability to do something, namely skills. And finally 'know-who' "involves information about who knows what, and who knows how to do what" (Lundvall; Foray, 1998:116). Here it can be seen that knowledge is a much broader concept than a synonym of information, which generally reflects only two components of knowledge: know-what and know-why. These two types of knowledge come closest to being market commodities. Know-how and know-who are more difficult to

codify and measure (OECD, 1996).

FIGURE 4 - TYPES OF KNOWLEDGE



Source: adapted from Lundvall and Foray (1998)
Note: Know-what, know-why, know-how and know-who, all four interact with each other to form a new knowledge.

The four kinds of knowledge differ in their level of public and private goods characteristics. For example, some parts of the know-why type is placed in the public domain, as academics have incentives to make their results accessible, so they publish all their findings and share them with everyone else. While know-why is the kind of knowledge in which public access is relatively open, it is more difficult to have public access to know-how (Lundvall; Foray, 1998; Lundvall, 2008b).

The learning process of each one of the kinds of knowledge mentioned takes place through different channels. Know-what and know-why can be obtained through reading books, attending lectures and accessing databases whilst the other two categories are rooted primarily in practical experience. Know-how is typically learned in apprenticeship-relationships, that is, the apprentice follows his master and finally know-who is learned through social practice and through specialized education environments. Finally know-who is learned in social practice and even in specialized educational environments, it

is socially embedded knowledge and it cannot be easily transferred through formal channels of information. (Lundvall; Foray, 1998)

2.2 Tacit knowledge versus codified knowledge

Codification of knowledge implies the transformation of knowledge into information which can be easily transmitted through informational infrastructures, i.e. it can be transferred over long distances and across organizational boundaries at a relatively low cost. However, as Lundvall and Foray (1998) suggest, codified knowledge (also known as explicit, discrete or 'digital' knowledge) is not easily exchanged in the market because there are market imperfections (Lundvall; Foray, 1998). "Explicit knowledge can be expressed in words and numbers, and easily communicated and shared in the form of hard data, scientific formulae, codified procedures, or universal principles." (Nonaka; Takeuchi, 1995:08). It is the increasing codification of some elements of knowledge which have lead to the term information society, that is "a society where a majority of workers will soon be producing, handling and distributing information or codified knowledge" (OECD, 1996:13).

Thanks to codification, knowledge has been commoditized. Market transactions are facilitated by codification, and diffusion of knowledge in then accelerated. Codification may also create bridges between fields and areas of competence and reduce the knowledge dispersion (OECD, 1996; Cimoli; Constantino, 2000) but codification of knowledge does not mean that the receiver of knowledge can use it immediately and without costs (Boekema, *et al.*, 2000).

Nonetheless, "knowledge that can be expressed in words and numbers only represent the tip of the iceberg of the entire body of possible knowledge" (Nonaka, 1994:16). There is also tacit (or embedded) knowledge that on the contrary, refers to knowledge that cannot be easily transferred. It happens because it has not been stated in an explicit form, that is to say, it has not been documented, so it cannot be easily disseminated to, or copied by, others and "the only way to transfer this knowledge is through a specific kind of social interaction similar to apprenticeship relationships" (Lundvall; Foray, 1998:118). Examples of tacit knowledge are skills, competences, shared beliefs, organizational routines and practices. "In short, tacit knowledge embedded in an organizational context is the key to competitiveness in the knowledge-based economy" (Boekema *et al.*, 2000:07).

> Tacit knowledge (...) requires a lot of intensive face-to-face communication to transfer not only the content, but also the context, of the knowledge. In order to be able to absorb and to use tacit knowledge, the receiver will have to (learn to) understand the context in which the knowledge is embedded. Intensive face-to-face gains from proximity. Thus, in the case of tacit knowledge, proximity – although not essential – greatly assists the process of knowledge transfer.

(Boekema *et al.*, 2000:10).

According to Lundvall (2008b) tacit knowledge can be distinguished between two types: tacit knowledge that can be made explicit (i.e. its tacit due to lack of incentives) and tacit that cannot be made explicit, that is tacit by nature. Taking this difference into consideration know-what and know-why can be made explicit while only approximations are possible for know-how.

