M I R R O R S

Monitoring Ideas Regards Research Organizations and Reasons in Science

SCIENCE AND SOCIETY IN THE EUROPE OF KNOWLEDGE

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EXECUTIVE SUMMARY

Introduction

Before presenting a summary of the work in this report, in this introduction we would like to briefly outline its general meaning and the assumptions that have supported it.

We interpreted our mandate to have two main concerns. Firstly, we were required to show the kind of contribution that the history, sociology and philosophy of science (HPSS) can offer to science policy making. Secondly, as a consequence, we were to try to formulate "recommendations" for science policy that fully exploit the kind of information obtained through HPSS. Both these tasks were to be carried out by pursuing policy finalities that aim to achieve a balance between the needs and wants of the private sectors and those of general society. The research results and conclusions are therefore relevant for HPSS scholars (including students) and policy makers; it also has important consequences for civil society.

The report is the joint work of HPSS experts and STS scholars in general working in a great variety of national environment. It is not, of course, impartial on many topics; it expresses the personal convictions of our researchers. But these convictions have changed over time thanks to the valuable comments and lively participations of economists, political scientists, policy makers, and many other figures of civil society that it would be impossible to list here.

The methodology we used has been both tested and backed up by a comparative study of the R&D policies already in use both in single EU member states and in extra-EU countries conducted in order to single out virtuous policy instances, with respect to innovation, funding policy, and the relationship between the private and public sector, and to analyze the condition of their transfer in the socio-economic context of the EU as whole. We have looked at current implementation of R&D policy through two prisms: the attempt made at the construction of a knowledge-based society as a consequence of the progressive development of the implementation of the Lisbon Strategy in the last years (Chapter 1) and the attempt at democratizing R&D decision processes (Chapter 2). In these respects we have singled out an imbalance between science policy means and ends. The imbalance lies in the need, pointed out by the Commission, to promote policy strategies that meet both the needs and wants of both the private industry sector and general society. The means put forward so far seem to be heavily weighted towards the interests of the private sector. This has been documented by showing that the efficacy of the R&D policies we have analyzed in different national environments is measured against the fulfilment of the aim to foster competitive advantage. In particular, the needs of the private industry sector and those of general society are artificially balanced by equating social well-being with economic well-being, as if the latter would be sufficient to achieve the former. Environmental literature, even of a more moderate type, has shown the price general society has paid because of a kind of industrial modernization that does not take societal and environmental costs into account. Europe has an old history of industrial modernization and it can see more clearly that the well-being of a sudden economic boom has devastating societal and environmental consequences; a bill that future generations, like ours, have to pay in terms of social disparity, pollution, ravishing of natural resources, increased scarcity of common resources, and so forth.

This is why we have tried to formulate our policy recommendations by first designing a descriptive methodology for the relationship between science and society that would enable policy makers to direct the governmental means at their disposal towards realistic, non-delusionary, ends. Nonetheless it is not a no-win situation; we do not have to choose whether to pursue competitive advantage and economic growth or to promote the interests of general society and the environment. We have documented the efforts made by the EC to create a common macroeconomic platform aimed at the demands of sustainable development in our post-industrial age. A new vision began to take shape at the end of the 1990s; a new industrial revolution, which seems able to balance the needs of the private sector and general society. Sustainable development strategies are giving new life blood to the economy: they are fostering techno-scientific innovation, suggesting new solutions for institutional design, redefining the labour market, and driving general entrepreneurship to the service of both the business community and the working class. We need to adjust policy strategy to the new objective – answering the needs of both the private industry sector and civil society – if we want the efficaciousness of the means addressed to its fulfilment to be evaluated effectively. We need to think again topics such as techno-scientific innovation, expertise, creativity, education reform and specialization/ professionalization (Chapter 5). Innovation, for instance, cannot be addressed to the sole aim of fostering the economic growth of a nation, because such a finality would strongly bias funding policy towards the development of innovative ideas that yield an immediate financial return while obstructing basic research. By the same token, market-oriented innovation policy would privilege creative endeavours that can result in marketable products and discourage creative enterprises that are not market-oriented, especially as far as initiatives for creating and/or safeguarding common assets are concerned. As far as Higher Education reform is concerned, solutions such as allowing public universities to finance themselves through patent rights and suchlike may certainly encourage the emergence of an entrepreneurship mentality, but it would drive theoretical disciplines, such as the humanities, to radically change their way of making culture. Finally, specialization has certainly played a role in the rationalization of the means of production and it has oiled up the process towards industrial modernization. Nonetheless, we believe a more general educational background (both before and after entering the labour market) may help citizens to recover critical thinking – a human quality that has been facing extinction since the 1950s– as well as to guarantee flexibility and awareness in a ever-changing and interconnected world.

