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May 2008

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[1] This essay is based on my Cranec paper (October 2007) and belongs to the research project "Dinamica strutturale: profili storici, tecnologici e organizzativo-istituzionali". This project is supported by Università Cattolica del Sacro Cuore, linea D.1 anno 2005, under the direction of Professor Alberto Quadrio Curzio at CRANEC. I should like to thank the participants at the 'New Technologies, Networks and Governance Structures', Seminar in Economics, Wettringen-Rothenberge, December 6-7, 2007, that contributed with their comments and observations, which are gratefully acknowledged. The usual disclaimer applies.
Keywords: Firms, Knowledge, Learning, Networks.
JEL Classification: D20, L10, L23.

1. Introduction

The factors determining the success of firms and of national economies are more dependent than ever on the capacity to create and use knowledge. Since firms today tend to become knowledge intensive and the industrial economies are transforming into *knowledge-based economies,* the rapid development of scientific and technological knowledge and the high level of innovation which characterize them are the crucial factors that improve their economic performance. In this world of "restless capitalism", communities, firms and individuals must equip themselves with new skills, new aptitudes and new strategies in order to survive and prosper.

Joseph A. Schumpeter (1912, 1942) had already pointed out the importance of technological innovations, scientific knowledge and managed knowledge creation for the economic performance of firms and economies. In this paper, which is essentially conceptual and theoretical, I follow a perspective sympathetic to the Schumpeterian tradition and different from mainstream economics, in the sense that the growth of knowledge, the learning processes and the innovation processes, which are connected with the performance of firms and economies, cannot be formulated as the outcome of a set of equilibrating forces, since nowadays the economies, which are knowledge-based, and firms, which are knowledge intensive, are always in continuous transformation.

The theoretical literature on the economics of knowledge, on industrial organization and on strategic management studies, which I refer to, has focused on the process of generation of knowledge and its consequences for innovation, on the mechanism of knowledge diffusion and its crucial relationship to learning, on the capabilities possessed by the firms and also on the crucial role of *networks.* In this paper I assume, therefore, that firms act within a knowledge-based economy, where the term '*knowledge-based economy'* means a "sea-change" from the past to point out the shift towards high intensity knowledge activity, it thus captures a qualitative distinction in the organization and conduct of modern economic life.

Knowledge-based economies are founded on increasing specialization, research, innovation and learning and are characterized by rapid transformations in the technological knowledge. One of the main features of knowledge-based economies is their reliance on the new information technologies. In these economies the creation and diffusion of knowledge, the structural change of demand and the process of selection determine a complex system based on variety and flexibility in the production that

characterize the performance of firms and of national economies. A consequence of this deep change is that in the knowledge-based economies the role and the weight of service activities have been increasing.

David and Foray (2003) maintain that what distinguishes the knowledge-based economies is the need to keep up with continuous and rapid change due to the unexpected and unpredictable evolution of technology and scientific discoveries that force all the people who are employed in various activities to develop new abilities, skills and jobs. Clearly, this is something more than the constant updating of technical knowledge, because it pertains to the capacity of understanding and anticipating change. The picture depicted by David and Foray seems to resemble that of a "restless capitalism" (Metcalfe, 2002), where communities, firms and individuals must equip themselves with new skills and new strategies in order to survive and grow, therefore in this picture the role of human capital and R&D activity is crucial.

The paper is organized as follows. First, I examine the issue of knowledge as a public good, and, therefore, the question of open knowledge. Second, I analyse the crucial relationship between knowledge and learning and, more specifically, the relationship between technological knowledge, learning and the environment, so the construct of absorptive capacity is investigated and also the related dynamic capability approach is considered. Finally, I look at the *networks* and investigate the rationale of networking. Therefore, in this context, I shall discuss the issue of competition/collaboration duality, since alliance is also a complex phenomenon, where collaborative behaviours and competitive relations coexist; a more eclectic view is, thus, offered on this issue with the aim to provide a new theoretical framework of inter-firm relations. The paper ends with a number of conclusions.

2. Is knowledge a public good?

In this section I consider the issue of knowledge as a public good, since there is a significant qualitative difference between knowledge held privately and knowledge that is public.

What is meant here by knowledge is fundamentally a matter of *cognitive capability*.[2] Knowledge is a particular good different from conven-

[2] Foray (2004), p. 4.

tional tangible goods, and it is an "ambiguous good".[3] This particular and ambiguous good has certain properties which make it similar to a public durable good; knowledge is, in fact, a *non-excludable* good. Yet, the condition of strict *non-excludability,* which is taken to be one of the hallmarks of a *pure* public good, does not hold in the case of codified knowledge, since patents, copyrights and trade secrecy are institutional devices for denying others access to information. So there is a tendency for intellectual property rights to exist in a privately marketable form. Nevertheless, in the production and use of knowledge there are knowledge externalities which are powerful and are said to be "non-pecuniary".[4] The economic use-benefits of knowledge are often hard to appropriate privately and therefore to market efficiently. Thus, making knowledge exclusive and controlling it privately is difficult and costly.

Knowledge is also a *non-rival* good, that is knowledge is a good which is infinitely expansible, without loss of its intrinsic qualities, so that it can be possessed and used jointly by as many as care to do so. Therefore, transmitting knowledge is a positive sum game that multiplies the number of owners of that knowledge indefinitely. The difficulty of private control and non-rivalry are then the features underlying the power of positive externalities in the case of knowledge production. Evidently, the ambiguous nature of knowledge can create a conflict between the social goal of efficient use of knowledge once it has been produced and the goal of providing motivation to the private producer.