Tacit knowledge is more valuable than the codified knowledge as it is harder to acquire in the market and because of this it does not 'leak' easily to others due to its low permeability (Connell *et al.*, 2003).

> This is why outstanding experts whose activities are based on their unique know-how and firms whose activities are based on unique competencies and permanent innovation may earn extra rents for long periods (Lundvall, 2008b:07).

The benefits derived from both codified and tacit knowledge can be ascertained through learning. It's fundamental role is the transformation of tacit knowledge into codified knowledge, which corresponds to a change in magnitude in the stock of knowledge of individuals and organizations (Cimoli; Constantino, 2000). In brief, it is possible to conclude that whilst knowledge is the most important resource in a knowledge-based economy, learning is the most important process (Boekema *et al.*, 2000).

In the following section the interaction between tacit and codified knowledge is presented in order to produce new knowledge.

2.3 Knowledge creation

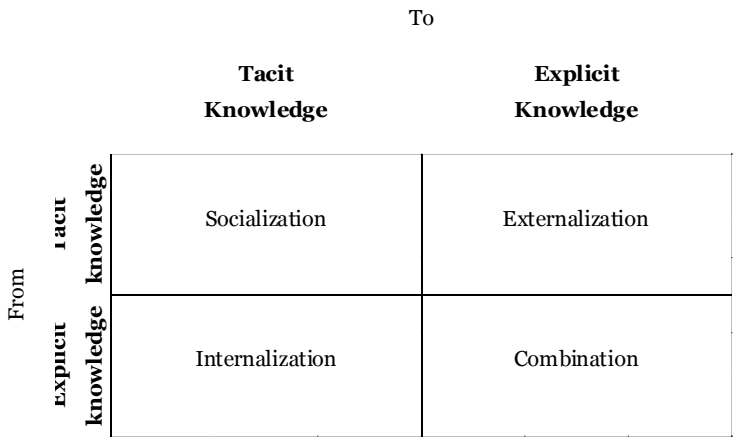
Nonaka (1994) suggests that knowledge is created through conversion between tacit and explicit knowledge and vice-versa, that is to say, "codified and tacit knowledge are constantly in interaction with each other, thus creating a dynamic spiral of knowledge conversion leading to innovation" (Boekema *et al.*, 2000:07). He identifies four different modes of knowledge conversion: from tacit knowledge to tacit knowledge; from explicit knowledge to explicit knowledge; from tacit knowledge to explicit knowledge; and from explicit knowledge to tacit knowledge. The first mode regards the interaction between individuals through shared experience, what can be called socialization. The second mode "involves the use of social processes to combine different bodies of explicit knowledge held by individuals" (Nonaka, 1994:19) and it can be called combination.

The last modes of conversion involve tacit and explicit knowledge, capturing the idea that tacit and explicit knowledge are complementary and can interact mutually. This interaction involves two different operations: the conversion of tacit to explicit knowledge, what is called externalization; and the oppo-

site conversion, of explicit to tacit knowledge what is called internalization (Nonaka, 1994). Figure 5 presents all the interactions mentioned and their outcomes.

According to Nonaka (1994) despite the fact that all the four modes separately create knowledge, the central theme is the knowledge creation based on a dynamic interaction between the different modes of knowledge conversion that can form a continual cycle. This cycle can start with the socialization mode thanks to building in a team of interaction. This team makes it possible for its members to share experiences and perspectives. Then once there are successive rounds of valuable dialogue the externalization mode is triggered. In this dialogue, the team members articulate their own perspectives and may even reveal tacit knowledge that would be hard to communicate. The concepts formed by teams can then be combined with external knowledge. This focus is within an institution (such as a firm) and according to Boekema *et al.*(2000) this approach may also be applied at the inter-institutional level, which means that the network must facilitate the interactive creation of knowledge between members of different organizations. "(...) the combination of knowledge from several organizations will lead to the creation of previously unthought-of new knowledge" (Boekema *et al.*, 2000:08).

FIGURE 5 - MODES OF THE KNOWLEDGE CREATION



Source: Nonaka, 1994:19.

