COGNITIVE STYLES IN ACADEMIC AND INDUSTRIAL RESEARCH (SOME REFLECTION FOR AN AGENDA OF RESEARCH)

Riccardo Viale (Italian Academy at Columbia University)

New York 4/4/2009

1) INTRODUCTION: THE NEED OF ACADEMY-INDUSTRY RELATIONS

We are living in a new economy driven by knowledge. According to Kendrick (1994) the stock of gross real capital in the US from 1929 to 1990 shows the increase of intangible over tangible capital: 6.075 billion dollars of tangible capital in 1929 and 28.525 in 1990 vs. 3.251 billion dollars of intangible capital in 1929 and 32.819 in 1990. Tangible capital comprises facilities, machineries, stocks and natural resources. Intangible capital comprises education, R&D and services. The importance of knowledge expressed by R&D and innovation comes also from other data. According to McCloskey (1985) the increase of annual productivity in the UK between 1780 and 1860 was of 1,33%. Only 0,14% derives from a greater capital intensity, while the remaining 1,19% was generated by innovations in processes and products. Similar data come from Solow (1971) regarding the US from 1909 to 1949: only a 12,5% increase in productivity was caused by a greater capital intensity while the remaining 87,5% derived from process and product innovations.
The growing importance of R&D&I was already present during the first industrial revolution in UK. The knowledge useful for innovation was embodied in the mind and body of the inventors. They worked alone or in small groups detached from universities. The knowledge they employed was mainly procedural, know-how that had the feature of being tacit and not transferable in any linguistic format (descriptions, blue prints, diagrams, and patents). The inventions gave rise to innovations subjects to the "law of diminishing returns" (Mokyr, 2002a; 2002b), because the lack of a scientific base didn't allow the enlargement of the area of application of innovation. Many factors, in particular the growing selective pressures of market competition and the new financial opportunities arising from the development of the joint-stock companies and share markets, changed the way of pursuing innovation. In particular in the US, after the Sherman Antitrust Act of 1890 forbidding the trust agreements among firms, followed by the decision of Supreme Court against horizontal fusions among firms and the new laws aimed at strengthening Intellectual Property Rights in industrial patents, there was a growing attention to the factors that might increase the rate of radical innovation, first of all science (Rosenberg & Mowery, 1998). Many industrialists, like Kodak and Du Pont, began to establish strong links with academic labs. Edison Menlo Park laboratory was the model of science applied to technology. A similar phenomenon had happened some time before in Germany with the organic chemistry revolution.

The convergence of university and industry was not an unilateral phenomenon caused by industrial striving to become more competitive. Also universities had gradually changed their attitude towards industry. While the academic world at the beginning of the century opened itself towards applied research in order to pursue social and political needs (mainly in agriculture, health, and geology) - change labelled as the First Academic Revolution - around the middle of the century another shift happened. The universities, in particular the American ones, following the MIT-Stanford model began to be active partners in companies, in order to earn industrial contracts, to sell academic patents, to establish spin-off companies, etc.. This radical shift in respect to the pure XIX century academic functions of teaching and basic research, seems to characterize the Second Academic Revolution (Etzkowitz, 1998). This metamorphosis of the university was caused by many factors, but mainly by the shortcomings of public funds (because of the fiscal crisis of the state) and by a new demand from government and society that universities contribute to local and national economic growth and welfare.

The convergence of university and industry driven by the government is also called the Triple Helix (Leydesdorff & Etzkowitz, 1996) and characterizes the current innovation policy and the academic transformation in most first world and emergent countries. Most of the models of local industrial development – cluster, regional innovation system, hub, milieu, tecnopoli, etc.. - are centred on the strong links and collaboration between university and industry.

The collaboration initially focused on the consultancy of academics to the company regarding upgrading the scientific literature or advices on specific technical problems. But soon, particularly in the States and in some certain field such as ICT and life sciences, the collaboration spread to many different aspects of technological innovation. In particular focus was placed on the transfer of knowledge, represented mainly by patents or patent applications to the company. But as shown by the results of a research conducted at MIT the importance of patent transfer seems greatly over estimated (Agarwal and Henderson, 2002; Lester, 2005). Infact MIT faculty members of Mechanical Engineering and Electrical Engineering and Computer Science, all of them patent holders, patenting and licensing activity was perceived to be responsible for less than 7% of the knowledge transfer out of university. Faculty consulting (26%), publications (18%), and recruiting of students (17%) were all ranked significantly higher (Agarwal and Henderson, 2002).

In any case the pursuit of academy-industry relations was and is not an easy task, particularly in some countries. According to many surveys the academy-industry relations remain difficult. The 2008 executive opinion survey of IMD on knowledge transfer between university and industry shows an assessment that doesn’t overcome 6.9 (in an index from 0 to 10) with most of country from continental Europe at the bottom of ranking (see the enclosure). A little better, but similar data are about the public and private sector ventures (see the enclosure). OECD in its paper on open innovation (2008) remarks the difficulty of collaboration in innovation activities between companies and universities or public research organization. The preference of companies direct themselves towards suppliers and customers (see the enclosure). The data coming from the 4th Community Innovation Survey (CIS-4) are confirmed by EPO applications with multiple applicants (1980-2003) that show that the co-assignments beween companies and public research institutions (universities and public research organizations) are less important than the business co-application (see the enclosure).

There are some data coming from empirical studies that tried to explain the causes of this difficulty in academy-industry relations. Some studies try to deepen the cultural distances between academicians and entrepreneurs (Nooteboom, et al., 2007). In one of them (Siegel et al., 1999) it was underlined the role of different norms, standards and values as a barrier to effective UITT (University Industry Technology Transfer). Lack of understanding was the main barrier for UITT. The cultural distance was evident from the primary motives for university scientists – recognition within scientific community – compared to those of entrepreneurs – financial gain. The organizational culture of universities values creativity, innovation and, mainly, advancement of knowledge. On the contrary the organizational culture of companies rewards timeliness, speed, and flexibility (Siegel, et al., 1999).

The main features of the studies trying to single out the obstacles to technology transfer are two: 1) They give a great emphasis to wrong structure of economic incentives as the main cause of distance between universities and companies; 2) They try to single out social and cultural differences without understanding and deepening which are their real effect in hindering the academy-industry collaboration. The first position is a typical economic reductionist thesis that fails to understand complex nature of human motivations to act. Is a thesis that can be applied to *econs,* that is *homo oeconomicus*, and not to *humans* (Thaler and Sustein, 2008). It is a well established empirical knowledge that, *ceteris paribus,* the economic incentives and the context of choice humans behave very differently according their history, their personality traits, their emotional and knowledge structure, their set of values and so on. When the context of choice is variable, as in the real world case of university-industry relations, complexity is greater. For example same economic incentives have a different impact according to the different frames and communication means that trasmit them. In any case, even if we can suppose that economic incentives may push academic and industrial scientists to interact, that doesn't mean that dialogue doesn't risk to be as in the *Theatre of Absurd* of Samuel Beckett. The interaction doesn't succeed to become a fruitful collaboration and problem solving because background knowledge, epistemological interests and ways of reasoning and decision making are incompatible and in some cases incommensurable each other. Economic incentives are important but are one of many variables to consider. The second thesis is more realistic, but it has the defect not to regard humans as emotional cognitive agent, but only as social actors. Knowledge of social and cultural differences between academic and industrial context is important. But they represent a true explanation of obstacles to university-industry interaction and knowledge transfer if we single out how these values can influence the internal mechanisms of collaboration and working of group. In other words we should single out how these values and norms influence linguistic coordination, psychology of group, and thinking, reasoning and decision making processes. At the level of internal mechanisms of collaboration and cognitive coordination it is possible to single out and understand real obstacles to knowledge transfer.

The obstacles will be analyzed according two dimensions: that of knowledge transfer through the licensing of a patent or of a technology and that of the knowledge transfer through the collaboration between academic and industrial researchers aimed at developing a commercial product. The first dimension will be analyzed very briefly. It will focus on the problem of tacit knowledge that has been analyzed in previous papers (Pozzali and Viale, 2007; Balconi, Pozzali and Viale, 2008; Viale and Pozzali, 2008). The present paper will deepen the second dimension of the obstacles to collaboration between academic and industrial researchers.

2) OBSTACLES TO KNOWLEDGE TRANSFER (1): TACIT KNOWLEDGE

2.1 In theory the relations between universities and business might be simple. The company asks for a technological solution and the university labs prepare it and sell or send the patent to the company.
In reality there are many institutional, social and legal features that hamper this collaboration. Every national and local dimension presents its own features. Obstacles can be negative social incentives inside the university. For example the negative assessment of the collaboration with the business can hinder one's academic career. The interest in knowledge can be very different: the university is interested only for curiosity driven research, whereas business is only interested in research for direct commercial aims. The legal constraints of academic employment can be strong disincentives to the collaboration with a corporate lab. Sometimes the law can also forbid an academic consultancy. There can be spatial and social distances between the two worlds. University buildings are generally far from industrial areas and the academic community that is inside this social network is often completely detached from that of entrepreneurs and of the business community.
These kinds of obstacles are still widespread and present in many situations in continental Europe as they are in emerging and third world countries. And some governments are undertaking initiatives to neutralize them. In some cases they have been successful, but our question is: if these obstacles are neutralized and knowledge transfer and collaboration remains still difficult, what might be the other obstacles?

The first answer concerns the fact that the transfer through some form of explicit representation of knowledge (e.g. patent, publication, report, diagram, flow chart, etc..) is, most of the times, incomplete because of the presence of some tacit aspects of knowledge.

The concept of "tacit knowledge", introduced in modern epistemological literature through the seminal work of the scientist and philosopher of science Michael Polanyi (1958; 1967), has experienced over the years an ever widening application in a growing number of disparate disciplines, that range from psychology to mathematics, from econometrics to religious thought, from aesthetics to evolutive economy

As could be expected, with the expansion of the use of the term, critical voices have also multiplied, whose objections are based particularly on two aspects:

On one hand, the concept of tacit knowledge is said to have been used in an indiscriminate manner in too heterogeneous a series of contexts, without concerns for coming to some conceptual clarification of the meaning to be attributed to the concept itself. As a result, the term "tacit knowledge" has become less precise and more vague: it can be used in many different instances, but in fact lacks any effective explicatory value (Cowan, David and Foray, 2000, 213).

On the other hand, the ever greater capillary diffusion of information and telecommunication technologies should increase the capacity to codify information and therefore to strongly limit the domain of "tacit knowledge". According to this viewpoint, in principle, all knowledge to some degree can be codified: it is only the different cost/benefit structures associated with the codification operation that determine if the given knowledge remains tacit and unexpressed (Dasgupta and David, 1994, 502; on the same subject, see also Foray and Cowan, 1997; Foray and Steinmueller, 2003).

As it is described in Balconi et al. (2008) the thesis about strong effect of computer and telecommunications advances on reduced degree of tacitness is groundless. The main flaw of this thesis is reduction of tacitness only to know-how. On the contrary tacitness can be present in other types of knowledge that play an important function in technology transfer and that can't be overcome by ICT advances.

Tacit knowledge can be classified in the following three categories (Pozzali and Viale, 2007):

Tacit knowledge as competence(C): this class includes all the forms of physical abilities and skills that refer to the capacity of a subject to know how to perform certain activities without being able to describe the knowledge he used to do the task. This kind of tacit knowledge operates in particular in physical-like abilities such as swimming or riding a bicycle: in all these *skilful performances*, the activity is carried out by following a set of rules that are not explicitly known by the person following them. The same holds also for more complicated and less common abilities, that are

at the base of the development of craftsmanship (for example, the ability to make a violin) and of large technological innovations (such as nuclear weapons, cfr. MacKenzie and Spinardi, 1995, or aircrafts, cfr. Vincenti, 1990).
Tacit knowledge in the form of competence is at the base of the concept of "*know-how*" (Ryle, 1949/1984) and of *procedural knowledge* (Anderson, 1983). This knowledge type also has an important role in the development of scientific and technological innovations, as has been pointed to in numerous works in the sociology of science and in the history of technology (Cambrosio and Keating, 1988; Vincenti, 1990; Collins, 1992, 2001; Jordan and Lynch, 1992; Mackenzie and Spinardi, 1995; Pinch, Collins and Carbone, 1996). In the economic field, the work of Nelson and Winter (1982) is the classic reference for the analysis of the importance of tacit skills in evolutionary economics and in the organizational capabilities approach to the theory of the firm.

Tacit knowledge as background knowledge (BK): in this class we find all those forms of interiorised regulations, of codes of conduct, of values and widespread knowledge that a determined subject knows from his direct experience. This knowledge cannot be articulated or formalised because of its extremely dispersed nature, which makes it difficult to access to it by conscious awareness. This type of tacit knowledge has more than one affinity with the notion of *background*, introduced by Searle in an attempt to find a solution to the problem of retrieving a stable foundation for the process of the interpretation of rules and of representations (Searle, 1992; 1995). *Background* is defined as that set of biological and cultural capacities, of assumptions, of presuppositions and of pre-theoretic convictions that are the preconditions of any form of theoretical knowledge.