Dasgupta and David (1994) in their seminal paper on the economic analysis of open knowledge provided an analysis of the intricate relationship between university and industry and, more specifically, between university scientific knowledge and industrial R&D, where they tried to offer an explanation for the prevalence of distinct norms, customs and institutions governing university scientific knowledge, on the one hand, and industrial R&D, on the other. One of their main propositions is that there are no economic forces that operate automatically to maintain dynamic efficiency in the interaction between university-based open science and commercial R&D. Their analysis concentrates on rules of priority and the role of validated priority claims in the reward structure of academic scientists, patenting and disclosure policies, institutions associated with scientific

[3] Foray (2004), p. 5. The codification of knowledge creates this ambiguity.

[4] These externalities denote the fact that knowledge produced by an agent benefits other agents without any compensation. Foray (2004), p. 92.

communication and the functioning of a collegiate reputational reward system.

Dasgupta and David examine the features of organized research activities from the perspective offered by the growing analytical literature that treats problems of behaviour and resource allocation under incomplete and asymmetric information. In particular, rules of priority and secrecy can create, along with the reward system entailed, an immediate tension between cooperative compliance with the norm of full disclosure and the individualistic competitive urge to win priority races. To explain these cooperative behaviours among potentially rivalrous researchers, Dasgupta and David make use of the theory of repeated games[5], together with a functionalist analysis of institutional structures, reward systems and behavioural norms of 'open science' community-networks derived from the sociology of science.

Applying game theoretic models to the research networks, that is, cooperative networks of information sharing among researchers, Dasgupta and David reach the conclusion that reputation and the self-interest of researchers in reinforcing adherence to the norm of disclosure will favour their common culture of science and make a rule of priority possible, especially if the *network of researchers* consists of a restricted number of colleagues. The authors also warn us that the dependence of knowledge-based industrial development upon the science-technology nexus must not be transformed into a regime of "universally privatized science".[6]

In a more recent paper, Paul David (2004) reminds us that the 'open science' mode of pursuing knowledge, in contrast with 'proprietary science', is a fragile cultural legacy of western Europe's history. This cultural legacy crystallized a new set of norms, incentives and organizational structures that reinforced scientific researchers' commitments to rapid disclosure of new knowledge. According to David, the power of modern science today derives from the radical social innovation that the 'open science' regime constituted. Moreover, the institutions of 'open science' are independent, and, in some measure, fortuitous, social and political constructs. They are cultural legacies of a long-ago epoch of European history; they

[5] They describe a game of incomplete information that is a typical two-person "Prisoners' Dilemma", from which adverse consequences can be anticipated. Dasgupta and David (1994) 502-503. On infinitely repeated games see Fudenberg and Tirole (1999), ch.5.

[6] Dasgupta and David (1994), 515.

are delicate and often imperfectly understood, piece of social machinery that may be damaged by careless interventions.[7]

Nelson (2004) also criticized the idea of a science that tends to become extensively privatized, since its science base is largely the product of publicly funded research, and the knowledge produced by that research is and must remain open and available for potential innovators to use.[8] He makes clear that the theoretical position on open scientific knowledge must be defended and that to privatize basic knowledge is a danger both for the advance of science and for the advance of technology.

Nelson finally stresses that technological advance is an evolutionary process. So there are great advantages of having multiple paths explored by a number of different actors. From this perspective the fact that most of scientific knowledge is open, is extremely important: many individuals and firms can use the scientific knowledge they need in order to compete intelligently in this evolutionary process.[9]

3. Knowledge and learning

The present section examines the role of knowledge and learning for the innovative and organizational performance of the firm, and their complex relationship. It focuses, in particular, on the absorptive capacity literature and on the dynamic capability approach to explain a firm's competitive advantage.

Knowledge is a basic resource and a strategic factor for the economic performance of the firm and also of the economy. Although scientific and technological knowledge is of key importance, knowledge on *how* to organize and manage economic activities is crucial in determining economic performance. These organizational and managerial improvements are becoming more important as the scientific and technological content of economic activity increases.[10] In this view, learning is the vital economic activity that marks the life of firms and economies, which are knowledge-based, since it allows the acquisition and the transfer of knowledge to become effective.

[7] David (2004), 585.
[8] Nelson (2004), 455.
[9] Nelson (2004), 460.
[10] Steinmueller (2002), 142.

Knowledge, however, is a factor subject to a continuous transformation, it assumes many forms and behaves in unpredictable ways. More specifically, the production of knowledge is characterized by the alternation of periods of continuous progress of knowledge within a stable learning pattern and by periods of radical changes pushed by the "process of creative destruction" that transforms the technological structure and also the learning pattern.

Over the last decade a wide literature on the theory of the firm, on organizational economics and on strategic management has emphasized the role of learning and of knowledge in developing a firm's resource base. More specifically, some scholars have suggested that knowledge generation and transfer capabilities are at the core of a knowledge-based view of the firm. So the firm's ability to produce new and highly specific knowledge and its ability to build on that knowledge greatly influence firm performance.[11]

This view also suggests that the basis for sustained competitive advantage is the firm's ability to develop rare and valuable knowledge through learning, and subsequently build upon and spread that rare knowledge throughout the organization. The argument that creating new knowledge is the genesis of the competitive advantage, supported by the knowledge based view of the firm (KBV), is coherent with the larger perspective of the resource based view of the firm (RBV).