Foray (2004) has a different analysis and according to him knowledge is produced in different ways that can be defined in terms of a dual dichotomy. On one side there are two main ways in which new knowledge comes into being: first through formal research and development (off-line process of knowledge creation) and second, through learn-by-doing (on-line process

of knowledge creation). On the other side, there is another dichotomy: the generation of knowledge may involve search processes within unexplored or underexploited domains where there is a need to produce integrative knowledge (i.e., norms, standards, etc.) (Foray, 2004). Table 1 simplifies this notion.

TABLE 1 - FOUR FORMS OF KNOWLEDGE PRODUCTION

	Off-line process of Knowledge creation	On-line process of Knowledge creation
Search model	R&D	Learning-by-doing
Coordination model	Formal integration	Informal integration

Source: Foray, 2004:50

The reproduction of knowledge concerns the composition and delivery and use of a script, as mentioned by Foray (2004). The first form identified is defining gestures and speech. The second is the codification of what was previously identified and at this time the script is detached from the person in possession of the knowledge. A problem emerges when tacit knowledge is in question because

> Tacit knowledge cannot be expressed outside the action of the person who has it. In general, we are not even aware of the fact that we have such knowledge, or else we simply disregard it. (...) for this very reason, tacit knowledge is a good that is difficult to make explicit for transfer and reproduction (Foray, 2004:71-72).

Therefore one important issue is how much effort should be made to codify knowledge as "codified knowledge is potentially shared while non-codified knowledge remains individual, at least, until it can be learnt in direct interaction with the possessor" (Lundvall, 2008:07). Another important issue is that once knowledge is created and codified, how it can be transferred.

3. Knowledge, National Innovation System and linkages

Den Hertog *et al.* (1995) suggest that the most important notion of a NIS is the idea that the creation and diffusion of knowledge occur primarily via interactions between different types of agents and institutions. According to the OECD (1997) findings, knowledge flows in NIS can happen in four different channels. These are: interactions among enterprises; interactions among universities, enterprises and public research laboratories; diffusion of knowledge and technology to firms; and movement of personnel.

The joint industry activities (interactions among enterprises) happen from technical collaboration among enterprises and informal linkages and contacts among firms. "Firms collaborate to pool technical resources, achieve economies of scale and gain synergies from complementary human and technical assets." (OECD, 1997:07). The collaborative enterprise activities in national innovation systems, can thus contribute to firm innovative performance generating competitive advantages.

Public/private interactions (interactions among universities, enterprises and public research laboratories) take into consideration the links among public research institutes and universities on one side, and on the other private enterprises and the way knowledge can flow from one to another. Basically in public research institutes and universities generic research is undertaken and knowledge produced for industrial use and new methods, instrumentations and other skills are developed (OECD, 1997).

Knowledge dissemination is "the most traditional type of knowledge flow in innovation systems" (OECD, 1997:15) and happens through the diffusion of new equipments and machinery. However this is a slow-moving process. Finally, the movement of personnel is the last way through which knowledge flows in national innovation systems according to the OECD. The knowledge that personal carry with them (tacit knowledge) when they move from one firm to another is a "key to implementing and adapting new technology" (OECD, 1997:18).

The distribution of knowledge is not a simple process. The static idea that "one does research, research then leads to development, development to production, (...) production to marketing" (Kline; Rosenberg, 1986:285, *apud* Den Hertog *et al.*, 1995:06) and once in the market it generates economic and social gains is incomplete. It is also known as the 'traditional linear innovation model' where it is believed that innovation has a logical and chronological sequence and that the diffusion is part of this linear sequence of happenings and there are no feedback loops in the process.

> In the linear mode of innovation process (...) pre-market activities related to technical change can be precisely separated from market activities: innovation process begins with an invention phase in which research and development activities take place. (...) the basic research and development efforts then give rise to the next stage of the innovation process, the commercialization phase. It entails the introduction of a new product or process to the market. After the commercialization of innovations has set in, the new technology (incorporated in the innovation) diffuses through the economy. In this process of diffusion, which constitutes the final stage of a linear innovation process, consumers demand the newly introduced goods and competitors start to imitate the innovation (Bazat, 2006:12).