Tacit knowledge as implicit cognitive rules(ICRs): As a matter of fact, the possibility of considering tacit knowledge as also having a cognitive dimension was for many years substantially ruled out in epistemology and in cognitive sciences. The only way of considering tacit knowledge was limited to admitting that it could have a role in skill-like abilities. In the last few years this kind of veto toward a form of "tacit cognition" is beginning to vacillate, thanks in particular to the empirical and theoretic evidences coming from cognitive psychology and from the neurosciences. The first and perhaps the most significant example of a form of tacit knowledge is linguistic knowledge (Chomsky, 1986, 263-273). This form of knowledge does not represent, in a strict sense, a form of skill, but must be considered as an actual cognitive system, defined in terms of mental states and structures that cannot be articulated in words nor described in a complete formal language. Moreover, not only the acquisition, but also the utilization of linguistic knowledge does not seem to imply a reference to the formalized rules of language, but rather an automatic and mostly unconsciously reference to the acquired abilities: "*the knowledge of grammatical structures (…) is*

not present in a conscious way in most of the cases where we use the language effectively and perfectly correctly" (Damasio, 1999, 357)[1].
Other examples of cognitive forms, not *skill-like* nor *background-like,* of tacit knowledge come from the substantial number of studies on implicit learning processes (Reber, 1993; Cleeremans, 1995; Cleeremans, Destrebecqz and Boyer, 1998), in particular those relating to experiments in artificial grammar and probabilistic sequence learning[2]. On the whole, it is possible to say that research on implicit learning shows how subjects are able to make use of the hidden structural characteristics that make up the essence of a given phenomenon, though they are not able to come to the complete and explicit knowledge of these same characteristics. The knowledge that enables the subjects of implicit learning experiments to obtain this type of results can be considered, together with linguistic knowledge, as a type of tacit knowledge that is neither a purely physical "skill", nor a form of "familiarity" or "background" knowledge. We propose to define this kind of tacit knowledge as *implicit cognitive rules* that can guide the actions and decisions of a subject while at the same time remaining confined to the tacit domain. The type of tacit knowledge subjects seem able to develop in implicit learning experiments is knowledge that can not be expressed and at the same time surely has a direct causal impact on subjects' decisions and performances. We can consider it as a kind of tacit analogue of other well known cognitive mechanisms such as pragmatic schemes, heuristics, mental models and so on. As it is knowledge able to influence the decisions made by the subject, it is a real cognitive rule, that is held in an implicit way. For this reason we propose to categorize it as implicit cognitive rules.
Even if empirical research on this type of tacit knowledge is still in great part lacking, we suspect that it may be considered as an important element in the development of heuristics, rules of thumb and case-based expertise that are commonly used in decision-making processes (Gigerenzer, 2000). In economic literature, we might find this type of tacit knowledge being described as a component of "expert knowledge" and of "organizational routines" (Nonaka and Takeuchi, 1995; Cohen, Burkhart, Dosi, Egidi, Marengo, Warglien and Winter, 1997). We believe the clarification of this elements to be one of the main future topics for the future advancement of tacit knowledge research in cognitive science and in economics both.

2.2 As we previously mentioned the potential for the development in information and communication technologies should significantly extend the realm of explicit knowledge and confine tacit knowledge to an increasingly marginal role (Dasgupta and David, 1994; Foray and Cowan, 1997; Foray and Steinmueller, 2003).

[1] Even if in certain cases it is possible to admit that, in the case of language, we can reach the formulation of an explicit rule, the fact remains that the total formalisation and codification of linguistic knowledge has not yet been reached, in spite of the considerable research efforts expended over the years.
[2] To remain in the field of neurosciences, further empirical evidence supporting the role of tacit knowledge in individual cognitive processes comes also from research on implicit memory and perception phenomena (cfr. Atkinson, Thomas and Cleeremans, 2000; Raichle, 1998; Zeman, 2001).

As correctly pointed out by Johnson, Lorenz and Lundvall, this type of reasoning cannot be conducted in the abstract, but must take into account the fact that different forms of knowledge can have different degrees of codifiability.
More current and precise informations on the different forms of codifiability and transmission of tacit knowledge come from the work of Margherita Balconi, who analyses with extreme detail how the processes of codification have taken place over these last years in different industrial sectors (steel, semiconductors, mechanical). Balconi correctly points out how different forms of complementarity/substitutability can exist between tacit knowledge and ICTs: while some types of tacit knowledge can be substituted by ICTs, others have to be considered complementary to ICTs:

> *"Tacit skills which have been substituted by codified know how and have become obsolete in most modern manufacturing processes, are those relying on the perceptions of sensory organs or manual ability. (…)* Either their tacit knowledge has been codified and the execution of their activity assigned to a machine/instrument, or a technological innovation has changed the production process and made their specific knowledge obsolete. *(…) Tacit skills which complement codified and automated manufacturing processes are those heuristics and interpretative skills which serve to decode and assign meaning to information-bearing messages (structured data inputs, codified know-how) and to create novelties"* (Balconi, 2002, 31).

A study conducted on innovation in the biotechnology sector enabled to collect empirical evidence that shows how, even in the high tech sector, tacit knowledge as competence has an important role in innovation processes, but it is also relatively easy to transfer to other subjects (Viale and Pozzali, 2003; Pozzali, 2004a). There are two principal methods with which this transmission can take place:

- the *embodiment* of the subject's tacit knowledge inside an automatic device that mimics the subject's performance step by step;
- the construction of algorithms that make use of the calculation power of an electronic processor to elaborate, wherever possible, computationally highly complex processes which manage to achieve the same results that the subjects are able to achieve by using physical and perceptive abilities impossible to implement in a technological device.

What is even more interesting in Balconi's work, however, concerns the second aspect, the one related to tacit knowledge that must be considered complementary to ICTs and not substitutable or codifiable. This type of knowledge is made up of heuristics of judgment, specific problem solving abilities, and individual intuitive capacities that have a specifically cognitive character, at the base of which we can trace a precise correlation of a neurological type:

> "*These categories draw upon the way the human brain functions, on the basis of* pattern matching *(Ginsberg, 1998). Humans have a clear advantage over computers in those situations that need to be addressed through a method of pattern matching instead of computing"* (Balconi, 2003, 362).

The suggestions that come from the empirical research conducted by Balconi can be inserted in that line of reflection on problems of tacit knowledge that detects in the sphere of *pattern matching* and of *signalling* activities (that is, the activation of a given behavioral or cognitive response to the repeated exposure to a series of external stimuli characterized by structural regularity: cfr. Dewey and Bentley, 1949) an extremely promising field of research (Gourlay, 2002; Pozzali, 2004b). Within this field it is possible, in fact, to find examples of those cognitive forms of tacit knowledge, (that is tacit knowledge as implicit cognitive rules), that are acquired and transmitted through processes of *implicit learning* like the ones mentioned above. This type of tacit knowledge is not easily codified or transmitted and ICT technologies, in this sense, are not a great help (Balconi, 2002, 359).
It is precisely this type of tacit knowledge that represents a kind of "cognitive bottleneck", which economic literature and studies on technological innovation and processes of technological transfer will inevitably have to consider.

3) RELATION BETWEEN BACKGROUND KNOWLEDGE AND COGNITVE RULES

3.1 The tripartition described above does not mean that there are no connections and blurred boundaries between the three types of tacit knowledge. In particular, the relationship between BK and ICRs appears to be one of strong cognitive integration. The close relationship between BK and ICRs is highlighted in the results of numerous studies on developmental psychology and cognitive anthropology. Our inferential and heuristic skills appear to be based on typical components of BK. Moreover, our reasoning, judgment, and decision-making processes seem to rely on principles that are genetically inherited from our parents.
Infants are endowed with an innate set of principles that allows them to begin to interact with the world. Data reported by developmental psychologists show how the capacity for reasoning and decision-making is built on a foundation of implicit principles, of innate origin, contained in the child's tacit background knowledge. In addition to the universal principles described earlier, the child also assimilates cultural-based schemes and principles that determine the development of cognitive

styles valid only at local level (Viale, 2006). These take the form of principles, values, and theories of a metaphysical, ontological and epistemological nature that vary depending on the cultural context and which generate different implicit cognitive rules. These different rules provide a unique characterisation of the perception and representation external reality, the use empirical data inductively, the use deductive methods of reasoning, of categorising phenomena, of making probability judgments, etc. This cultural and acquired aspect of BK gives rise to profound differences between various cultural areas in terms of the cognitive style of ICRs. A case in point is provided in the studies of the cognitive and perceptive differences among Asians and Americans reported by Nisbett and Masuda (2006), Nisbett, Peng, Choi and Norenzayan (2001) and Nisbett (2003). They rely on an impressive number of cognitive tests that try to compare the manner of reasoning of North Americans, mainly university students, and East Asians –Korean, Chinese and Japanese – mainly university students. The East Asians and the Americans respond in qualitatively different ways to the same stimulus situation in many different tests. For example, American participants showed large primacy effects in judgements about co-variation, whereas Chinese participants showed none. "Control illusion" increased the degree of co-variation seen and the reported accuracy of Americans but tended to have the opposite effects on Chinese. Koreans were greatly influenced in their causal attribution by the sort of situational information that has no effect for Americans. Koreans showed great hindsight bias effects under conditions where Americans showed none. Finally, Americans responded to contradiction by polarising their beliefs, whereas Chinese responded by moderating their beliefs.

We can summarise the results as follows.

The *American* vs. *East Asian style of thinking* (Nisbett et al., 2001).

1) ***Explanation***: East Asians tend to explain events, both social and physical, more with respect to the field and Americans tend to explain events more with respect to a target object and its properties.
2) ***Prediction*** and "***postdiction***": East Asians tend to make predictions with reference to a wider variety of factors than Americans do. Consequently, they are less surprised by any given outcome and they are more prone to "hindsight bias", or the tendency to regard events as having been inevitable in retrospect.
3) ***Attention***: since East Asians locate causality in the field instead of the object, they tend to be more accurate at "co-variation detection", that is the perception of relationship within the field.
4) ***Control***: Americans are more subject to the "illusion of control", that is, a greater expectation of success when the individual is involved in interaction with the object – even when that interaction could not logically have an effect on the outcome.
5) ***Relationships and similarities*** vs. ***rules and categories***: East Asians tend to group objects and events on the basis of their relationships to one another, for

example, “A is a part of B”. Americans would be expected to group them more on the basis of category membership, for example, “A and B are both Xs”. Americans are inclined to learn rule-based categories more readily than East Asians and to rely on categories more for purposes of inductive and deductive inference.

6) ***Logic*** vs. ***experiential knowledge***: East Asians are more influenced by prior beliefs in judging the soundness of a formal argument. Americans are more able to a set aside prior beliefs in favour of reasoning based on logical rules.
7) ***Dialectics*** vs. ***the law of non-contradiction***: East Asians are inclined to seek compromise solutions to problems (“Middle Way”) and to reconcile contradictory propositions. Americans tend to seek solutions to problems in which a given principle drives out all but one competing solution, to prefer arguments based on logic, and to reject one or both of two propositions that could be construed as contradicting one another.

The crucial thesis of Nisbett et al. (2001) and Nisbett & Masuda (2006) is that the different ways of reasoning, that is the different ICRs, are not a contingent and superficial feature, but are rooted in two completely different systems of thinking, that is, in different metaphysical and epistemological principles contained in the BK, that shape American and East Asian cognition differently. These two different systems of thinking originated causally from two different socio-cultural environments: the old Greek trading society and classical philosophy on one hand and the old Chinese agricultural society and Confucian philosophy on the other. In fact, according to them, social organisation and economic structure are the major determinants of the causal chain metaphysics-epistemology-cognition. Different socio-economic configurations generate fixed irreversible different causal chains. Different social and economic variables gave birth to different styles of thought that we can summarise under the heading of “holistic” and “analytic” thought. Nowadays, these different styles of thought continue to be effective in differentiating the reasoning processes of contemporary Americans and East Asians.

Norenzayan (2006) also confirms, experimentally, the results of Nisbett & Masuda (2006), Nisbett (2003) and Nisbett et al. (2001). The cultural differences between Western and Asiatic populations are examined in a variety of cognitive tasks that involve formal and intuitive reasoning. “Formal reasoning is rule-based, emphasises logical inference, represents concepts by necessary and sufficient features, and overlooks sense experience when it conflicts with rules of logic. Intuitive reasoning is experience-based, resists decontextualising or separating form from content, relies on sense experience and concrete instances, and overlooks rules and logic when they are at odds with intuition. The reasoning of European American, Asian American, and East Asian university students was compared under conditions where a cognitive conflict was activated between formal and intuitive strategies of thinking. The test showed that European Americans were more willing to set aside intuition and follow rules than East Asians”.

Norenzayan (2006)) agrees with the previous consideration about the relationships between BK and ICRs. The human mind is equipped with basic cognitive primitives and possesses cognitive processes that carry out many tasks, such as exemplar-based categorisation, deductive reasoning, causal attribution, and so on. However, this basic endowment does not rule out differentiated development in response to cultural and environmental stimuli. These differences are manifested in various ways. Firstly, different cultural practices can make a given cognitive process, which is universally available in principle, accessible in a differentiated way. Asians appear to have a greater propensity than Westerners for exemplar-based categorisation, and a lesser propensity to decontextualise deductive arguments tending more to explain behaviour by referring to the situational context. Secondly, through discoveries and inventions, societies often introduce artificial and complex new ways of thinking which differentiate one culture from another. One needs only think of the statistic and probabilistic revolution in the 17^{th} century and its impact on Western rationality and decision-making models, or of the development and influence of the ancient Taoist notion of yin and yang in the contemporary Chinese way of reasoning in relation to modal concepts like change, moderation and relativism.

In conclusion, the cultural diversities of BK lead to different ICRs. This diversity at the level of BK is often an underlying factor for difficulties involving social coordination and the communication and transmission of knowledge. This can often be seen in the relationship between individuals belonging to radically different cultures, for example from Eastern and Western cultures:

> *“There are very dramatic social-psychological differences between East Asians as a group and people of European culture as a group. East Asians live in an interdependent world in which the self is part of a large whole; Westerners live in a world in which the self is a unitary free agent.*
>
> *Easterners value success and achievement in good part because they reflect well on the groups they belong to; Westerners value these things because they are badges of personal merit. Easterners value fitting in and engage in self-criticism to make sure that they do so; Westerners value individuality and strive to make themselves look good. Easterners are highly attuned to the feelings of others and strive for interpersonal harmony; Westerners are more concerned with knowing themselves and are prepared to sacrifice harmony for fairness. Easterners are accepting of hierarchy and group control; Westerners are more likely to prefer equality and scope for personal action. Asians avoid controversy and debate; Westerners have faith in the*

rhetoric of argumentation in arenas from the law to politics to science.” (Nisbett, 2003, pp.76.77)

The different composition of BK in terms of its principles and values generates profound differences between various aspects of everyday life and social organisation. In particular, as is highlighted by Nisbett (2003, pp.193-201), there are dramatic differences in the way in which medicine, science, law, contracts, conflicts, rhetoric, political relations, human rights and religion are developed and perceived. These differences emerge as the result of contextual diversity in the causal relationship between BK and ICRs. Such diversity is also found in more homogeneous cultural settings.