The resource based view of the firm (RBV) is a theoretical framework based on the idea that what the firm can do essentially depends on what resources the firm can muster. This theoretical framework is aimed at understanding how competitive advantage within firms is achieved and how that advantage might be sustained over time; it can be traced to the works of authors such as Schumpeter (1912), Penrose (1959), Nelson (1991) and, more recently, Teece, Pisano and Shuen (1997). RBV assumes that firms can be conceptualized as bundles of resources, that those resources are heterogeneously distributed across firms, and that resource differences persist over time. Based on these assumptions RBV states that firms with superior structures offer a markedly better quality and product performance. RBV highlights the importance of firm-specific factors in explaining firm performance. This view also invites consideration of

[11] Bogner and Bansal (2007). In their knowledge-based view, the new knowledge is an outcome of a Schumpeterian process by which new combinations of knowledge are created (2007, 167).

managerial strategies for developing new capabilities, the management of knowledge and learning then become fundamental strategic issues.

Moreover, the vast literature on learning, referring in particular to the firm, covers a wide spectrum of modes of learning: from unplanned learning to highly deliberate learning, from trial-and-error learning to learning-by-doing. Learning enables the creation and extension of existing capabilities and competences via the application, integration, and deployment of acquired (from external sources) and experimental (internally conceived) knowledge. Learning is usually a path dependent process wherein what firms learn depends on what they already know[12], so the way firms learn and how they change tends to depend on the length of their history and the development stage of their organizational routines.

However, learning is also strictly related to the conditions of the external environment. The role of the external environment is, therefore, crucial for the firms in the knowledge-based economies, including the system of higher education and the relationship between firms and universities, the community-network of science, and the institutional framework, which is a critical element of business environment. The regulatory system, the quality of the intellectual property rights (IPR) system, antitrust laws, *et cetera*, are also part of the environment.

Cohen and Levinthal analyse the relationship between technological knowledge, learning and the environment. According to them[13], the innovative performance of firms depends on how successful they are appropriating from the different external knowledge sources. In particular, R&D activity not only generates innovations, but it also develops the firm's ability to identify, assimilate, and exploit knowledge from its environment. Cohen and Levinthal call this capability a firm's 'learning' or 'absorptive' capacity, which represents, therefore, an important part of a firm's ability to create new knowledge. Unlike learning by doing[14], which allows firms

[12] Teece, Pisano and Shuen (1997); Zahra and George (2002).

[13] Cohen and Levinthal (1989), p. 569. They construct a theoretical model of the generation of a firm's technological knowledge to explore the implications of the dual role of R&D for the analysis of the adoption and diffusion of innovations. They also provide empirical tests supporting their explanations.

[14] This concept, formulated by Arrow (1962), constitutes the basis for a relationship between productive experience (the accumulation of "doing") and the improvement of productive performance, and is a source of innovation that is not recognized as a component of the R&D process. This notion of learning by doing expresses the fundamental idea that the long term evolution of a technology is governed by accumulated experience. Foray (2004), 59.

to get better at what they already do, absorptive capacity allows firms to learn to do something quite different. Cohen and Levinthal's paper is noteworthy because it identifies several key determinants of a firm's willingness to invest in absorptive capacity: the scope of technological opportunities available to the firm, the nature of technological opportunity, that is, basic versus applied science, and the degree of improvement in technological performance through using external knowledge.

In a subsequent much cited paper on absorptive capacity, Cohen and Levinthal (1990) provide a socio-cognitive set of explanations for the model put forward in their 1989 paper. They use research on individuals' cognitive-structures and problem solving to develop a richer explanation. Since individuals' learning is cumulative and learning performance is greatest when the object of learning, that is the new knowledge to be assimilated, is related to what the individuals already know, Cohen and Levinthal redefine absorptive capacity, extending our insights from the individual level to the organizational level, as a firm's ability to value, assimilate and commercially utilize new external knowledge.

These authors maintain that the ability to exploit external knowledge is a critical component of innovative capabilities.[15] They also suggest that absorptive capacity is a by-product of prior innovation and problem solving and is itself dependent on the individual absorptive capacities of the organization's members. Accordingly, the development of an organization's absorptive capacity builds on prior investments in its members' individual absorptive capacities, tends to develop cumulatively and to be *path-dependent*, and depends on the organization's ability to share knowledge and communicate internally.

In conclusion, the following view of absorptive capacity is offered by Cohen and Levinthal in their two papers (1989, 1990): first, absorptive capacity is one of a firm's fundamental learning capabilities. Second, through its R&D-activities a firm develops organizational knowledge of certain areas of science and technology and of the way these areas relate to the firm's products and markets, that is the ability to identify and value external knowledge. Over time, the firm develops processes, policies and procedures that facilitate sharing that knowledge internally, i.e. the ability to assimilate and commercially utilize external knowledge.

The absorptive capacity construct has been analyzed and defined by many researchers after Cohen and Levinthal (e.g. Mowery and Oxely,

[15] Cohen and Levinthal (1990), 128.