This notion was outmatched by what is called a 'complex process', namely the 'integrated model of innovation' or 'dynamic innovation process', a process

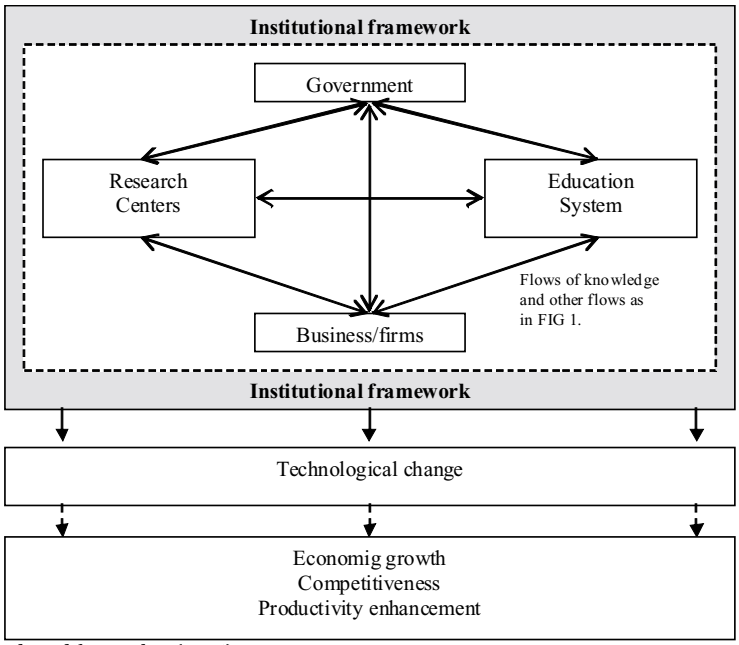
of continuous 'creative destruction', in neo-Schumpeterian terminology (Den Hertog *et al.*, 1995) which takes into consideration the interactive nature of learning. "This approach is grounded on the presumption that innovation processes cannot be decomposed into several, isolated phases that take place in a strictly proceeding sequence" (Bazat, 2006:12). Freeman pioneered this vision and reassured that innovation should be understood as an interactive process (Lundvall, 2008).

> In this view [the traditional linear model], innovation begins with new scientific research, progresses sequentially through stages of product development, production and marketing, and terminates with the successful sale of new products, processes and services. It is now recognised that ideas for innovation can stem from many sources, including new manufacturing capabilities and recognition of market needs. Innovation can assume many forms, including incremental improvements to existing products, applications of technology to new markets and uses of new technology to serve an existing market. And the process is not completely linear. Innovation requires considerable communication among different actors – firms, laboratories, academic institutions and consumers – as well as feedback between science, engineering, product development, manufacturing and marketing (OECD, 1996:14).

Innovation is a result of numerous interactions among actors and institutions[4] rather than isolated search and development efforts, as Figure 6 shows. Those interactions consist of knowledge flows and relationships that happen through learning and searching activities which can benefit the correlated agents in a great deal of ways like gaining access to new research results, acquiring key technological components of a new product or process, sharing assets in manufacturing, marketing and distribution and developing science and technology. Hence, a NIS consists of organizations and institutions that influence each other in developing, absorbing and diffusing knowledge in order to generate innovation, through learning. The interdependencies of its elements are central features of NIS, as thanks to the relationships between different actors, generation and dissemination of knowledge occur. There are different types of linkages between the actors in a NIS as well as between the actors and the nation-specific institutional framework with which actors in a NIS are endowed, as Balzat (2006) suggests.

[4] Here it is necessary to state that based on North (1990) there is a difference between the terms 'institutions' and 'organization'. The first can be defined as a system of social rules that structure social interaction, as North (1990:3) suggests, they are "the rules of the game in a society", whilst organizations are the players, the actors. Many authors use the term in an interchangeable way, but "instead of being synonymous expressions, organizations are a particular subgroup and thus specific types of institutions" (Balzat, 2006:19).

FIGURE 6 - SIMPLIFIED ILLUSTRATION OF A NIS AND ITS ECONOMIC IMPACT.



Source: adapted from Balzat (2006).