3.2 The dependence of implicit cognitive rules from tacit background knowledge can be explained by cognitive science. Infants are endowed with an innate set of principles that allows them to begin to interact with the world. Among these principles, one of the most important allows a causal attribution to relations between physical events. At around the age of 6 months, the infant is able to apply the principle of cohesion – a moving object maintains its connectedness and boundaries – the principle of continuity – a moving object traces exactly one connected path over space and time – and the principle of contact – objects move together if and only if they touch (Spelke, Phillips & Woodward, 1995). Moreover, there are theories of biology and of psychology. These theories show that infants individuate some theory-specific causal mechanisms to explain interactions among the entities in a domain. A child has an intuition of what characterises a living being from an artefact or an object. Between the ages of 2 and 5, the child assumes that external states of affairs may cause mental states and that there is a causal chain from perception to beliefs to intentions and to actions (see Sperber, Premack & Premack, Eds., 1995). What are the features of these principles? Data from developmental studies and a certain universality of causal perception in cross-cultural studies seem to support the hypothesis that we are endowed with early-developed cognitive structures corresponding to maturational properties of the mind-brain. They orient the subject’s attention towards certain types of clues, but they also constitute definite presumptions about the existence of various ontological categories, as well as what can be expected from objects belonging to those different categories. Moreover, they provide subjects with “modes of construal” (Keil, 1995), different ways of recognising similarities in the environment and making inferences from them. These principles constitute a core of probably innate “intuitive theories” which are implicit and constrain the later development of the explicit representations of the various domains. As Gelman highlights, “different sets of principles guide the generation of different plans of action as well as the assimilation and structuring of experiences” (1990, p. 80). They establish the boundaries for each domain which single out stimuli that are relevant to the conceptual development of the domain. Data reported by developmental psychologists show how the capacity for reasoning and decision-making is built on a foundation of implicit principles, of innate origin, contained in the child's tacit background knowledge. In addition to the universal principles described earlier, the child also assimilates culture-based schemes and principles that determine the development of cognitive styles valid only at local level (Viale, 2006). These take the form of principles, values, and theories of a metaphysical, ontological and epistemological nature that vary depending on cultural context and which generate different implicit cognitive rules. These different rules provide a unique characterisation of the way of perceiving and representing external reality, the way of using empirical data inductively, of using deductive methods of reasoning, of categorising phenomena, of making probability judgments, etc. This cultural and acquired aspect of BK gives rise to profound differences between various cultural areas in terms of the cognitive style of ICRs.

The dependence of ICR from BK is not justified by the cognitive theories that support an autonomous syntactic mental logic. According to these theories (Beth and Piaget, 1961; Braine, 1978; Rumain, Connell and Braine, 1983) the mind contains a natural deductive logic (which for Piaget is the propositional calculus) that allows to do some inference and not other. For example the human mind is able to apply the *modus ponens* and not *modus tollens*. In the same way, we could also presuppose the existence of a natural probability calculus, causal reasoning rule, risk assessment rule, and so on. Many empirical studies and some good theories give an alternative explanation that neglect the existence of mental logic and of other syntactic rules (for the pragmatic scheme theories: Cheng and Holyoak, 1985, 1989; Cheng and Nisbett, 1993; for the mental models theory: Johnson Laird, 1983, 2007; for the conceptual semantic theory see Jackendoff, 2007). The first point is that there are many rules that are not applied when the format is abstract, but which are applied when the format is pragmatic, that is when it is linked to every-day experience. For example the solution of the *selection task problem*, that is the successful application of *modus tollens,* is possible when the questions are not abstract but are linked to problems of everyday life (Politzer, 1986; Politzer and Nguyen-Xuan, 1992). The second point is that, most of the time, the rules are implicitly learned through pragmatic experience (Reber, 1993; Cleeremans, 1995; Cleeremans, Destrebecqz and Boyer, 1998). The phenomenon of implicit learning seems so strong that it occurs even when the cognitive faculties are compromised. From recent studies (Grossman, Smith, et al, 2005) with Alzheimer patients it seems that they are able to learn rules implicitly but not explicitly. Moreover, the rules that are learnt explicitly in a class or are part of the inferential repertoire of experts are often not applied in everyday life or in test based on intuition (see the experiments with statisticians of Kaheneman and Tversky).

At the same time the pragmatic experience and the meaning that people give to the social and natural events are driven by background knowledge (Searle, 1995 and 2008; Smith and Kossylin, 2007). The values, principles, and categories of background knowledge, stored in memory, allow us to interpret reality, to make inferences, to act, that is to have a pragmatic experience. Therefore, background knowledge affects implicit learning and the application of the cognitive rules through the pragmatic and semantic dimension of reasoning and decision making[3]. The mental structure that connects background knowledge and cognitive rules can be represented by a *schema* (an evolution of the *semantic network* of Collins and Quillian, 1969), that is a structured representation that captures the information that typically applies to a situation or event (Barsalou, 2000). They establish a set of relations that links properties. Thus the schema for a birthday party might include guests, gifts, cakes, and so on. The structure is that the guests give gifts to the birthday celebrant, and that everyone eats cake, and so on. What it is important is that the relationships within schemas and among different schemas allow us to make inferences, that is, they correspond to the implicit cognitive rules. For example consider our schema for glass. It specifies that if an object made of glass falls onto a hard surface, the object may break. This is an example of causal inference. Similar schemas can allow you to make inductive, deductive, analogical inferences, to solve problems and to take decisions (Markman & Gentner, 2001; Ross, 1996). In conclusion the schema theory seems to be a good candidate to explain the dependence of ICR from BK.

4) OBSTACLES TO KNOWLEDGE TRANSFER (2): COGNITIVE STYLES

4.1 Usually the obstacles to the collaboration between universities and companies are analyzed comparing entrepreneurs or managers and academic scientists (plus the academic TTO officers as in the case of Siegel et al. , 1999). In my opinion this choice is correct in the case of transfer of patent and in licensing technology, because the relation is between academic scientist and entrepreneur or manager, often through academic TTO officer. Different situation is that of collaboration between the university and industrial labs in order to achieve a common goal, like development of a prototype, invention of a new technology, solution to an industrial problem, and so on. In these cases the interaction is mainly between academic and industrial researchers. Entrepreneurs, managers and TTO officers might play only the role of starting and making easier the relation. Since the academy-industry relations don't reduce themselves only to patents and licences (Agarwal and Henderson, 2003) but find in the joint research collaboration their priority, I prefer to focus on academic and industrial researchers behaviours. As I wrote above, previous studies on obstacles between universities and companies analyzed only superficial economic, legal, and organizational aspects, mainly focused in transfer of patents and licences. Since research collaboration implies a complex phenomenon of linguistic and cognitive coordination and attuning among members of the research group I think that a deeper cognitive investigation about this dimension might give some interesting answer to *academy-industry problem*. The main hypothesis is that there

[3] It is not clear if the process is not linear but circular and recursive. In this case the cognitive rules might become part of the background knowledge and that could change its role in the pragmatic experience and in the reasoning and decision making processes.

can be different cognitive styles in thinking, problem solving, reasoning and decision making that can hamper the collaboration between academic and industrial researchers. These different cognitive styles are linked and mostly determined by a different set of values and norms that are part of background knowledge (as we have seen above). Different background knowledge is also responsible of bad linguistic coordination and understanding and of the difficulty of a successfull psychology of group.
The general hypotheses that will be inferred in this paper represent a research programme of empirical tests to control the effects on cognitive styles of different scientific and technological domains and geographical contexts.

4.2 What is the different background knowledge between university and industrial labs and how can this influence cognitive styles?
There were studies in the sociology of science that have focused on the values and principles that drive scientific and industrial research.
Academic research seems to be governed by a set of norms and values that are close to Mertonian *ethos* (Merton, 1973). Communitarism, scepticism, originality, disinterestedness, universalism and so on were proposed by Robert Merton as the social norms of scientific community. He justified theoretically the proposal. Other authors like Mitroff (1974) criticized the Mertonian ethos on an empirical base. He discovered that scientists follow often the Mertonian norms. Nevertheless there are cases in which they seem to follow the contrary of the norms. More recent studies (Broesterhuizen and Rip, 1984) confirm most of the norms of Merton. The research should be Strategic, founded on Hybrid and interdisciplinary communities, able to stimulate the Innovative critique, Public and based on Scepticism (SHIPS). Recent studies (Siegel et al., 1999; Viale, 2001) confirm the presence of social norms that remind the Mertonian ethos. Scientist believe in the pursuit of knowledge per se, in the innovative role of critique, in the universal dimension of the scientific enterprise, in science as a public good. They believe in scientific method based on empirical testing, comparison of hypotheses, better problem solving and truth as representation of the world (Viale, 2001, 216-219). The fact that scientists have these beliefs don't prove that they act accordingly. The beliefs can be deviated by contingent interests and opportunistic reasons. They could also represent the pretended image of what they want to show to society. They also can vary from one discipline and specialization to another. Nevertheless the presence of these beliefs seems to characterize the cultural identity of academic scientists. Therefore they constitute part of their background knowledge and they can influence the implicit cognitive rules for reasoning and decision making. On the contrary industrial researchers are driven by norms that are contrary to academic ones. They can be summarized by the acronym PLACE (Ziman, 1987): Propriety, Local, Authoritarian, Commissioned, Expert. The research is commissioned by the company that has the ownership of results, that can't be diffused, and are valid locally to improve the competiveness of the company. The researchers are subjected to authoritarian decisions of the company

and they develop a particular expertise valid locally. PLACE is a set of norms and values that characterizes the cultural identity of industrial researchers. They constitute part of their background knowledge and they may influence the inferential processes of reasoning and decision making.
To sum up, the state of art of studies on social norms in academic and industrial research seems insufficient and empirically obsolete. A new empirical study of norms contained in the background knowledge is essential. The study should control the main features characterizing cultural identity of academic and industrial researchers, established by previous studies. They can be summarized in following way:

Criticism vs. Dogmatism: academic researchers follow the norm of systematic critique, scepticism, falsificatory control of knowledge produced by colleagues; industrial researchers aim at maintaining knowledge that works in solving technological problems.

Interest vs. Indifference: academic researchers are not pushed in their activity mainly by economic interest but by epistemological goals; industrial researchers are pushed mainly by economic ends like technological competiveness, commercial primacy, and capital gain.

Universalism vs. Localism: academic researchers believe in a universal audience of peers, in universal criteria of judgement that can establish their reputation; industrial researchers think locally both for the audience and for the criteria of judgement and social promotion.

Comunitarism vs. Esclusivism: academic researchers believe in the public and open dimension of pool of knowledge which they must contribute to increase; industrial researchers believe in the private and proprietary features of knowledge.

4.3 To the different backgrounds we should add also the different contingent features of the contexts of decision making (we refer to the decision-making context of research managers, that is heads of a research unit or of a research group) that become *operational norms*. The main features are related to time, results and funding. In the pure academic context[4] the time for doing research is usually loose. There are some temporal requirements when one is working with funds coming from a public call, but, in a contract with a public agency or government department the deadline is usually not so strict, and the requested results are quite not well defined and not specified as to a particular product (e.g. a prototype or a new molecule or a new theorem). Therefore, time constraints don't press the reasoning and decision making processes of the researchers. On the contrary when an academic researcher works with an industrial contract, the time constraints are similar to those of the corporate

[4] The analysis refers mainly to academic environment of Universities of Continental Europe.

researcher. Moreover, in a fixed given time a precise set of results must be produced and presented to the company. According to private law the clauses of a contract with a company can be very punitive for the researcher and for the university that don't follow the signed expected requirements. In any case the effect of sub-optimal results for an academician working with a company are less punitive than for a corporate researcher. For him the time pressure is heavier because the results, in a direct or semi direct way, are linked to the commercial survival of the company. Sub-optimal behaviour increases the risks for his career and also for his job. Therefore the great expectations on the fast production of positive concrete results press him in a heavier way. The different environmental pressure may generate a different adaptive psychology of time and a different adaptive ontology of what the result of the research might be. In the case of academic research, time might be less discounted. That is, future events tend not to be so underestimated as might happen in industrial research. The corporate researcher might fall into the bias of time discounting and myopia because of the overestimation of short term results. Even the ontology of an academic researcher in respect to the final products of the research might be different from the corporate one. While the former is interested in a declarative ontology that aims at the expression of the result in linguistic form (i.e. a report, a publication, a speech) the second aims at an object ontology. The results for him should be linked in a direct or indirect way to the creation of an object (i.e. a new molecule, a new machine, a new material, or a new process to produce them, or a patent that describe the process to produce them).

The third, different operational norm concerns financial possibilities. In this case it is not a problem of quantity of funding. The funding for academic research is usually less for each unity of research (or, better, for each researcher) than that in industrial research. But the crucial problem is the psychological weight of the funds. That is, how much the funds constraint and affect the reasoning and decision making processes of the researchers. In other words ceteris paribus the amount of money at disposal, how much the cognitive processes and in particular the attention processes refer to a sort of *value for money* judgment in deciding how to act. From this point of view it seems - but it is a topic to be investigated - that the psychological weight of money on academic researchers is less than on industrial researchers. Money is perceived with less value and therefore, influences decision making less. The reasons for this different mental representation and evaluation may come from: a) the way in which the funding is communicated and it can constitute a decision frame (with more frequency and relevance in the company because it is linked to the important decision of the annual budget); b) the symbolic representation of the money (with much greater emphasis in the company that has its *raison d'etre* in the commercial success of its products and in its increased earnings); c) from the social identity of the researchers linked more or less strongly to the monetary levels of the wage (with greater importance to the monetary level as an indicator of a successful career in a private company than in the university). The different psychological weight of the money has been analyzed by many authors, and in particular by Thaler (1999).

To summarize the operational norms can be schematized in *loose time vs. pressing time*; *undefined results vs. well-defined results*; *financial lightness vs. financial heaviness.*

4.4 How can the values in background knowledge and the operational norms influence the implicit cognitive rules of reasoning and decision making, and how are they an obstacle to the collaboration among industrial and academic researchers?