1995). In particular, Eisenhardt and Martin (2000) and Zahra and George (2002) have proposed a re-conceptualization and a broader interpretation of absorptive capacity as a dynamic capability pertaining to knowledge creation and utilization that enhances a firm's ability to gain and sustain a competitive advantage. Accordingly, absorptive capacity is defined as a set of organizational routines and processes, by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability. The transformation dimension of this definition helps to open the *black box* of organizational and strategic change. Further, absorptive capacity influences the creation of other organizational competencies and provides the firm with multiple sources of competitive advantage, thereby improving economic performance.

The dynamic capabilities approach has been influenced by Teece, Pisano and Shuen (1997), who embedded this approach in the resource based view of the firm (RBV) wherein firms are heterogeneous with respect to their resources, capabilities and endowments. These authors define dynamic capabilities as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments.[16] Dynamic capabilities thus reflect an organization's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions.

According to Teece, Pisano and Shuen, the dynamic capabilities approach places emphasis on the internal processes that a firm utilizes, as well as how they are deployed and how they will evolve. The focal concern of this approach is on asset accumulation, replication and inimitability, and the role of industrial structure is endogenous. Path dependencies and technological opportunities mark the road ahead. Because of the non-tradability of 'soft' assets like values, culture, and organizational experience, distinctive competences and capabilities generally cannot be acquired, they must be built.

Teece, Pisano and Shuen consider their paradigm better than an approach based on strategizing, because it focuses on the 'assets' the firm has to play with, more than on how the firm plays the game. However, the dynamic capabilities theoretical framework is also essentially strategic in nature, although it sets definite limits on strategic options, at least in the short run. It emphasizes some crucial aspects that are absent in other theoretical views on firms' strategies. In particular, it points to the capacity to

[16] Teece, Pisano and Shuen (1997), 516.

renew competences so as to achieve congruence with the changing business environment. Teece, Pisano and Shuen do not reject completely the game theoretic models to analyze strategic problems. They argue that when there are gross asymmetries between firms, the results of game theoretic analysis are likely to be obvious and uninteresting. The latter approach, whose focal concern is strategic interactions, unfortunately ignores competition as a process involving the development, accumulation, combination and protection of unique skills and capabilities. On the other hand, if firms' competitive positions are more delicately balanced, then strategic conflict is of interest to competitive outcomes. Therefore, Teece, Pisano and Shuen suggest that the two approaches can be considered complementary.[17]

In this regard I propose, in a section below, an analysis of the strategic problem in terms of inter-firm dynamics using game theoretical models. In particular, I adopt and try to develop the *coopetition* framework, earlier suggested by Brandenburger and Nalebuff (1995), where firms simultaneously pursue competition and cooperation.

The theoretical and practical importance of dynamic capabilities to a firm's competitive advantage, especially in complex, uncertain and changing external environments, has captured the attention of many scholars, this issue is at the forefront of the research agendas.

Zahra, Sapienza and Davidsson (2006), in particular, have addressed the question how *dynamic capabilities* come into existence and what the role is of the firm's entrepreneurial and learning processes in creating and sustaining these capabilities. These authors provide a theoretical model (i.e. a set of propositions), which is based primarily on learning theories (Cohen and Levinthal, 1990) and on behavioural theories (Cyert and March, 1963) that reveal key differences between firms, in particular between new ventures and established firms.

Zahra, Sapienza and Davidsson define dynamic capabilities as

> "*the abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker(s)*".[18]

[17] Teece, Pisano and Shuen (1997), 512-513.
[18] Zahra, Sapienza and Davidsson (2006), p. 918.

This definition makes explicit the role of decision-makers in enacting and directing the *dynamic capabilities*; the definition puts 'managerial choice' at the centre of the analysis. Such choices give direction, substance and variety to the firm's entrepreneurial activities.

The authors also distinguish between *substantive capability*, the ability to solve a problem, from *dynamic capability*, the dynamic ability to change or reconfigure the existing *substantive capabilities*. This distinction emphasizes the strategic role perspective of their view.

A stylized model of capability formation and performance is put forward by these authors, where entrepreneurial activities influence the selection of resources and skills and promote organizational learning processes to capture external knowledge, whereby these choices create new *substantive capabilities* and the organization's knowledge base. Thus, *organizational knowledge* and *substantive capabilities* together determine which *dynamic capabilities* are necessary to adapt to emerging conditions, and these relations are bi-directional. All this, clearly, affects directly and indirectly the organization performance.

The four sets of propositions developed by Zahra, Sapienza and Davidsson are based on the fundamental assumption that there are costs to developing and using *dynamic capabilities*. An important outcome of their theoretical reasoning is that although such capabilities are developed in order to realize strategic advantages, their development does not ensure organizational success.[19] Thus, the effect of *dynamic capabilities* on performance will depend on the quality of the organization's knowledge base.

Further, in accordance with Teece, Pisano and Shuen (1997), Zahra, Sapienza and Davidsson sustain that major or continual environmental change, as in high-technology industry, stimulates the development and use of *dynamic capabilities*. A set of propositions in their model[20] regards the links between organizational age and learning modes for dynamic capability development and are based on theory and logical inferences. Zahra, Sapienza and Davidsson maintain, in particular, that young firms tend to learn by doing, but as time passes, these firms tend to experiment in order to increase their capabilities.