Firstly linkages differ regarding their formal content, that is to say, it is necessary to distinguish formal and informal linkages. Formal agreements of co-operation exist and are often prepared and applied especially when collaboration partners lack geographical and/or cultural proximity. In contrast, informal linkages emerge spontaneously and depend on the shared values of the partners involved; their impact can be at best approximated. Examples of informal links are: the impact of national institutional conditions on innovative activities; trade fairs and the knowledge transfer through personal interaction; personal mobility; scientific conferences and the exchange of ideas and knowledge among participants in such conferences; scientific publications and the diffusion of research etc. (Balzat, 2006).

Linkages may also be differed between horizontal and vertical linkages. The former refers to the links among actors that belong to the same organizational category who co-operate in their research and development efforts whilst the latter refers to the links among actors that belong to different types of organization who innovate collaboratively, such as 'science-industry links' (Balzat, 2006).

Finally, according to Balzat (2006), there is another pair of linkages: direct and indirect ones. Direct linkages in a NIS involve the collaborating partners

only and they include direct interaction among the actors involved, and they are purposely created. On the other hand, indirect linkages can emerge automatically and unintentionally, that is, if the technological knowledge of a party spills over (positive externality) to a third party, an indirect linkage to this third party has been established.

Final Comments

We have discussed in this review paper that it is not simply the creation of new knowledge which counts for the innovation process, but in a knowledge-based economy the flow of such knowledge is of great value. The problem emerges when we recognize that there are market failures and the flow of knowledge is by no means a straightforward process, due to uncertainty, information asymmetry and lack of ways to process (and distribute) knowledge being available for all the parties involved. Other problems related to the market failure is that by being a semi-public good, knowledge has no easily enforceable property rights, so its diffusion may be good for social well being, but may be bad for private returns. This means that no one has incentives to invest in the creation of new knowledge if the rents generated are not, at least partly, appropriable. Thus, one possible way to overcome the market's deficiency consists in the government engaging itself directly in the production of knowledge, allowing free use of it, promoting and fostering development from the creation of functional devices that serve as a basis for knowledge creation, use and diffusion and, enhancing the framework condition for university-industry-government collaborations. A second possible way is to grant intellectual property rights to private producers for their discoveries and a last way is for society to encourage the private production of knowledge by offering public subsidies for its production (Navaretti *et al.*, 1998).

It was also shown that knowledge is a multifaceted concept and can be divided into four different kinds: 'know-what'; 'know-why'; 'know-how' and 'know-who'. Each one of them differ in their level of public and private goods characteristics. It ought to be said again that there is no knowledge that is totally public nor those that are totally private, thus knowledge can be understood as a hybrid good, namely semi-public, because it presents characteristics of both private and public goods. This has to be taken into account when talking about knowledge flow, that is, if the type of knowledge is 'more private' than public, it is harder to be shared.

Besides the private/public attribute of knowledge it is necessary to identify in knowledge different levels of tacitness, which is important to understand how it can be transferred. Know-who and know-how are the most tacit types of knowledge, due to their social embeddedness character thus they cannot be easily transferred through formal channels of information.

Knowledge is created through conversion between tacit and explicit knowledge

and four different modes of knowledge conversion were identified: from tacit knowledge to tacit knowledge; from explicit knowledge to explicit knowledge; from tacit knowledge to explicit knowledge; and from explicit knowledge to tacit knowledge. Despite the fact that all the four modes separately generate knowledge creation, the central theme is knowledge creation based on a dynamic interaction between the different modes of knowledge conversion that can form a continual cycle. So knowledge understood as input (competence) can generate more knowledge as output (innovation).

Here we finally come to the conclusion that the interaction between these four different modes generates more knowledge which in turn may generate continuous innovation thus creating competitive advantage. The European Union has already recognized the importance of knowledge diffusion and it has been investing in many different projects to facilitate it, even though its outcomes are uncertain. Despite the fact it is impossible to quantify and qualify accurately the direct and indirect effects in a short period of innovation policies such as those that the European Commission has been taking, it is well recognized that innovation is a cumulative process, oriented towards the future and the initiatives done by EU should be taken into consideration by other nations.

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Submissão: 18 de setembro de 2008.
Primeira resposta: 12 de janeiro de 2009.
Aceite: 30 de janeiro de 2009.