There are many aspects of cognition that are important in research activity. We can say that every aspect is involved, from motor activity to perception, memory, attention, reasoning, decision making and so on. Our aim however is to focus on the cognitive obstacles to the reciprocal communication, understanding, joint decision making and coordination between academic and corporate researchers and how that might hinder their collaboration.

I will analyse 6 dimensions of the interaction: language, group, thinking, problem solving, reasoning, and decision making.

1) It might be interesting to investigate the pragmatic aspects of ***communication***. To collaborate on a common project means to communicate, mainly by natural language. To collaborate means to exchange information in order to coordinate one's own actions to pursue a common aim. This means "using language", as in the title of Clark's book (1996), in order to reach the established common goal. Any linguistic act is at the same time an individual and a social act. It is individual because it is the subject that by motor and cognitive activity articulates the sounds that correspond to words and phrases and it is the subject that receives these sounds and makes the interpretation. Or in Goffman's (1981) terminology about the linguistic roles, it is the subject that *vocalizes, formulates*, and *means* and it is another subject that *attends the vocalization*, *identifies the utterances* and *understands the meaning* (Clark, 1996, p.21). It is social because every linguistic act of a speaker has the aim to communicate something to one or two addressees (also in the case of *private settings* where we talk to ourselves because we ourselves play the role of an addressee). In order to achieve this goal there should be a coordination between the speaker's meaning and the addressee's understanding of the communication. But meaning and understanding is based on the knowledge, beliefs, and suppositions shared, that is, in shared background knowledge. Therefore the first important point is that it is impossible for two or more actors of a conversation to coordinate meaning and understanding without reference to their common background knowledge. "A common background is the foundation for all joint actions and that makes it essential to the creation of the speaker's meaning and addressee's understanding as well" (Clark, 1996, p. 14). A common background is shared by the members of the same cultural community.

A second important point is that the coordination between meaning and understanding is more effective when the same physical environment is shared (the same room in university or the same bench in a park) and the vehicle of

communication is the richest possible. The environment represents a communicative frame that can influence meaning and understanding. Even more, gestures and facial expressions are rich in non-linguistic information and therefore are very important aids for coordination. From this point face-to-face conversation is considered the basic and most powerful setting of communication.
The third point is that the more simple and direct the coordination is the more effective the communication. There are different ways of making communication complex. The roles of speaking and listening (see above regarding linguistic roles) can be decoupled. Spokesmen, ghost writers, and translators, are examples of decoupling. A spokeswoman for a minister is only a vocalizer, while the formulation is the ghost writer's and the meaning is the minister's. Obviously, in this case, the coordination of meaning and understanding becomes more difficult (also because it is an institutional setting with many addressees). The non-verbal communication of the spokesman might be inconsistent with the meaning of the minister and the ghost writer might not be able to formulate correctly this meaning. Moreover in many types of discourse – plays, story telling, media news, reading – there is more than one domain of action. The first layer is the layer of the real conversation. The second layer is that of the hypothetical domain that is created by the speaker (when he is describing a story). By recursion there can be higher layers as well. For example the play requires three layers: the first is the real world interaction among the actors, the second is the fictional role of the actors, and the third is the communication with the audience. In face-to-face conversation there is only one layer and no decoupling. The role of vocalizing, formulating, and meaning is in the same person. And the domain of action identifies itself with the conversation. The coordination is direct without intermediaries. Therefore it is the most effective way of coordinating meaning and understanding with a minor distortions of meaning and less misunderstandings. Academic and industrial researchers are members of different cultural communities, therefore they have different background knowledge. In the collaboration between academic and industrial researchers the coordination between meanings and understandings can be difficult if the background knowledge is different. When this is the case, as we have seen before, the result of the various linguistic settings will likely be the distortion of meaning and misunderstanding. When fundamental values are different (SHIPS vs. PLACE) and also when the operational norms of *loose time vs. pressing time*; *undefined product vs. well defined product*; *financial lightness vs. financial heaviness* are different it is impossible to transfer the knowledge without losing or distorting shares of meaning.
Moreover, difficult coordination will increased in settings that utilize intermediaries between the academic inventor and the potential industrial user (*mediated settings* in Clark, 1996, p. 5). These are cases of an intermediate technology transfer agent (as in the case of the members of TTO of university or private of government TTA) that tries to transfer knowledge from the university to corporate labs. In this case, there is *decoupling* of speaking. The academic researcher is he who formulates and gives meaning to the linguistic message (also in a written setting), while the TT agent is

only a vocalizer. Therefore, there may be frequent distortion of the original meaning, in particular when the knowledge contains a great share of tacit knowledge. This distortion is strengthened by the likely different background knowledge of the TT agent in respect to the other two actors in the transfer. The TT agents are members of a different cultural community (if they are professional from a TT private company) or from different sub-communities inside the university (if they are members of TTO). Usually they are neither active academic researchers nor corporate researchers. Finally, in the technology transfer there can be also the complexity of having more than one domain of action. For example, if the relation between an academic and industrial researcher is not face-to-face, but is instead mediated by an intermediary there is an emergent second layer of discourse. This is the layer of the story that is told by the intermediary about the original process and the techniques to generate the technology invented by the academic researchers. The story can also be communicated with the help of a written setting, for example patent or publication. All the three points show that a common background knowledge is essential for reciprocal understanding, and that face-to-face communication is a pre-requisite for minimizing distortion of meaning and misunderstanding that can undermine the effectiveness of knowledge transfer.

2) The second dimension of analysis is that of the of the ***group***. When two or more persons collaborate to solve a common problem they elicit some interesting emergent phenomenon. In theory a group can be a powerful problem solver (Hinsz, Tindale, and Vollrath, 1997). But to be so members of the group must share information, models, values and cognitive processes (Hinsz, Tindale, and Vollrath, 1997). It is likely that the heterogeneity about skill and knowledge might be very useful for detecting more easily the solution. Some authors have analyzed the role of heterogeneity in cognitive tasks (e.g. the solution of a mathematical problem) and generation of ideas (e.g. the production of a new logo) and they have found a positive correlation between it and the success in these tasks (Jackson, 1992). In theory, this result seems very likely since finding a solution needs to look at the problem from different points of view. Different perspectives allow overcoming the phenomenon of *entrenched mental set,* that is, the fixation on a strategy that normally works well in solving many problems, but that does not work well in solving this particular problem (Sternberg, 2009) However the diversity that works is about cognitive skills or personality traits (Jackson, 1992). On the contrary when the diversity is about values, social categories, and professional identity it can hinder the problem solving ability of the group. In fact this heterogeneity generates the categorization of the differences and the similarities between the self and the others and the emergent phenomenon of the conflict/distance between *ingroup* and *outgroup* (Van Knippenberg and Schippers, 2007). The relational conflict/distance of *ingroup vs. outgroup* is the most social expression of the negative impact of diversity of background knowledge on group problem solving. As it was showed by Manz and Neck

(1995) without a common background knowledge there is not sharing of goals, of social meaning of the work, of criteria to assess and to correct the ongoing activity, of foresight on the results and on their impact, and so on. As it is described by the theory of *teamthink* (Manz and Neck, 1995), the establishment of an effective group in problem solving relies on the common sharing of values, beliefs, expectations and a priori on physical and social world. For example academic and industrial researchers present a different approach concerning disciplinary identity. The academic has a strong faithfulness towards the *disciplinary matrix* (Kuhn, 1962), that is composed by the members of a discipline with their set of disciplinary knowledge and methods. On the contrary the industrial researcher tend to be opportunistic in using knowledge and in choosing peers. He doesn't feel to be member of *disciplinary invisible college* of peers and chooses *à la carte* which peer is helpful and what knowledge is useful to attain the goal of research. This asymmetry between academic and corporate researchers is an obstacle to the well functioning of the *teamthink.* The epistemological and social referents are different, therefore the communication becomes a dialogue between deafs. Lastly there is the linguistic dimension. As we have seen above, without a common background knowledge the coordination of meaning and understanding among the members of the group, that is the fundamental basis of collaboration, is impossible. Moreover without a common background knowledge, the pragmatic context of communication (Grice, 1989; Sperber and Wilson, 1986) doesn't allow the generation of correct automatic and non automatic inferences between speaker and addressee. For example the addressee would not be able to generate proper *implicatures* (Grice, 1989) to fill the lack of information and the elliptical features of the discourse.
Lastly, different background knowledge influences problem solving, reasoning and decision making activity, in other words the implicit cognitive rules. Different implicit cognitive rules mean asymmetry, asynchrony, and dissonance in the cognitive coordination among the members of the research group. That means obstacle in the knowledge transfer, in the application of academic expertise and knowledge to the industrial goal, in the development of an initial prototype or technological idea towards a commercial end.

Now I will tackle the hypothetical effect of values and operational norms onto the implicit cognitive rules of academic and industrial researchers.

3) The third dimension is about ***thinking***. There are two systems of thinking that affects the way how we reason, decide and solve problem. The first is the *associative system* which involves mental operations based on observed similarities and temporal contiguities (Sloman, 1996). It can lead to speedy responses that are highly sensitive to patterns and to general tendency. This system corresponds to the system 1 of Kahneman (2003). The system represents the intuitive dimension of thinking. It is fast, parallel and mainly implicit. It is

switched on by emotional and affective factors. Knowledge is mainly procedural. It is dominant on the second when the reasoning and decision making must be fast without the possibility to analyze all the details of a problem. The second is the *rule-based system* which involves manipulations based on the relations among symbols (Sloman, 1996). It usually requires deliberate slow procedures to reach the conclusions. Through this system, we carefully analyze relevant features of the available data, based on rules stored in memory. It corresponds to system 2 of Kahneman (2003). This system is slow, serial, mainly explicit. Knowledge is mainly declarative. It can be overridden by the first when there is time pressure, there are emotional and affective interferences and when the context of decision making doesn't pretend any analytical effort. The intuitive and analytical systems can give different results in reasoning and decision making. Generally all the heuristics are example of the first system. On the contrary the rational procedures of deductive and inductive reasoning are examples of the second. This system is switched on when there is epistemic engagement in reasoning and decision making and when the individual shows *need for cognition* (Cacioppo and Petty, 1982). Therefore the intuitive system is responsible of biases and errors of everyday life reasoning, whereas the analytical system allow us to reason according the canons of rationality. In reality often the first system is more adaptive than the second in many instances of everyday life (Gigerenzer, 2007). The prevalence of one of the two systems in the cognitive activity of academic and industrial researchers will depend from contingent factors, as the need to end quickly the work, but also from the diverse styles of thinking. I can hypothesize that the operational norms of *pressing time*, *well defined results* and the social norm of *dogmatism* and *localism* will support a propensity to the activity of the intuitive system. On the contrary the operational norms of *loose time,* and *undefined results,* and the social norms of *criticism,* and *universalism* can support the activity of the analytical system. It is evident the role of time on activation of the two systems. Industrial researchers are used to follow time limits and to give value to time. Therefore this operational norm influences the speed of reasoning and decision making and the activation of the intuitive system. The contrary happens in academic labs. The other operational norm regarding the results seems less evident. Who has not constrain of well defined results has the attitude to indulge in slow, and attentive way of analyzing the features of the variables and in applying rule based reasoning. Who should end with an accomplished work can't stop on analyzing the details and should go quickly to the final results. The social norm of criticism is more evident. The tendency to control and to criticize results produced by other scientists strengthens the analytical attitude in reasoning. Any form of control is a slow and precise analysis of the logical coherence, methodological fitness, and empirical support of a study. On the contrary in corporate labs the aim is to use good knowledge for practical results and not to increase the knowledge pool by overcoming previous hypotheses through control and critique. Finally the social norm of universalism vs. localism is less evident.

Scientists believe in a universal dimension of their activity. The rules of scientific community should be clear and understandable by the peers. The scientific method, the reasoning style and the methodological techniques can't be understood and followed only by a small and local subset of scientists. Therefore they should be explicit in order to be diffused to the entire community. Thus the universality tends to strengthen the analytical system of mind. The contrary happens where there is no need of explicitness of rules and the evaluation is locally made by peers according to the working of the final product.

4) The fourth dimension is about ***problem solving***. At the end of '50 Herbert Simon with some colleagues analyzed the effect of professional knowledge in problem representation. They discovered the phenomenon of "*selective perception*" (Dearborn & Simon, 1958), that is the relation between different professional roles and different problem representations. For example, in explaining the causes of a company crisis, marketing manager will represent the problem mainly in terms of commercial communication, the staff manger mainly in terms of insufficient employment, and the book-keeper mainly in terms of an obsolete book-keeping and lack of liquidity. In the case of industrial and academic scientists I can suppose that the *selective perception* will be effective not only in relation with the professional and disciplinary roles but also with social values and operational norms. These norms and values might characterize the problem representation and therefore might influence reasoning and decision making. For example in representing the problem of a failure of a research programme, industrial researchers might point more to variables like cost and time whereas the academic scientists might more oriented towards insufficient critical attitude and too local approach. Expert from novice are differentiate by different amount, organization, and use of knowledge in problem solving. What differentiates expert from novice is their schema for solving problems within their own domain of expertise. (Glaser and Chi, 1988). The schemas of experts involve large, highly interconnected units of knowledge. They are organized according to underlying structural similarities among knowledge units. In contrast, the schemas of novices involve relatively small and disconnected units of knowledge. They are organized according to superficial similarities. (Bryson & al., 1991). Through practice in applying strategies experts may automatize various operations. The automatization involves consolidating sequences of steps into unified routines that require little or no conscious control. Through automatization experts may shift the burden of problem solving from limited-capacity working memory to infinite-capacity long-term memory. The freeing of their working memory capacity may better enable them to monitor their progress and their accuracy during problem solving. Novices in contrast, must use their working memory for trying to hold multiple features of a problem and various possible alternatives. This effort may leave novices with less working memory available for monitoring and evaluation. Another difference between expert and novice problem solvers is the time spent

on various aspects of problems. Experts appear to spend more time determining how to represent a problem than do novices (Lesgold, 1988), but they spend much less time that do novices actually implementing the strategy for solution. Experts seem to spend relatively more time than do novices figuring out how to match the given information in the problem with their existing schemas. Once they find a correct match they quickly can retrieve and implement a problem strategy. Thus expert seems to be able to work forward from the given information to find the unknown information. In contrast novices seem to spend relatively little time trying to represent the problem. Instead, they choose to work backward from the unknown information to the given information. In the collaboration between academic and industrial scientists a cognitive dissonance might stem from asymmetric expertise in problem solving. Industrial researchers can be novice in aspects where academic scientists are expert and vice versa. If this is the case the opposite backward vs. forward approach and the different time in problem representation might produce cognitive dissonance and asymmetry. In any case it might be interesting to analyze the time spent by academic and industrial researchers in *problem representation*. The hypothesis is that time pressure together with intuitive system of thinking might bring the industrial researchers to dedicate less time in problem representation than academic researchers.