In conclusion, this framework highlights the role of organizational learning in the evolution of capabilities, extending the ideas of Cyert and

[19] Zahra, Sapienza and Davidsson (2006), p. 927. They agree with Eisenhardt and Martin's (2000) view that having dynamic capabilities *per se* does not lead to superior firm performance.

[20] Propositions 6a-6d (Zahra, Sapienza and Davidsson (2006)), 937-939.

March (1963), who suggest that organizational learning is multifaceted and centres on adaptations of goals. The key feature of the model is that *dynamic capabilities* mediate the relationships between *substantive capabilities* and *organizational knowledge*, resulting in an indirect impact of *dynamic capabilities* on performance.

The progress in understanding the concept of *dynamic capabilities* as coordinative management process, in particular, has certainly influenced also the research on inter-organizational learning and its relationship with Cohen and Levinthal's absorptive capacity construct. Many of these studies are on network relationships. Thus, a firm which is a member of an inter-organizational network (but the analysis can also be applied to developed countries!) is considered to be linked to higher absorptive capacity, since collaborations and partnerships can be a vehicle for new organizational learning. The analysis of networks is, therefore, the topic of the next section.

4. Networks of firms, community networks and inter-firm dynamics

Recent years have seen a growth of different forms of partnering and inter-organizational networks in increasingly knowledge-based economies. Therefore, another way of looking at the process of knowledge creation is through the analysis of those networks.

The generation of knowledge is traditionally conceived as a process internal to a single entity. But, in knowledge-based economies, it has increasingly become a product of networked entities often situated in new ways, yet motivated to find new solutions to specific problems, needs and circumstances and, in many cases, to reveal these solutions to others. Thus, knowledge creation is essentially collective, particularly in areas intimately connected with commercial application.

At the base of the concept of networks we find the Schumpeterian idea that an economy based on knowledge is an ensemble of connected elements rather than an aggregate entity. In addition, networks can be a privileged way of innovating, since they can provide the flexibility with which to exploit opportunities for the recombination of new technical and other components. Actually, new technologies require multiple sets of

complementary technical developments, which necessarily go beyond the scope of even the largest firms.[21]

Learning also plays a crucial role in this process of networking, which requires mutual adaptation, transfer and co-creation of knowledge. In contrast to internalization solutions, networks provide a broader set of experiences, encourage learning from other sets of clients and suppliers, leave scope for varied applications and experimentation and reduce sunken investments and irreversible technical commitments. Not all uncertainties and risks can be eliminated by networks, but some can be greatly reduced, like technological uncertainties, secondary market uncertainties, *et cetera*. At large, the literature assumes that technical cooperation, when successful, results in super-additive gains, which resulted in interpretations as a positive-sum game. In fact, the cooperative perspective implicitly assumes that firms interact on the basis of a fully collaborative game structure. Most of the studies confirm that the convenience of forming a network is constrained by the expected future gains in knowledge, technology creation and strategic advantages that must be potentially larger than the considerable coordination costs and possible rent losses.

In this section I try to offer an eclectic and more realistic view about network structures, which also takes into consideration competitive relations, acknowledging the complexity in the alliance phenomenon, since competitive and collaborative behaviours coexist and tend to co-evolve. This view stems from various lines of research related to industrial organization studies, knowledge-based theories, studies on inter-organizational networks carried out by sociologists and, finally, analyses of inter-firm dynamics by management scholars. Therefore, I shall go through these different lines of research, taking into consideration a number of selected contributions on networks and on competitive and collaborative behaviours, with the purpose to explain the complex environment of networking and to trace out a new kind of inter-firm dynamics.

The concept of a network has been used to examine different configurations, such as networks of individuals in research projects, or of innovating business firms working together. Let us take the networks of innovating firms first. A definition proposed in Freeman (1991) reads:

[21] In the biotechnology field, an innovative firm cannot exist without links on the supply side with university research centers, on the demand side it also needs links with hospitals and government regulatory bodies.

> *"A network may be defined as a close set of selected and explicit linkages with preferential partners in a firm's space of complementary assets and market relationships, having as a major goal the reduction of static and dynamic uncertainty…."*.[22]

In this definition, Freeman underscores the importance of networks to reduce uncertainty, and also the choice of preferential partners which have complementary assets in order to establish linkages and, therefore, a network. The importance of cooperative relationships among firms, as a key linkage mechanism of network configurations, is the essential feature of these networks. Networks of innovative business firms, that imply formal R&D collaboration agreements and/or technology exchange agreements between firms, are important forms of strategic alliance for innovation.

Both empirical and theoretical research has long since demonstrated the importance of both external and internal networks of collaboration and information, although a strong theoretical framework that facilitates the understanding of inter-firm cooperation has been lacking.

Freeman (1991) and Hagedoorn (1995,2002) show in their empirical studies the changing patterns of collaborations in innovative networks in the 1980s and 1990s, and the changing motivations of firms to enter into different modes of inter-firm R&D cooperation. In particular in biotechnology, information technologies and new materials, inter-firm strategic technology partnering seems related to the emergence of new technological paradigms.

In contrast to the previous literature in which considerations of cost-sharing and cost-minimising appeared to be decisive, here the strategic objectives relating technology, such as appropriability and technological complementarities, sociological factors like inter-personal relationships of trust and confidence, and the markets seem to play a relatively major role. For many R&D partnerships, however, cost-economizing and strategic motives are inter-twined.[23] In particular, the literature of the 1990s on R&D partnerships, cited by Hagedoorn (2002), seems to confirm a variety of strategic and cost-economizing motives for these R&D forms of cooperation and networking.