The report is the result of the work of many people, with different economical, ideological and political convictions, different fields of expertise, different life and work experiences. Furthermore, to this variation among our researchers we should add the variation coming from the many working groups and individual scholars in the STS field, economics and political science. We have offered an extensive summary of the ideas developed in the before mentioned fields over the last two years and we have tried to summarize their different points of view to the best of our ability. This has made our search for the production of original results more difficult, but it has greatly helped our search for a common perspective to be shared with at least a consistent portion of the people we have confronted throughout our work as well as many occasion to revise hard-headed views and, as a consequence, to allow our own theoretical horizons to change and be enlarged with ever less resistance.

The policy recommendations listed and briefly discussed at the end of the report (Chapter 6) are therefore a synthesis of a very rich and intensive exchange of ideas that does not intend to say anything conclusive, but does outline what we believe is the right path for the EU science policy practice to follow.

Towards the knowledge society
(Chapter 0)

Our analysis was introduced by a study of the main directions in which reflection on society and its relationships with science and technology has gone in the last fifty years. In particular we have examined the set of themes linked to the idea according to which we have entered an era characterized by a series of "posts": post-industrial, post-modern, post-democracy, post-positivism, post-structuralism, post-Fordism, post-Marxism, post- or trans-humanism and so on. This has all been inserted, from a certain point onwards, within the general framework of globalization, which in its turn was made possible by the so-called society of knowledge, whose centre and crucial point is the development of Information and Communication Technology (ICT). Having examined the key concepts of post-industrial and postmodern, we have tried to show how at the end, everything merges into the idea of a society of knowledge, which is the objective set by the EU with the Lisbon strategy. We have tried to trace the origin and development of the society of knowledge, starting from the famous report of Vannevar Bush of 1945, trying to trace its main characteristics. Finally, we have tried to clarify in what sense we must speak of "knowledge" within the society of knowledge, distinguishing (in the wake of Lundvall) the know-what, the know-why, the know-how and the know-who, underlining how this break down throws into light the dimension of "tacit knowledge", which will be dealt with later (§ 5.2).

The Lisbon Strategy
(Chapter 1)

We also believed that we could not carry out our mandate adequately without a preliminary analysis of what has been done so far in the field of the Lisbon Strategy Therefore, in Chapter 1 we used the descriptive methodology of STS to critically discuss the attempts to implement the Lisbon Strategy, its development and its future prospects. The economical, social, and political environment in which normative proposals for the creation of a democratic European knowledge society have been set and tentatively implemented can be better understood as constraints on the implementation of the Lisbon Strategy which has informed the work of science policy makers in the last decade. In fact, despite its failure and defects, the Lisbon Strategy functions as a regulative ideal. The Strategy has given us a common working platform: decision processes in S&T practice need to be democratized and as a consequence no one but the consensus of the majority of citizens should decide on choices involving the relevant community. Having briefly examined where the need arose to implement the Lisbon Strategy and having examined the serious risks that the EU runs in the field of innovation and research if it does not manage to accelerate its economic growth on the basis of the implementation of new technologies and therefore requires greater capacity for investment in R&D, we have underlined in particular the main historical and conceptual links of the strategy that we believe are important to articulate our proposals in the following chapters: the importance given to the close union of development and research; the relevance of human capital (Europe can boast that it has the best in this respect, compared to countries that have recently seen a swift economic boom); and finally, the recent environmental turn which places Europe at the forefront and give her new tasks, also in terms of innovative capacities. We have not hesitated to highlight the limits of the strategy that has been put into operation up to now and the need to make adjustments to the path taken so far, which we have explicitly expressed in the final recommendations. In particular, in Chapter 1 we have tried to summarize the economic, social, and political environment in which normative proposals for the creation of a European knowledge society are set and attempts made to implement them. Several means have been put forward in the last decade, all of them addressed to the implementation of a common objective: to make the Lisbon Strategy a reality.