Time pressure can affect the entire *problem solving cycle* which includes (Sternberg, 2009): *problem identification, definition of problem, constructing a strategy for problem solving, organizing information about a problem, allocation of resources, monitoring problem solving, evaluating problem solving.* In particular it might be interesting to analyze the effect of pressing vs. loose time in *monitoring and evaluation* phases. More time pressures could diminish the time devoted to these phases. Also dogmatism can accelerate the time spent for monitoring and evaluation whereas criticism might be responsible of better and deeper monitoring and evaluation of the problem solution.

Finally time pressure might have an effect also on *incubation.*In order to permit the old association resulting from negative transfer to weaken one needs to put the problem aside for a while without consciously thinking about it. You do allow for the possibility that the problem will be processed subconsciously in order to find a solution. There are several possible mechanisms for the beneficial effects of incubation (Sternberg, 2009). The incubation needs time. Therefore the pressing time norm of industrial researcher might hinder the problem solving success.

5) The fifth dimension is about ***reasoning.*** Reasoning is the process of drawing conclusions from principles and from evidence. In reasoning we move from what is already known to infer a new conclusion or to evaluate a proposal conclusion. There are many features of reasoning that can differentiate academic and corporate scientists. I will concentrate on three aspects of reasoning that are crucial in scientific problem solving and that may affect the cognitive coordination between academic and industrial researchers.

The first is about ***probabilistic reasoning*** aimed to up-to-date an hypothesis according some new empirical evidence. In other words how the scientist deals with new data in order to strengthen or to weaken a given hypothesis. There is a canon of rationality, the Bayes theorem that prescribes how we should reason. The mathematical notation is the following:

P(H/D)=P(D/H)P(H)/P(D/H)P(H) + P(D/nonH)P(nonH)

This theorem tells us how to calculate the effect of new information on the probability of a thesis. Kahneman and Tversky (1973) and Tversky and Kahneman (1980, 1982a and 1982b) has experimentally proved that often we fall in *base rate neglect* that is we focus mainly in the new information and we neglect the prior probability. For example if we are controlling a theory T having prior probability P(T) we tend to neglect it when we have new experimental data that change the prior probability in posterior probability P(T/D). That is we give an excessive weight to new experiments and we forget the old ones compared to what it is prescribed by Bayes Theorem. Why do we forget prior probability and we give excessive weight to new data? According to Bar Hillel (1980) we give more weight to new data because we consider them more relevant compared to the old ones. Relevance in this case might mean more affective or emotional weight given to the data and consequently stronger attentional processes on them. An opposite conservative phenomenon happens when the old data are more relevant. In this case we tend to ignore new data. In the case of industrial researchers an hypothesis may be that the time pressure, the financial weight, and well defined results tend to give more relevance to new data. New experiments are costly and they should be an important step towards the conclusion of the work. Therefore they are more relevant and privileged by the mechanisms of attention. On the contrary academic scientists without the influence of cost, time and the conlusion of the project can have a more balanced perception of relevance between old and new data.

The second is about ***deductive reasoni*****ng** and in particular the hypothesis testing. It is well known in propositional logic the rule of *modus tollens* of conditional statements:

$T \rightarrow d$
$\neg d$
$\neg T$

If a theory T implies an experimental datum d and if d is falsified then the theory T is falsified. The only way to test the truth of a theory is modus tollens, that is trying to find its falsification. In fact it is wrong to test a theory in the following way, called the *Fallacy of Affirmation of the Consequent*:

T →d
d
T no

Modus tollens was popular in philosophy of science, mainly through the work of Karl Popper and in cognitive psychology mainly through the work of Peter Wason and Phil Johnson Laird. Wason (1966) and Johnson Laird (1983) have proved that in formal test people mistake the rule and tend to commit confirmation bias that corresponds to the Fallacy of Affirmation of the Consequent. More realistic tests (Griggs and Cox, 1982) or tests linked to our pragmatic schemes (Cheng and Holyoak, 1985, 1989) improved the deductive performances. Also in science confirmation bias disappears when the falsificatory data are easy to produce, and non ambiguous (Mynatt, Doherty and Tweney, 1977; Gorman, 1992) . New studies that have analyzed the emotional and affective dimension of hypothesis testing have found that when individual is emotionally involved in a thesis he will tend to commit confirmation bias. The involvement can be various, economic (when one has invested money in developing an idea), social (because your social position is linked to the success of a project), organizational (because a leader that holds a thesis is always right) or biographical (because you have spent many years of your life in developing the theory). The emotional content of the theory causes a sort of regret phenomenon that pushes the individual to avoid falsification of the theory. From this point of view it is likely that financial heaviness and dogmatism together with other social and organizational factors would induce industrial researchers to commit more easily confirmation bias. Research is costly and it is fundamental for the commercial survival of company. Therefore their work should be successful an the results should be well defined in order also to keep or to improve their position. Moreover they don't follow the academic norm of criticism that prescribes the falsificationist approach towards scientific knowledge. Contrary to what happen to academic scientists that tend to be critic and should not be obliged to be successful in their research. It is likely that they are less prone to confirmation bias.

The third aspect deals with ***causal reasoning***. It is a fundamental aspect of reasoning in science and technology. Most of models, hypotheses and theories representing scientific and technological knowledge are causal. The main tenets of experimental method correspond to the technical evolution of Millian methods of *agreement* and *difference* (Mill, 1887). It is not the place to deepen the epistemological discussion on causality and neither that on causal cognition (for a survey on the relationship between epistemological and cognitive dimension of causality see Viale, 1997, 1999a, 1999b). The aim of this paper is to single out potential different styles of reasoning between academic and corporate researchers. In this case a different approach to causal reasoning and causal models might have a strong effect in the cognitive coordination. According to Mackie (1974) every causal reasoning is based on a *causal field*, that is the set of relevant variables able to cause the effect. It is well known that in front of the same event, for example a car accident or a disease, each expert will support a particular causal explanation (for a town planner the wrong design of the street, for a doctor the rate of alcohol of the driver, for an engineer the bad mechanics of the car, and so on). Usually once the expert have identified one of the suspected causes of a phenomenon he stops searching for additional alternative causes. This phenomenon is called *discounting error*. From this point of view the hypothesis may be that the different operational norms and social values of academic and corporate research may produce different discounting errors. Financial heaviness, pressing time, well defined results compared to financial lightness, slow time and ill defined results may limit different causal fields of the entire project. For example the corporate scientist can find the time as a crucial causal variable for the success of the project whereas the academic researcher doesn't care about it. In the same time the academic researcher can find crucial the value of universal scientific excellence of the results whereas the industrial researcher doesn't care about it. There is also the possibility of a deeper difference worth to be studied. One of the commonest bias in causal reasoning is to infer *illusory correlations* (Chapman & Chapman, 1975). We confuse correlations with causal relations, that is we fall down in a sort of *magical thinking.* According to Johnson Laird and Wason (1977) magical thinking happen for association based on contiguity, temporal asymmetry and resemblance between two events. The associative or intuitive system of thought is responsible of this phenomenon. As we know it is switched on when the time is little and there is no need of an articulated analysis of the problem. Consequently the values of dogmatism and localism and the operational norm of pressing time and well defined results of industrial researchers can be responsible of this causal bias. On the contrary the analytic or rule-based system of thought, more present in academic reasoning - because of social values of criticism and universalism and the operational norms of loose time - can neutralize the danger of illusory correlations and magical thinking.

6) The sixth dimension is about ***decision making***. Decision making involve evaluating opportunities and selecting one choice over another. There are many effects and biases connected to decision making. I would focus on some aspects of decision making that can differentiate academic and industrial researchers.

The first deals with ***risk***. In the psychological literature risk[5] is the multiplication of loss for the probability, whereas uncertainty is when an event is probable. Usually to the risk of loss is associated also the possibility of gain. In many cases to a bigger risk is associated a bigger gain (as in the case of gambling). People can have risk adversity when they don't want to take great risk in order to gain a big pay-off. They prefer to bet on red or black and not on a single number. On the contrary risk propensity exists when one takes bigger risk for bigger gain. For example betting on the least favoured horse with a bigger listing. The risk behaviour seems not linear. According to *prospect theory* (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992) risk propensity is stronger in situation of loss and weaker in situation of gain. A loss of 5 $ cause a negative utility bigger than the positive utility caused by the gain of 5$. Therefore people react to the loss with risky choices aimed to recover the loss. Another condition that increases the risk propensity is *overconfidence* (Fischhoff, et al., 1977; Kahneman and Tversky, 1996) and *illusion of control* (Langer, 1975). People often tend to overestimate the accuracy of their judgements and the probability of success of their performance. They believe to have better control of future events than the chance probability. This phenomenon is associated often to the *egocentric bias* of manager and to forms of *quasi-magical thinking* (like that of a dice player that throws the dices after having blown to them and thinks to have a better control on the results). Both the perception of loss and the overconfidence happen when there is competition, the decisions are charged of economic meaning, and have an economic effect. The operational norm of financial heaviness, and pressing time, and the social value of exclusivity, and interest of industrial researcher can increase the economic value of the choices, the perception of competiveness, and consequently can increase the risk propensity. On the contrary the social values of communitarism, and indifference, and the operational norms of financial lightness and slow time of academic scientists may create an environment that doesn't induce any perception of loss and overconfidence. Thus the behaviour tends to be more risk adverse.

A second feature of decision making is connected to ***regret*** and ***loss aversion***. We see before that according to prospect theory individual doesn't like to loose and react with risk propensity. The loss aversion is based on the regret that loss produce to the individual. The regret is responsible of many effects. One of the most important is the *irrational escalation* (Stanovitch, 1999) in any kind of investment (economic, but also political and affective). When one is involved in an investment of money to reach a goal, as the building of a new prototype of missile or the creation of a new molecule to care the AIDS, has to consider the possibility of failure. One should monitor the various steps of the programme and especially when the funds are finished he has to analyze coldly if the project has

[5] In economics, risk is when we have probability assessment whereas uncertainty is when we have no probability assessment.

some chance to succeed. In this case he should consider the moneys invested in the project as *sunk cost*, forget them and decide rationally. On the contrary people tend to be affectively attached to their project (Nozick, 1990; Stanovitch, 1999). They feel strong regret in admitting the failure and the loss of money and tend to continue the investment in an irrational escalation of wasted money to attain the established goal. The psychological mechanism is linked also to prospect theory and risk propensity under conditions of loss. The irrational escalation is stronger when there is stronger emphasis on the economic importance of the project. That is the typical situation of a private company that links the success of their technological projects to its commercial survival. The same industrial researchers have the perception that their job and the possibility of promotion are linked to the success of the technological projects. Therefore it is likely that they will tend more easily to fall in an irrational escalation compared to academic researchers that have the operational norm of financial lightness, and social norm of indifference and whose career is only loosely linked to the success of research projects.

The third aspect of decision making has to do with an irrational bias called *myopia* (Elster, 1979) or ***temporal discounting***. People tend to strongly devaluate the gains in time. They prefer small gain at once than big gain in the future. Many behaviours of everyday life witness this bias. The small pleasure of a cigarette today is more than the big gain of being healthy after 20 years. The perceived utility of a choice of a certain job without perspective now is bigger than the choice of unstable work now with greater future professional perspectives. And so on. More recently these observations about discount functions have been used to study savings for retirement, borrowing on credit cards, and to explain addiction. Drug dependent individuals discount delayed consequences more than matched nondependent controls, suggesting that extreme delay discounting is a fundamental behaviour process in drug dependence (Bickel & Johnson, 2003). Some evidence suggests pathological gamblers also discount delayed outcomes at higher rates than matched controls (Petry & Casarella, 1999). All these phenomena show a complex risk behaviour. People are risk adverse in the present, that is they want to have now a certain satisfaction (effect of drug, pleasure of gambling, certainty of a job), whereas they show high risk propensity for the future (high risk of death for drug, high risk of becoming poor for gambling, high risk of professional decline in the case of a job without perspectives). Usually this behaviour is associated with overconfidence and illusion of control. Time discounter prefer the present because he thinks to be able to control the output, the results beyond any chance esteem. In the case of industrial researcher and of entrepreneurial culture, in general, the need to have results at once, to find fast solution to the problems, to assure the share holders and the market that the company is fine and is growing seems to match with the propensity with time discounting. The future results don't mind. What it is important is the “now”, that is the ability to have new competitive products to commercially survive.

Financial heaviness, pressing time, and well defined results might be responsible of the attitude to give more weight to the attainment of fast and complete results at once with the risk of products that in the future will be defective, little innovative and easily overcome by competing products. In the case of academic scientists the temporal discounting might be less strong. In fact the three operational norms – financial lightness, loose time, and undefined results – together with criticism and universalism might immunize them from myopic behaviours. Criticism is important because pushes the scientist not to be easily satisfied by quick and unripe results that can be easily falsified by the peers. Universalism is important because the academician wishes to pursue results that are not valid locally, but that can be recognized and accepted by the entire community and that can increase his scientific reputation. In academic community it is well known that reputation is built through a lengthy process, but it is destroyed in a fast way.