Riccaboni and Pammolli (2002) examine network growth. Their empirical findings show that the processes of network growth are sustained

[22] Freeman (1991), 502.
[23] Hagedoorn (2002), p. 479.

by dynamic complementarities between patterns of specialization in knowledge production (originators) and processes of diversification of in-house capabilities of large multi-product, multi-technological companies (developers). Thus firm growth is driven by specialization and division of labour in the processes of generation, attraction and development of technological opportunities.

In the knowledge-based economies networks are not simply networks of firms. We also encounter knowledge communities, which are networks of individuals involved in the production, reproduction and circulation of knowledge through an intensive use of ITCs that strongly reduce the marginal cost of copying, transmitting, and sharing knowledge. In this type of *community-network* the members are motivated by the reward systems and social ethos reinforced by specific institutions to disclose and share their knowledge.[24] These networks also bring about spillovers and feedback mechanisms. A positive virtue that comes from them is that learning productivity is increased by the fact that an individual can «learn to learn» through reproducing the knowledge of others. So these knowledge communities become agents of economic change and of innovation, because they cut across the boundaries of firms and other non-firm organizations and exchange knowledge within a framework of a network operating by the rules of disclosure and reciprocity.[25] Hence, these networks are characterized by knowledge openness, but open knowledge does not mean the absence of incentives and, moreover, knowledge openness can be viewed as a mechanism generating economic efficiency.

Further, the literature on strategic alliances and partnerships has identified several barriers to inter-organizational knowledge transfer. In particular, the level of tacitness, uniqueness, and complexity of knowledge creates an ambiguity obstructing the inter-organizational sharing of knowledge. However, collaborative and competitive behaviours are often featuring knowledge-intensive firms and network-based knowledge relations. It is widely known that sociologists, even before economists, started the study of networks and did a great deal of work on them. In particular they analysed network organizations.

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[24] Dasgupta and David (1994). They examine, in particular, networks of cooperative behavior of information-sharing in science.

[25] David and Foray (2003), 8. Open source software, like Linus, is a recent example of a technological community based on openness.

The sociologist Amalya Oliver (2004) proposes the following definition of such a network [26]:

> "*Any collections of actors (N ≥ 2) that pursue, repeated, enduring exchange relations with one another and, at the same time, lack a legitimate organizational authority to arbitrate and resolve disputes that arise during the exchange"*.

The aforesaid definition is aimed at distinguishing the concept of a network from market transactions that are non-enduring, and from hierarchies that have a legitimate authority to resolve disputes.

Oliver, in this study of inter-organizational networks for knowledge creation, argues that the adoption of a duality framework collaboration/competition, which focuses on certain parameters that introduce complexity, is needed for this analysis of network-based knowledge relations. The concept of duality adopted by Oliver implies that the understanding of collaboration and competition in knowledge intensive industries, such as biotechnology, can be enhanced by applying a method of observation capable to reveal the spectrum of relational forms that co-exist in many network-based knowledge relations.

Amalya Oliver uses a flexible «prism methodology» for exploring the competition/collaboration dualities in network-based knowledge relations. The prism concept is adopted here as a metaphor to point out that through a "prism methodology" it is possible to observe the sometimes hidden range of 'sub-colours' of competition and collaboration, which means that the relations observed may be composed by many sub-relations that may sometimes contradict one another. Therefore, such an approach can be helpful to trace the interplay between collaborative and competitive behaviours among firms in networks. The search for knowledge and capabilities in networks stems from the environmental constraints which firms have to cope with, and where knowledge assets are becoming important for firms, promoting increasing returns in the knowledge-intensive industries.

The complexity involved in understanding network-based knowledge relations depends on the firm's particular stage in its life cycle, and the cycle of the firm is characterized by two stages, *exploration* and *exploitation.* Actually, most cases of inter-organizational relations in knowledge-

[26] Oliver (2004), 153.

intensive industries represent various hybrid forms of competition and collaboration. Hybrid forms, in which it is possible to observe a duality of competition and collaboration, can be characterized by permeable boundaries shaped by the two relational forces.

Amalya Oliver proposes five hypotheses relating collaboration and competition in knowledge intensive firms. The general argument of the paper, that follows from the hypotheses of her theoretical framework, is that duality is generated by the ongoing reciprocal relationship between exploration and exploitation and between network-based exploration and privatization, all stemming from the tension surrounding the appropriation of knowledge, a tension in which the learning processes are embedded.[27]

The collaboration-competition duality in networks is also evident in the analysis of possible network externalities. Oliver tries to break the common perception of positive externalities from collaboration and negative externalities from competition, showing a few examples of the opposite effects.

What emerges form the analysis by Oliver is that external knowledge is more vital to firms in industries characterized by a dynamic and complex technological environment, like biotechnology; therefore biotechnology firms foster their learning process by networking.

The competition/collaboration duality framework and the empirically observed hybrid forms of inter-firm relations in knowledge intensive industries have been analyzed also by scholars of management. Some of them suggest that cooperation is affected by the intrusion of competitive issues and that, consequently, results in a game structure that moves away from the ideal circumstances of complete convergent interests.