5) A LITTLE OF DATA FROM AN EMPIRICAL STUDY

5.1 We have decided to begin the collection of empirical data on different cognitive styles between academic and industrial researchers starting with a pilot study based on some focus groups (Pozzali and Fondazione Rosselli, 2008).
The focus groups were three and they have been made in Milan in three technological sectors, *biotechnology*, *production systems* and *domotics.*
The participants were 8 on average for each group plus the moderator and an observer that registered the data.
Half of the participants came from university (professors involved in business consultancy and technology transfer) and half from entrepreneurial world (manager of R&D and industrial researchers).
The topics of the focus groups were:

-evaluation of time constraints
-evaluation of regret for financial loss and sunk costs fallacy
-evaluation of risk behaviour
-evaluation of values of communitarism vs. exclusivity
-evaluation of discipline oriented vs, problem oriented in problem solving

5.2 We decided to submit two tests, one for risk behaviour and the other for the sunk costs whereas the other topic were analyzed through discussion in the focus group.
The test for risk behaviour was an adaptation of the “problem of Asiatic disease” (Kahneman and Tversky, 1979) that showed the presence of *frame effect*. People tend to make different choice of options that have the same value according to the frame of loss or gain of the options. When people perceive a frame of gain they tend to be risk adverse and choose the least risky option. When people perceive a frame of loss they tend to be risk inclined and choose the most risky option. The different answers

are explained by *prospect theory* (Kahneman and Tversky, 1979). The test was the following:

Imagine that your University/Company has invested in a project that is a complete failure. There is the risk to lose 600.000 $.
Two alternative projects A and B for one group and C and D for the other group are proposed aimed to reduce the losses.

1 Group (context of gain)

 # if project A will be chosen 200.000 $ will be recovered
 # if project B will be chosen there is 1/3 of probability that 600.000 $ will be recovered and 2/3 of probability that nothing will be recovered.

2 Group (context of loss)

 # if project C will be chosen 400.000 will be lost
 # if project D will be chosen there is 1/3 of probability that nothing will be lost and 2/3 of probability that 600.000 will be lost.

In this test the choice of A and C expresses risk adversity whereas the choice of B and D expresses risk propensity. The results are shown in the following table 1:

Table 1. Results of the test on *framing effect*

	Company	University
Programme A (positive frame-sure option	1	2
Programme B (positive frame-risky option)	5	5
Programme C (negative frame-sure option)	1	1
Programme D (negative frame-risky option)	5	4

There are not great differences between academic and industrial participants. We also find no differences according the different technological domains. There is a risk seeking propensity that seems to neutralize the framing effect. There is the same risk inclined answer in the two different context of gain and loss. The explanation of this result that has no quantitative pretension is that also the academic participants used to interact with the company and being involved in risky project had developed a business risk behaviour similar to the entrepreneurial participant.

5.3 to study the *sunk cost* phenomenon and the regret for financial losses we use a variant of the problem of fly company (Fox and Staw, 1979):

1 Scenario

Imagine to be the president of a new spin-off company. Thank to the contribution of some venture capitalists your company has invested 5 million $ in a research project for production system based on nanotechnology. When the project is completed another company begins the promotion of a similar production system. It is clear that the system of competitor is more efficient than your. Would you invest the remaining 10% of funds to complete your project?

2 Scenario

Imagine to be the president of a new spin-off company. One of your collaborator advised you to invest the last 500.000 $ of your funds to build a new production system based on nanotechnology. You know that another company has began to promote a similar production system. It is clear that the system of competitor is more efficient than yours. Would you invest the last 500.000 research fund to build the new system proposed by your collaborator?

In this test the regret for the financial loss and the sunk cost effect is the choice of not to invest in the 1st scenario. The results are shown in the following table 2:

Table 2. Results of the test on *sunk costs fallacy*

	Company	University
1st Scenario-investing	5	4
1st Scenario-not investing	-	2
2nd Scenario-investing	1	-
2nd Scenario-not investing	6	6

The results show that when there is direct responsibility for the financial loss then there is regret for the possible loss, difficulty to accept it in front of you and the others, and therefore people choose to continue to finance the failed project. This phenomenon is present in both the academic and industrial participants. It expresses the same weight given to the money (financial heaviness) in academic and industrial participants.

In conclusion we can suppose that there might be a distance between pure academic scientists and business oriented academic scientists. From one side the pure academicians, having no contact with the business world, can maintain a decision making style that reflects the operational norm of financial lightness and the social value of disinterest for economic gain. From the other side the business oriented academicians have absorbed the social norm of economic interest and the operational norm of financial heaviness present among industrial participants. Therefore they have more regret for losses and are more risk inclined. This hypothesis must be controlled empirically.

5.4 The focus groups have analyzed the other topics without using formal tests. Time perception and the operational norms loose time vs. pressing time differentiated business oriented academicians from entrepreneurial researchers. For the last ones time is pressing and it is important to find soon concrete results and not to waste money The answers show a clear temporal discounting. The charge of business participants to academicians was of looking too much ahead and not caring about the practical need of present. The different temporal perceptions were linked to the risk assessment. The need to obtain fast results to allow the survival of the company increased the risk perception of the money spent in the projects of R&D. On the contrary even if the academic participants were not pure but business oriented they didn't show the temporal discounting phenomenon and the risk was perceived in connection with the scientific reputation inside the academic community (the social norm of universalism). For them what was risky was the failure of scientific recognition and not that of a business (vestiges of academic values). They also were inclined more to communitarism than exclusivity (vestiges of academic values). Knowledge should be open and public and not exclusive private property and monopole. For all participants misunderstandings about time and risk are the main obstacles to the collaboration. University members accuse company members to be too short minded and prudent in the development of new ideas; entrepreneurial participants charge university members with being too far minded and advanced in innovation proposal.

6) CONCLUSIONS

The present paper was a hypothetical deductive and analogical exercise to define potential interesting topics for empirical studies about the cognitive styles of academic and industrial researchers. My current proposals are general but the empirical studies should be made according different variable as disciplinary and technological domains; size of University/company; geographical context. Since the goal of the studies is to single out the obstacles to the academy-industry collaboration, the subjects of the test should be articulated in at least four categories:

pure scientists, business oriented professor, academic entrepreneurs, and industrial researchers. In the case of technology transfer also the category of TTO officers should be included. The next passage will be to articulate the test for each of the cognitive variables summarized in the table 5 and a questionnaire to control the presence of social values and operational norms. The tests and questionnaires will be submitted by email. Politecnico of Torino, Universita' degli Studi of Torino, FIAT Research Centre and Telecom Research Centre accepted to submit the tests (Viale, Pozzali, and Franzoni, inpreparation). Next step is to find a foreign University and company in a radical different context, like the American one, to compare the results.

What can we expect to infer from the results?
If the main hypotheses of this paper were confirmed we would know what are the main determinants of the cognitive dissonance. This knowledge would give us some clues on how to *nudge* (Thaler and Sustein, 2008) the main stakeholders of academy-industry relation in order to improve the collaboration. For example if the results confirm the link between social values and operational norms with the cognitive style it might be difficult to overcome the distance between pure academic scientist and entrepreneurial researchers. What can be more affordable it is to strengthen the emergence of a *dual career*. Together with the pure academic researcher, university must promote a mestizo, a hybrid figure that as a two-faced Janus (Etzkowitz and Viale, 2009) is able to activate mentally two inconsistent set of values and operational norms, the academic and entrepreneurial ones. They would not believe them, but would accept them as if they believed (Cohen, 1992). They would be the cultural mediators and translators of the two world. They should be members of the same department of the pure scientists and would collaborate with them and with the industrial scientists. The reciprocal figure in the company is more difficult to introduce, except when the company is big and financially endowed. Two-faced Janus figure is different from that involved in TTO. The first is a figure that should collaborate directly in research activity with corporate scientists whereas the second has the function to establish the bridge between academics and company. The first allows the research & development collaboration whereas the second the technology transfer.
Empirical confirmation of the emergence of this figures can be found in the trajectories of development of strongly science-based sectors such as biotechnologies, that has followed totally different path in America and Europe (Orsenigo, 2001). While the American system is characterized by a strong proximity between the industrial system and the world of research, with the universities in the first line in internalizing and in taking on many functions typical of the business world, in Europe the universities have been much more reluctant to take on a similar propulsive role.

A second *nudge* suggestions that might come from the results of the study is the importance of face to face interaction and proximity between Universities and companies. The need of proximity has been underlined in recent studies (Arundel and

Geuna, 2004: for an explanation according the theory of complexity see Viale & Pozzali, forthcoming). Virtual cluster and meta district can't play the same role in innovation. Proximity and face-to-face interactions are not only important to minimize the tacitness bottleneck in technology transfer. Face-to-face is fundamental for collaboration because of linguistic and pragmatic effect on understanding (see above). It also improves the rate of trust as it is proved by neuroeconomics (Camerer et al, 2005). Proximity can also increase the respective permeability to social values and operational norms. From this point of view Universities might promote the birth of open spaces of discussion and comparison where academicians and business members might develop a kind of learning by interacting.

Finally a more theoretic result may be that of weakening the thesis of *technological paradigm* (Dosi, 1982). A technological paradigm are changes in technological systems that have a major influence on the behaviour of economics and are linked to Schumpeter's idea of "creative gales of destruction". The pervasivity of this change should affect every component of the paradigm: knowledge, organization, production techniques, behaviours. Therefore every agent involved in the revolution should show a convergence towards similar values, norms, and way of thinking, reasoning, and deciding. As in the words of Kuhn "a paradigm is what members of a scientific community, and they alone, share". From this point of view the entire knowledge chain producers of a technological paradigm (ICT or Biotechnology), from pure scientists to entrepreneurial researchers should display a convergence in social values, operational norms and mainly cognitive styles. If this is not the case then the use of the concept of paradigm seems unjustified.

BIBLIOGRAPHY

Agarwal, A., and Henderson, R. (2002). "Putting patents in context: Exploring knowledge transfer from MIT". *Management Science.* Vol. 48, 1.

Anderson J.R., (1983), *The Architecture of Cognition*, Harvard University Press, Cambridge.

Anderson J.R., (1987), "Skill Acquisition: Compilation of Weak-Method Problem Solutions", *Psychological Review*, 94, 192-210.

Arundel, A. And Geuna, A. (2004). "proximity and the use of public science by innovative european firms". *Economic Innovation and New technologies.* 13(6), 559-580.

Balconi M., (2002), "Tacitness, Codification of Technological Knowledge and the Organization of Industry", *Research Policy*, 357-379.

Balconi, M, Pozzali, A., and Viale, R. (2007). "The 'codification debate' revisited: a conceptual framework to analyze the role of tacit knowledge in economics", *Industrial and Corporate Change,*16 (5), 823-849.

Bar Hillel, M. (1980). "The base-rate fallacy in probabilistic Judgements. *Acta Psychologica*, 44, 211-233.

Barsalou, L.W. (2000). "Cocepts: Structure." In A.E. Kazdin (ed.) *Encyclopedia of Psychology.* (Vol. 2). Washington: American Psychological Association.

Beth, E. And Piaget, J. (1961). *Etudes d'Epistemologie Genetique, XIV: Epistemologie Mathematique et Psichologie.* Paris: PUF

Bickel, W.K., and Johnson, M.W. (2003). "Delay discounting: a fundamental behavioural process of drug dependence". Un G.Lowenstein, D. Read & R.F. Baumeister (eds.). *Time and Decision*. New York: Russell sage Foundation.

Brain, M.D.S. (1978). "On the relation beween the natural logic of reasoning and standard logic" *Psychological Review,* 85, 1-21.

Broesterhuizen, E. and Rip, A. (1984). "No Place for Cudos". *EASST Newsletter, 3*

Bryson, M., Bereiter, C., Scarmadalia, M., and Joram, E. (1991). "Going bejond the problem as a given: Problem solving in expert and novice writers". In R.J. Sterneberg and P.A. Frensch (eds.). *Complex problem solving.* Hillsdale: Erlbaum.

Cacioppo, J.T. and Petty, R.E. (1982). "The need for cognition", *Journal of Personality and Social Psychology", 42,* 116-131.

Cambrosio A. and Keating P., (1988), "Going Monoclonal: Art, Science, and Magic in the Day-to-Day Use of Hybridoma Technology", *Social Problems*, 35, 244-260.

Camerer, C., Loewenstein, G., and Prelec, D., (2205). "Neuroeconomics: how neuroscience can inform economics?" *Journal of economic Literature,* vol. XLIII, 1, 9-64.

Chapman, L.J., and Chapman, J.P. (1975). "The basis of illusory correlation. *Journal of Abnormal Psychology,*84(5), 574-575.

Cheng, P.W., Holyoak, K.J., Nisbett, R., and Oliver, L.M. (1986). "Pragmatic versus syntactic approaches to training deductive reasoning" *Cognitive Psychology,* 18, 293-328.

Cheng, P.W., and Nisbett, R. (1993). "Pragmatic constraints on causal deduction" in R. Nisbett (ed.). *Rules for Reasoning.* Hillsdale: Erlbaum.

Chomsky N., (1986), *Knowledge of Language*, Praeger, New York.

Clark, H.H. (1996). *Using Language.* Cambridge : Cambridge University Press.

Cleeremans A., (1995), "Implicit Learning in the Presence of Multiple Cues", *Proceedings of the 17th Annual Conference of the Cognitive Science Society*, Erlbaum, Hillsdale.

Cleeremans A., Destrebecqz A. and Boyer M., (1998), "Implicit Learning: News from the Front", *Trends in Cognitive Science*, 2, 406-416.

Cleeremans A. and Jiménez L., (1999), "Fishing with the wrong nets: How the implicit slips through the representational theory of mind", *Behavioral and Brain Sciences*, 22, 771.

Cohen, J. (1992). *An essay on belief and acceptance.* Oxford: Blackwell.

Cohen M.D., Burkhart R., Dosi G., Egidi M., Marengo L., Warglien M. and Winter S., (1996), "Routines and Other Recurrent Action Patterns of Organizations: Contemporary

Collins H.M., (2001), "Tacit Knowledge, Trust, and the Q of Sapphire", *Social Studies of Science*, 31, 71-85.

Collins H.M., (1992), *Changing Order. Replication and Induction in Scientific Practice*, University of Chicago Press, Chicago.