It is widely known that in the competition framework firms seek competitive advantages that cannot be reached but at the expense of the competitive advantage of other firms. A main implication of the competition framework is, therefore, that inter-firm interdependences define a zero sum game structure. In this theoretical inter-relational framework firms have an opposite interest game structure; consequently they tend not to trust each other, since they follow a self-interest-oriented behaviour.

Brandenburger and Nalebuff (1995), in their seminal paper, present an original and complex image of inter-firm relations, where competitive and cooperative features equally shape firms interdependencies. To this image they attach the new label of *coopetition.* Brandenburger and

[27] Oliver (2004), 167.

Nalebuff develop a framework that draws on the insights of game theory. They do not start their analysis from the resources and capabilities a firm possesses or can develop, rather they analyze how the firm must play the game to be successful.

The authors underscore the limitation of the competitive paradigm, since firms see the advantages of cooperative behaviours (i.e. positive-sum game), that determine commitment, cooperation and trust building. According to Brandenburger and Nalebuff, in their inter-firm relations, companies should consider both cooperative and competitive strategies to be successful. Consequently, companies must change the game following a collaboration/competition framework in order to achieve or to approximate an equilibrium solution of the game.

To get a better understanding of the competition/collaboration duality in its practical functioning, it is useful to take a look at the car industry. In the car industry the percentage of the *value chain* (Porter, 1985) which is controlled by a single company (i.e. any player in this industry) has been shrinking in the last years and, in any case, has become a small proportion of the total value of the final output. Therefore, each company aims at focusing on its core business and, at the same time, tries to make strategic alliances with other firms, even with its competitors.

A good example is the case of the vans produced by Fiat. The Italian car company has signed an agreement with Citroën, so that the *chassis* of the vans are produced by the French company and the engines are produced by Fiat. The final result is that the Fiat van and the Citroën van are very similar (like, for instance, the 'Fiat Ducato' and the 'Citroën Jumper'), and are produced through a strategic partnership of the two companies, which are, at the same time, competitors when they sell their vans in the market. So, these two important players of the car industry collaborate, on one side, and compete, on the other side. Let's go back now to theory.

Padula and Dagnino (2007) adopt the complex construct of *coopetition* suggested by Brandenburger and Nalebuff (1995), yet they develop an idea that acknowledges the intrusion of competitive issues in the effort to reach a collaborative advantage[28], thus offering a more realistic representation of inter-firm dynamics. The concept of *coopetition* is, in fact, adopted by these scholars of management to represent an integrative framework, characterized by the presence of firms which are competitors

[28] Padula and Dagnino (2007), 33.

and, also, by other industry actors (suppliers, customers). However, it can be extended to industry actors such as knowledge communities and/or *networks of researchers*. The qualifying point of their framework is that all these actors interact on the basis of a partially convergent interest structure.

The coopetitive game framework of Padula and Dagnino consists of four propositions linking the rise of *coopetition* to a set of environment-related factors and a set of firm related factors that are the forces responsible for the intrusion of competitive issues (i.e. the drivers of the rise of *coopetition*) within a cooperative game structure.

In this *coopetition* model, the environmental factors, which were also considered by Oliver, are the exogenous drivers. So a change in the competitive environment (like, for instance, growing markets, or the development of new technological opportunities) affects the existing alliances; in particular, these changes affect the awareness about the viability of an alliance in supporting the strategy and performance of each partner. Actually, changing environmental conditions may make the trade-off between collaboration and competition more serious, mainly because they give rise to a high level of uncertainty that encourages conflicting views as well as diverging responses about more suitable actions. The firm-related factors, which are instead the endogenous drivers, concern the knowledge structure of the network (the knowledge profile of the firms), which is, in turn, strongly characterized by the knowledge content and by the firms' cultural model.

A basic assumption made in the model is that firms' behaviour is underpinned by an enlightened self-interest, and that cooperation with other firms proves a viable, often indispensable strategy to realize self-improvement. In this context, the shape of the coopetitive nature of the inter-firm relations is heavily influenced by the strategic interaction processes that operate at the core of the trade-off between common and self-improvement interests, thus affecting the performance of firms.

Moreover, *coopetition* is not a fully dichotomic structure, which may be depicted as a fixed point along a continuum between competition and cooperation, two opposite game structures. It is, instead, a multidimensional variable which may assume a number of different values, when observed in an orthogonal structure (a '*coopetitive matrix'*) between the two constructs of competition and cooperation. This '*coopetitive matrix*' represents the possible combinations of the two constructs (i.e. competition and cooperation), where the case of pure competition with a result of a

zero sum game can be considered an extreme or 'trivial' solution, since the result implies that competition does not stimulate cooperation, but on the contrary it stops any possible alliance. The multidimensional character of this variable constitutes the relevant driver of the complexity of *coopetition*, which requires a change in the cognitive maps of the various industry actors in order to accommodate it.[29]

Padula and Dagnino also make use of Cohen and Levinthal's absorptive capacity concept, shifting it from a firm-level construct to a dyadic level construct (which can be extended to a network-level construct). So absorptive capacity can be seen as a defined set of cooperation processes specifically related to the cooperative relationships for learning purposes.[30]

Although *coopetition* is investigated by Padula and Dagnino as a dyadic construct, it can also be investigated at the higher, network level of analysis, then becoming relevant for the discussion of networks and economic performance within the knowledge-based theories.

I have just discussed above that Amalya Oliver adopted the «prism methodology» to face complexity in the analysis of network-based knowledge relations, with the aim to capture the hybrid forms of competition and collaboration characterized by permeable boundaries. Here I follow the idea that her analysis, which is essentially descriptive, can be complementary to the theoretical framework of *coopetition* proposed by Padula and Dagnino.

Amalya Oliver considers, in fact, the environmental factors as exogenous constraints and the knowledge assets and capabilities of firms as the endogenous factors influencing the network-based relations, where the duality collaboration/competition is the outcome of the relationship between network-based exploration and privatization. Padula and Dagnino's coopetitive game structure model, instead, aims at exploring the drivers of the intrusion of competitive issues within a cooperative context, where firms interact on the basis of partially overlapped private interests. The game structure of *coopetition,* which is a multidimensional construct, gives and explains different and diverging solutions of the game.

In the *coopetition* model a possible solution can be the end of a strategic cooperation, whereas another solution could be that firms struggle to reach an equilibrium point to continue to cooperate. Therefore, the theo-

[29] Padula and Dagnino (2007), 37-38.
[30] Padula and Dagnino (2007), 42.

retical framework of *coopetition* is able to explain the mechanism of knowledge appropriation and of privatization, similarly to Amalya Oliver' contribution, but adopting a different methodology based on game structures. This new inter-firm dynamic framework, which does not exclude the existence of competitive pressures, helps to provide a rationale in the cooperative behaviour of firms, explaining, for instance, the long-run stability of certain alliances, or the volatility of other cooperative agreements.

In conclusion, the new *coopetition* framework underscores the limitations of the cooperative model based only on cooperative behaviours, and, therefore, on unbounded trust, providing a more realistic view of inter-firm dynamics, that overcomes the collaborative bias of the past literature on this topic.

Finally, the new *coopetition* framework allows looking at strategic networks as effective governance devices of inter-firm relationships, but it must be enriched with other approaches to offer a more eclectic view. In particular, it must take into account the dynamic capabilities approach put forward by Teece, Pisano and Shuen, where the emphasis is on the assets the firm has to available, and on the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments; and it must consider the contribution by Zahra, Sapienza and Davidsson that puts 'managerial choice' at the centre of their analysis on dynamic capabilities. Moreover, it must take also into account approaches like the "prism methodology", provided by the sociologist Amalya Oliver, to disentangle the complex competition/cooperation duality framework.

5. Conclusions

This paper has been an attempt to analyze a number of crucial factors that determine the economic performance of knowledge intensive firms in *knowledge-based economies*, with the aim to provide an eclectic view regarding the theoretical framework of inter-firm relations.

Along a line of research close to the literature on the economics of knowledge, organizational learning and strategic management, I have considered the relation between knowledge and learning as a key relationship of the performance of firms. Knowledge in its multidimensional aspects has been analyzed. Since the diffusion of technological knowledge requires sophisticated learning, learning constitutes a fundamental factor at

the base of technological development and economic performance of firms, because it enables individuals, organizations and networks to acquire the capabilities to cope with the new technologies. However, learning is a complex process for the firm, which depends on organization, forms of management and strategies. In this context, the construct of absorptive capacities has been considered to underscore the importance of external sources of knowledge and the capability of the firm to absorb this knowledge, trying to connect this construct with the analysis of inter-organizational networks.

Further, the related dynamic capabilities approach has been examined, an approach framed within the resource based view (RBV) of the firm, with the aim to explain the organizational performance and the competitive advantages of the firm in a changing environment; an explanation based on the "dynamic" abilities to reconfigure the firm's internal and external resources in innovative ways, where the role and the choices of managers and entrepreneurs become crucial.

An important place in this paper has been also given to the analysis of innovation, which is conceived, different from mainstream economics, like a process that involves a radical change from past familiar practices. Therefore, innovation is a strategic factor for the performance of firms, but the technological and organizational environment in which firms must innovate and operate is complex and dynamic, and firms must develop adequate capabilities to cope with. Moreover, the uneven diffusion of innovations among firms and industries is the cause of their different performance.

Finally, the analysis has been focused on networks, which constitutes the central argument of the paper. The role of networks becomes essential for the knowledge intensive firms, since the production of knowledge is the outcome of networked entities, as Schumpeter already emphasized. Thus, networks are important for the innovative performance and the growth of firms.

I have pointed out that networks contribute to maintaining a system of open knowledge and are a powerful means of transmission of scientific and technological knowledge. These networks emerge because of the heterogeneity of the actors in the economy; therefore they allow access to complementarities in knowledge and, likewise, allow the integration of different capabilities. I have considered different typologies of networks: networks of innovative business firms, networks of individuals, in particular knowledge communities, and *community networks* of science.

The main purpose of this analysis on networks is to explain the complexity of networking, and to offer an eclectic view of network structures and competitive relations within a continually changing environment. Here the aim is to map out a new form of inter-firm dynamics by adopting a theoretical framework along the lines set out by Brandenburger and Nalebuff. Such a framework is based on *coopetition* which integrates competitive and collaborative behaviours. We furthermore complement this framework with certain learning theories (Cohen and Levinthal, 1990) and developments (i.e. Zahra, Sapienza and Davidsson, 2006) of the theoretical approach to the resource-based view (RBV), in order to emphasize the importance of specific factors such as knowledge assets, dynamic capabilities and managerial choices, in explaining firm performance.

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