Collins, A.M. and Quillian, M.R. (1969). "Retrieval time from semantic memory". *Journal of Verbal Learning and Verbal Behaviour,* 8, 240-248.

Cowan R., David P.A. and Foray D., (2000), "The Explicit Economics of Knowledge Codification and Tacitness", *Industrial and Corporate Change*, 9, 211-253.

Damasio A.R., (1999), *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*, William Heinemann, London.

Dasgupta P. and David P.A., (1994), "Towards a New Economics of Science", *Research Policy*, 23, 487-521.

Dewey J. and Bentley A.F., (1949), *Knowing and the Known*, Beacon Press, Boston.

Dosi, G. (1982). "Technological paradigms and technological trajectories*"Research Policy,* 11(3): 147-162.

Elster, J. (1979). *Ulysses and the Syrenes. Studies in Rationality and Irrationality.* Cambridge: Cambridge University Press.

Etzkowitz, H. (1998). "The norms of entrepreneurial science: cognitive effects of the new university-industry linkages". *Research Policy,* 27(8), 823-833.

Etzkowitz, H. & Viale, R. (2009). "The Third Academic Revolution: Polyvalent Knowledge and the Future of the University", *Critical Sociology*, (in press).

Fischhoff, B., Slovic, P., and Lichtenstein, S. (1977). "Knowing with certainty: the appropriateness of extreme confidence". *Journal of Experimental Psychology, 3*, 552-564.

Foray, D. (2000). *L'Economie de la connaissance.* Paris: La Découverte.

Foray D. and Cowan R., (1997), "The Economics of Codification and the Diffusion of Knowledge", *Industrial and Corporate Change*, 6, 595-622.

Foray D. and Steinmueller W.E., (2003), "The Economics of Knowledge Reproduction by Inscription", *Industrial and Corporate Change*, 12, 299-319.

Fox, F.V. and Staw, B.M. (1979). « The trapped administrators : effects of Job Insecurity and Policy Resistance Upon Commitment to a Course of Action », *Administrative Scienec Quaterly,* 24, 449-471

Gelman R. (1990) First principles organize attention to and learning about relevant data: number and the animate-inanimate distinction as examples, *Cognitive Sciences*, 14, 79-106;

Gigerenzer G., (2000), *Adaptive Thinking. Rationality in the Real World*, Oxford University Press, Oxford.

Gigerenzer, G. (2007) *Gut Feeling.* London: Viking.

Ginsberg M.L., (1998), “Computer, Games and the Real World”, *Scientific American Presents*, 9 (4), 84-89.

Glaser, R., and Chi, M.T.H. (1988). « Overview ». in M.T.H. Chi, R. Glaser, and M. Farr (eds.). *The nature of expertise.* Hillsdale : Erlbaum.

Goffman, E. (1981). *Forms of Talk.* Philadelphia: University of Pennsylvania Press.

Gorman, M. (1992). *Simulating Science.* Indiana University Press.

Gourlay S., (2002), “Tacit Knowledge, Tacit Knowing or Behaving”, mimeo.

Grice, H.P. (1989). *Studies in the Way of Words.* Cambridge Mass: Harvard University Press.

Griggs, R.A. and Cox, J.R. (1982). “ The elusive thematic-materials effect in Wason’s selection task”, *British Journal of Psychology,* 73, 407-420

Grossman, M., Smith, E.E., Koenig, P., glosser, G., Rhee, J., and dennis, K. (2003). “Categorization of object descriptions in Alzheimer’s disease and frontal temporal demential: limitation in rule-based processing” . *Cognitive Affective and Behavioural Neuroscience. 3(2),* 120-132.

Hinsz, V., Tindale, S., and Vollrath, D. (1997). “The emerging conceptualization of groups as information processors”. *Psychological Bulletin,* 96, 43-64.

IMD (2008). *World Competiveness.*

Jackendoff, R. (2007). *Language, Consciuosness, Culture.* Cambridge Mass: MIT Press.

Jackson, S. (1992). “Team composition in organizational settings: Issues in mamaging an increasingly diverse work force”. In S.Worchel, W.Wood and J.Simpson. (eds.). *Group Process and Productivity.* Nrwbury Park: Sage.

Johnson B., Lorenz E. and Lundvall B.-A., (2002), “Why All This Fuss about Codified and Tacit Knowledge?”, *Industrial and Corporate Change*, 11, 245-262.

Johnson-Laird, P. (1983). *Mental Models* . Cambridge Cambridge University Press.

Johnson Laird, P. (2008). *How We Reason.* Oxford: Oxford University Press.

Johnson Laird, P.N. and Wason, P.C. (1977). (eds.). *Thinking.* Cambridge: Cambridge University Press.

Kahneman, D (2003). *Maps of Bounded Rationality.* In T Frangsmyr (ed.) *Nobel Prizes 2002.* Stckolm: Almquist and Wiksell.

Kahneman, D. and Tversky, A. (1973). " On the Psychology of Prediction". *Psychological review,* 80.

Kahneman, D. and Tversky, A. (1979) "Prospect theory: an analysis of decision under risk", *Econometrica,* 47, 263-291.

Kahneman, D. and Tversky, A. (1996). "On the reality of cognitive illusions". *Psychological Review,* 103, 582-591.

Kendrick, J.W. (1994). "Total Capital and Economic Growth". *Atlantic Economic Journal,* 22,1.

Keil F.C. (1995), "The growth of causal understandings of natural kinds", in Sperber D. et al., eds.), 1995, *Causal cognition*, Oxford University Press, Oxford.

Kuhn, T. (1962). *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Langer, E. (1973). "reduction of psychological stress in surgical patients", *Journal of Experimental Social Psychology",* 11, 155-165.

Leydesdorff, L. & Etzkowitz, H. (1996). 'Emergence of a triple helix of university-industry-government relations', *Science and Public Policy*, 23, pp.279-286.

Lesgold, A. M. (1988). "Problem Solving". In R.J. Sternberg and E.E. Smith (eds.) *The Psychology of Human Thought.* New York: Cambridge Universty Press.

Lester, K. R. (2005). "Universities, innovation, and the competiveness of local economies. *Industrial Performance Center, MIT, IPC working Paper series, MIT-IPC-05-010.*

Mackie, J. (1974). *The cement of the universe. A study on causation.* Oxford: Oxford University Press

Machlup, F. (1962). *The Production and Distribution of Knowledge in the United States.* Princeton: Princeton University Press.

MacKenzie D. and Spinardi G., (1995), “Tacit Knowledge, Weapons Design and the Uninvention of Nuclear Weapons”, *American Journal of Sociology*, 101, 44-99.

Manz, C.C., and Neck, C.P. (1995). “Teamthink. Beyond the groupthink syndrome in self-managing work teams”. *Journal of Managerial Psychology,* 10, 7-15.

Markman, A.B. & Gentner, D. (2001). <<Thinking>> *Annual Review of Psychology*, 52, 223-247.

McCloskey, D. (1985). “The industrial revolution 1780-1860: a survey” in J Mokyr (ed.) *The Economics of the Industrial Revolution.* Totowa: Rowman & Allanheld.

Merton, R. (1973). *The Sociology of Science. Theoretical and Empirical Investigations.* Chicago: University of Chicago Press.

Mill, J.S. (1887). *A System of Logic.* New York: Harper & Brothers.

Mitroff, I.I. (1974). *The subject side of science.* Amsterdam: Elsevier.

Mokyr, J (2002a). *The Gifts of Athena: Historical Origins of the Knowledge Economy,* Princeton: Princeton University Press.

Mokyr, J. (2002b). “Innovations in an Historical Perspective: Tales of Technology and Evolution”, in B.Steil, G. Victor and R.Nelson (eds.), *Technolgical Innovation and Economic Performance,* Princeton: Princeton University Press.

Mynatt, R., Doherty, M.E., and Tweney, R.D. (1977(. “Confirmation bias in a simulated research environment: an experimental study of scientific inference” in P.N. Johnson Laird and P.C.Wason (eds.). *Thinking.* Cambridge: Cambridge University Press.

Norenzayan A., (2006), “Cultural Variation in Reasoning”, in Viale R., Andler D., Hirschfeld L., *Biological and Cultural Bases of Human Inference*, Lawrence Erlbaum Associates Inc., Mahwah.

Nelson R.R. and Winter S., (1982), *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge.

Nisbett R.E. and Masuda T., (2006), “Culture and Point of View”, in Viale R., Andler D., Hirschfeld L., *Biological and Cultural Bases of Human Inference*, Lawrence Erlbaum Associates Inc., Mahwah.

Nisbett R.E., (2003), *The Geography of Thought*, The Free Press, New York.

Nisbett, R.E., Peng K., Choi I., and Norenzayan A. (2001) “Culture and systems of thought: holistic vs. analytic cognition”, *Psychological review*, 108: 291-310.

Nonaka I. and Takeuchi H., (1995), *The Knowledge-Creating Company*, Oxford University Press, New York.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing V., and Van den Oord, A. (2007). “Ptimal cognitive distance and absorptive capacity”. *Research Policy. 36,* 1016-1034.

Nozick, R. (1990). “Newcomb’s problem and two principles of choice”. In P.K. Moser (ed.). *Rationality in action. Contemporary approach.* New York: Cambridge University Press.

OECD. (2008). *Open Innovation In A Global Perspective. What Do Existing Data Tell Us. STI Working paper2008/4*

Petry, N.M. and Casarella, T. (1999). “Excessive discounting of delayed rewards in substance abusers with gambling problems” *Drug and Alcohol Dependence,*56, 25-32

Pinch T., Collins H.M. and Carbone L., (1996), “Inside Knowledge: Second Order Measures of Skill”, *Sociological Review*, 44, 2, 163-86.
Politzer

Politzer, G. (1986). “ Laws of Language Use and Formal Logic”, *Journal of Psycholinguistic Research,* 15, 47-92.

Politzer, G. And Nguyen-Xuan, A. (1992). “Reasoning about Promises and Warnings: Darwinian Algorithms, Mental Models, Relevance Judgements or Pragmatic Schemas?. *Quarterly Journal of Experimental Psychology.* 44, 401-421.

Pozzali A., (2004b), “Tacit Knowledge, Implicit Learning and Scientific Reasoning” Paper Presented at the MBR-04 Model Based Reasoning in Science and Engineering. Abduction, Visualization, Simulation, Pavia, Collegio Ghislieri, University of Pavia, 16-18 December.

Pozzali, A. and Fondazione Rosselli (2008). "Different cognitive styles between academic and industrial researchers. A pilot study."

Pozzali, A. & Viale, R. (2007). "Cognition, Types of 'Tacit Knowledge' and Technology Transfer". In R.Topol and B.Walliser (eds.). *Cognitive Economics. New Trends.* Elsevier

Reber A.S., (1993), *Implicit Learning and Tacit Knowledge. An Essay on the Cognitive Unconscious*, Oxford University Press, Oxford.

Ryle G., (1949/1984), *The Concept of Mind*, Chicago University Press, Chicago.

Rosenberg, N., and Mowery, D. (1998). *Paths of Innovation. Technological Change in 20th-Century America*, Cambridge: Cambridge University Press.

Ross, B.H. (1996). "Category Learning as Problem Solving". In D.L. Medin (ed.). *The Psychology of Learning and Motivation: Advances in research and theory.* 35, 165-192.

Searle J., (1992), *The Rediscovery of the Mind*, MIT Press, Cambridge.

Rumain, B., Connell, J., and Braine, M.D.S. (1983). "Conversational comprehension processes are responsible for fallacies in children as well as in adults: If is not the biconditional" *Developmental Psychology,* 19, 471-481.

Searle, J. (1995). *The Construction of Social Reality.* New York: Free Press.

Searle, J. (2008). *Philosophy in a new century.* Cambridge: Cambridge University Press.

Siegel, D., Waldman, D., and Link, A. (1999). "Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study". *NBER Working Paper#7256.*

Sloman, S.A. (1996). "The empirical case for two systems of reasoning" *Psychological Bulletin,* 119, 3-22.

Smith, E.E. and Kossylin, S.M. (2007). *Cognitive Psychology. Mind and Brain.* Upper Saddle River, NJ: Prentice Hall.

Solow, R. (1971). "Technical change and the aggregate production function", in N.Rosenberg (ed.), *The Economics of Technological Change*, Hammondsworth: Penguin.

Sperber, D. and Wilson, D. (1986). *Relevance. Communication and Cognition.* Oxford: Oxford University Press.

Spelke, E.S., Phillips, A., and Woodward A.L., (1995), “Infants’ Knowledge of Object Motion and Human Action”, in Sperber D., Premack D., and Premack A.J. (eds.), *Causal Cognition*, Oxford University Press, Oxford.

Sperber D., Premack D., and Premack A.J., (1995), *Causal cognition*, Oxford University Press, Oxford.

Sternberg, R.J. (2009). *Cognitive Psychology*. Belmont. Wadsworth.

Stieglitz, J.E. (1999). *Public Policy for a Knowledge Economy*. London: Department for Trade and Industry and Center for Economic Policy Research.

Thaler, R. (1999). “Mental accounting matters”. *Journal of Behavioural Decision Making”*, 12, 183-206.

Thaler, R.H. and Sunstein, C.R. (2008). *Nudge. Improving Decisions About Health, Wealth, and Happiness.* New Haven: Yale University Press.

Tversky, A. And Kahneman, D. (1980). “Causal Schemas in Judgements under Uncertainty”. In M.Fishbein (ed.). *Progress in Social Psychology.* Hillsdale (N.J.): Erlbaum.

Tversky, A. And Kahneman, D. (1982a). “Judgements of and by Representativeness” in D.Kahneman, P.Slovic, and A.Tversky (eds) *Judgement under Uncertainty: Heuristics and Biases.* Cambridge: Cambridge University Press.

Tversky, A. And Kahneman, D. (1982b) “ Evidential Impact of Base Rate” in D.Kahneman, P.Slovic, and A.Tversky (eds) *Judgement under Uncertainty: Heuristics and Biases.* Cambridge: Cambridge University Press.

Tversky, A. And Kahneman, D.(1992). “Advances in propspect theory: cumulative representation of uncertainty”, *Journal of Risk and Uncertainty,* 5, 547-567.

Van Knippenberg, D., and Schippers, M.C. (2007). “Work group diversity”, *Annual Review of Psychology,* 58, 515-541.

Viale, R. (1997) Causality: epistemological questions and cognitive answers, in G. Costa, G. Calucci and M. Giorgi (eds.), *Conceptual Tools for Understanding Nature,* Singapore: World Scientific;

Viale, R. (1999a). Causal Cognition and Causal Realism, *International Studies in the Philosophy of Science*, vol. 13, n. 2, pp. 151-167;

Viale, R. (1999b) Causality: cognition and reality. The impact of psychological models of causality on causal realism, in R. Rossini Favretti, G. Sandri and R. Scazzieri (eds.), *Translating Languages: Communication, Formal Reconstruction and Theory Change*, Aldershot: Edward Elgar;

Viale, R. (2001). "Reasons and Reasoning: What comes First". In Boudon, R., Dmeleulenaere, P., and Viale, R. (eds.). *L'explication des normes sociales.* Paris: Presses Universitaires de France.

Viale, R. (2006). "Local or Universal Principles of Reasoning?" in Viale R., D.Andler, and L.Hirschfeld (eds.). *Biological and Cultural Bases of human Inferences.* Hillsdale: Erlbaum.

Viale, R. (2009). "Knowledge Driven Capitalization of Knowledge", in R.Viale & H. Etzkowitz (eds.). *The Capitalization of Knowledge: A Triple Helix of University-Industry-Government*, Aldershot: Elgar.

Viale, R., & Pozzali, A. (2007). "Cognitive Aspects of Tacit Knowledge and Cultural Diversity", in L.Magani and P. Li (eds.). *Model-based Reasoning in Scienec, technology, and Medicine.* Berlin Heidelberg: Springer.

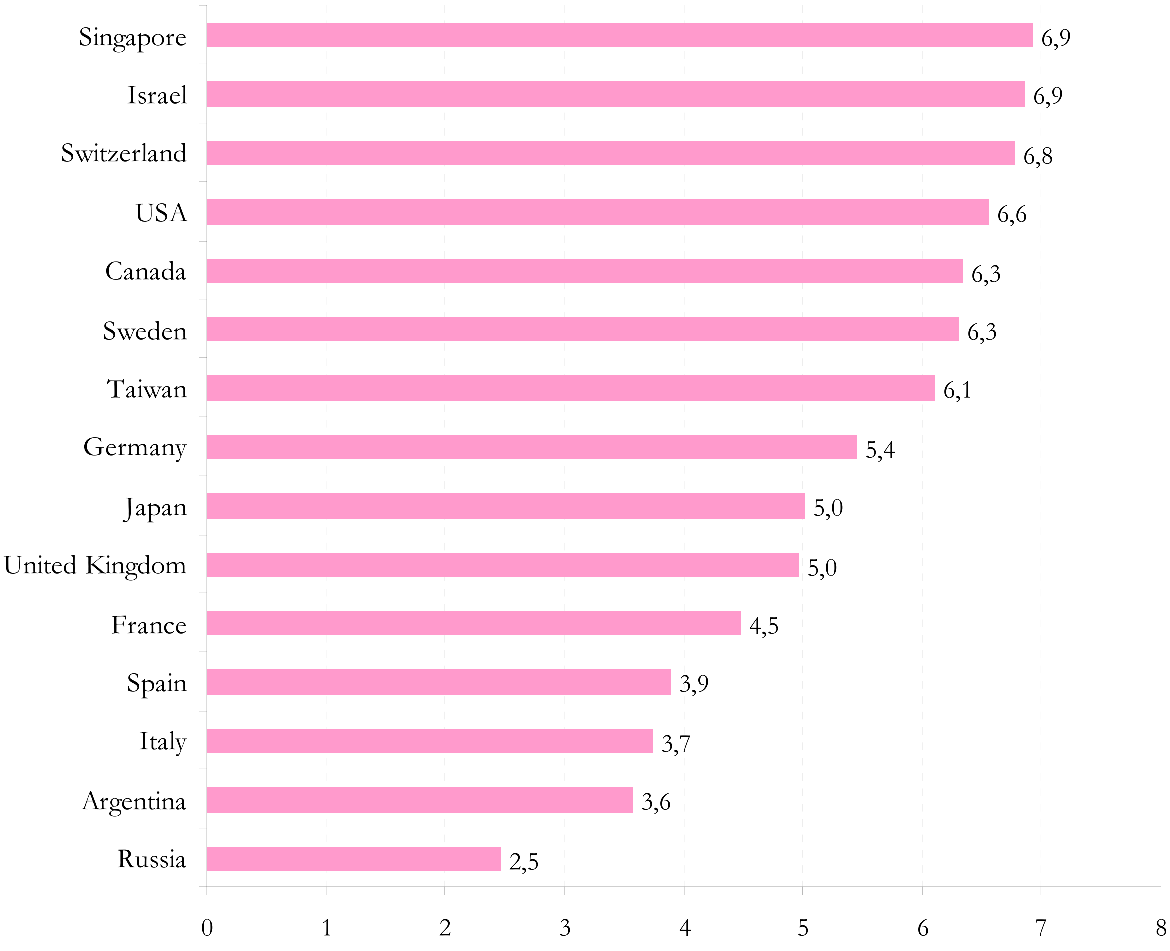
Viale, R. & Pozzali, A. (in press). "Complex Adaptive Systems and the Evolutionary Triple Helix", *Critical Sociology*.

Vincenti W.G., (1990), *What Engineers Know and How They Know It*, Johns Hopkins University Press, Baltimore.

Wason, P.C. (1960). "On the failure to eliminate hypotheses in a conceptual task". *Quaterly Journal of Experimental Psychology,* 12, 129-40

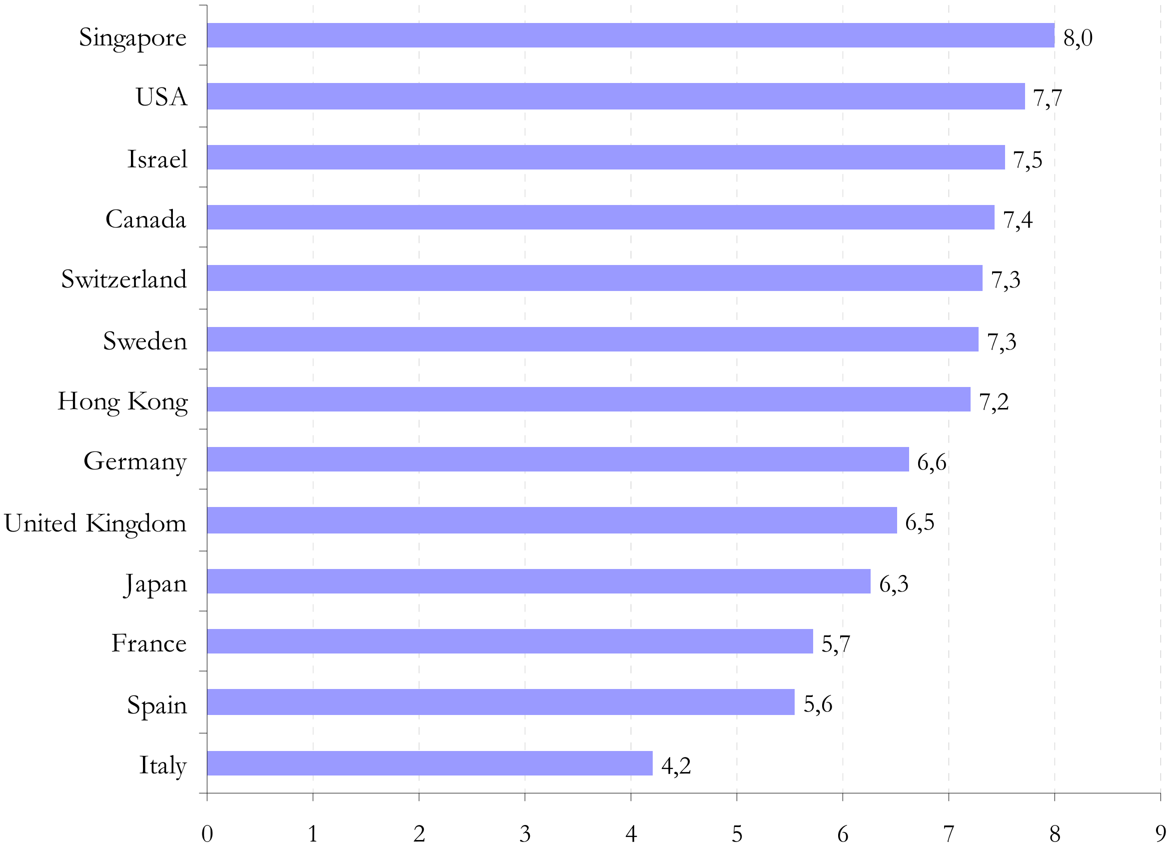
Ziman, J.M. (1987). "L'individuo in una professione collettivizzata", *Sociologia e Ricerca Sociale,* 24, 9-30

Knowledge transfer between universities and companies, 2008



Source: IMD (2008)

Public and private sector ventures, 2008



Source: IMD (2008)

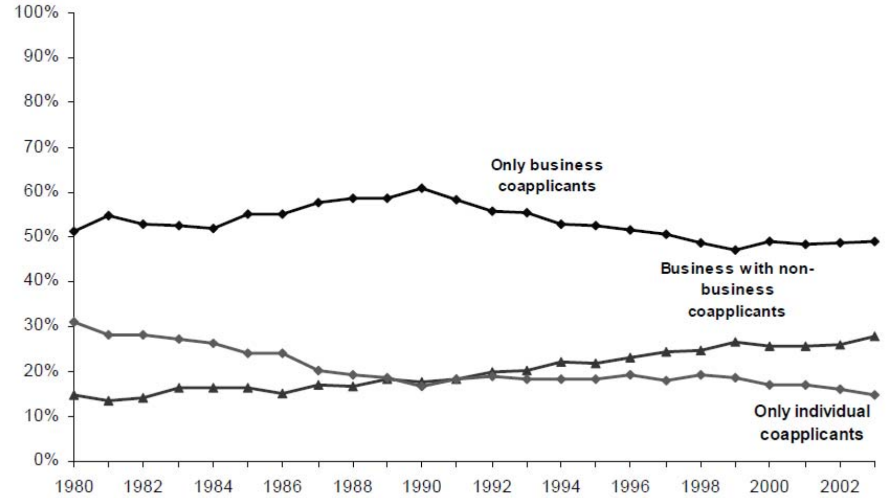
Companies collaborating in innovation activities, by partner, 2002-04
As a percentage of all companies collaborating in innovation

	Suppliers	*Customers*	*Competitors*	Consultants and private R&D institutes	*Universities and other higher education*	*Government and public research*
Belgium	73%	59%	27%	42%	37%	26%
Bulgaria	74%	61%	35%	34%	27%	18%
Czech Republic	80%	68%	40%	39%	34%	19%
Denmark	66%	65%	35%	44%	32%	16%
Germany	44%	51%	27%	18%	53%	26%
Estonia	67%	66%	53%	29%	25%	17%
Ireland	72%	78%	19%	31%	31%	18%
Greece	46%	32%	47%	27%	27%	10%
Spain	52%	23%	17%	23%	26%	28%
France	65%	50%	36%	32%	26%	18%
Italy	56%	39%	37%	50%	36%	11%
Luxembourg	79%	73%	49%	36%	33%	27%
Hungary	71%	53%	37%	34%	37%	14%
Malta	70%	52%	17%	43%	13%	13%
Netherlands	75%	55%	31%	38%	31%	24%
Austria	43%	45%	22%	42%	58%	30%
Poland	67%	39%	20%	19%	15%	21%
Portugal	71%	60%	35%	45%	39%	25%
Romania	79%	57%	37%	28%	21%	25%
Slovenia	79%	70%	43%	42%	41%	28%
Slovakia	84%	80%	56%	49%	39%	30%
Finland	92%	93%	77%	74%	75%	59%
Sweden	75%	65%	25%	46%	41%	15%
United Kingdom	74%	73%	36%	41%	33%	25%
Iceland	68%	68%	48%	23%	17%	45%
Norway	70%	67%	36%	61%	45%	49%

1. Or nearest available years.

Source : CIS-4 data.

EPO applications with multiple applicants, by institutional sector, priority years 1980-2003



Note: Non-business institutions are government, higher education, private non-profit, hospitals, individuals and others, according to the EUROSTAT algorithm.

Source: OECD patent database.

TAXONOMY OF COGNITIVE STYLES

		Thinking	Problem solving			Reasoning			Decision making		
		Analytical (**A**) Intuitive (**I**)	Careful representation ***(Cr)*** Inaccurate representation (**IR**)	Slow evaluation (**Se**) Fast evaluation (**Fe**)	Longer incubation (**Li**) Shorter incubation (**Si**)	*Inductive support* Conservative (**C**) Revolutionary (**R**)	*Deductive control* Falsifier (**F**) Confirmatory (**C**)	*Causal inference* Causal relation (**Cr**) Illusory correlation (**Ic**)	*Risk* Adversion (**A**) Propensity (**P**)	*Time* Counting (**C**) Discounting (**D**)	*Emotion* Acceptance (A) Regret (**R**)
Social norms	Universalism vs Localism	**A** **I**						**Cr** **Ic**		**C** **D**	
	Criticism vs Dogmatism	**A** **I**		**Se** **Fe**			**F** **C**	**Cr** **Ic**		**C** **D**	
	Indifference vs Interest								**A** **P**		**A** **R**
	Communitarism vs Esclusivism								**A** **P**		**A** **R**
Operational norms	Loose time vs Pressing time	**A** **I**	**Cr** **Ir**	**Se** **Fe**	**Li** **Si**	**C** **R**		**Cr** **Ic**	**A** **P**	**C** **D**	
	Undefined results vs Well defined results	**A** **I**				**F** **C**	**F** **C**			**C** **D**	

	Financial lightness vs Financial heaviness					**C** **R**	**F** **C**		**A** **P**	**C** **D**	**A** **R**