We also discussed the cultural and practical conditions that led to the formulation of the Lisbon Strategy (§ 1.1) and its development during the last decade (§ 1.2). The Lisbon objective has not be fully implemented by 2010 as expected, but a good deal of sub-objectives have been fulfilled; first and foremost, we argue that although the Lisbon Strategy could not have been effectively implemented in certain areas of Europe, it has served the purpose of mobilizing intellectual and material resources toward democratization and modernization. Specifically, the failure of the Lisbon Strategy has helped to create a new environmental consciousness that seems to be able to unify the "modernizing" needs of the private sector with the "democratizing" needs of general society (§ 1.3).

Today the Lisbon Strategy has further postponed its objectives, but it has also qualitatively improved them in perspective. The main aim is no longer simple economic growth, with the consequent idea that it alone would suffice to meet society needs. It is undergoing a transformation towards sustainable development strategies and a greater attention towards the preservation of public goods (including knowledge) that we see as the right platforms towards the construction of a truly democratic knowledge-based society (§ 1.4).

Science and democracy
(Chapter 2)

One of the mandates we have been given indicates the best strategies to allow greater public participation in science choices and therefore to overcome the mistrust towards science and technology that has spread in recent decades, even among the most educated levels of society. This is also one of the main objectives of the Lisbon strategy.
Therefore, in Chapter 2 we have discussed the strategies needed to democratise techno-scientific praxis, focalising our attention on the difficult question of the perception of techno-scientific activity on the part of public opinion.
First of all, we have stressed how the twentieth century has seen a change in the perception of the role and function of science in society. In the Modern Age, science has always played a pivotal, instrumental and beneficial role. The eighteenth century is characterized by its "scientific" revolution that also implied a change in the way mankind would perceive the world and organize its social life. In the eighteenth century, for Enlightenment thinkers, science – in itself and as a paradigm of impartial reasoning and inter-subjective agreement – became the instrument for achieving individual emancipation from religious dogmatism and political despotism. The same applies to the nineteenth century with "positivism" investing all areas of cultural thought as well as institutional arrangements. There again science would serve the purpose of emancipating man from superstition and ignorance. Furthermore, industrial modernization was perceived as a beneficial, material instantiation of the emancipatory powers of science.
Up to the first decades of the twentieth century, science enjoyed unconditional support from the general public and political institutions until the two World Wars showed the bad side effects of its powers. After that, in the midst of the Cold War, pollution, overpopulation, economic disparity, and suchlike prompted many to call for a critical discussion over the main tenets of positivistic modernism. This was the conclusion everybody could agree on: in the postmodern age, science cannot be left uncontrolled. Its display of power during the two world conflicts had led governments to take up the role of controllers. Here, in the aftermath of World War II, the prestige of nations (or factions) during the Cold War depended on their economic and military edge, which, due to the paralysis (to some degree) of material conflicts within Western civilization ultimately depended on the techno-scientific edge – while ethnic and political aggressiveness was played on the outside in the form of economic coercion, cultural advertising, espionage, and suchlike. It is especially with the official end of Cold War in 1989 that a radical change in the way the perception of science of both professionals and the general public oc-

curred. All the techno-scientific resources accumulated during those thirty years could be directed towards public, social and civic purposes. It is at this point in history that public opinion entered an area of social organization that was previously held only in government quarters and discussed within university walls: science policy. Once the thirty-year threat of a nuclear and final conflict between the (then) two poles of the planet had stopped exercising a sort of coercive assent towards public expenses for techno-scientific development for defence purposes, the general public's risk perception was turned entirely towards other potential and real effects of government control over science. The environmental and social effects of industrial modernization became the object of public debate and it is still so in contemporary times.

We have briefly analysed also the development of the research policies promoted by the EC since the 1980s and we have tried to show how the negative perception of science, linked to the risk of the annihilation of our species during the Cold War by destructive technological apparatus, has given rise to the search for ways of involving society in general in the decisions concerning the use of research for non-bellicose aims and for broader public interest, especially in the light of a growing environmentalist awareness. We concluded by arguing that it is the use of technoscience, not the specific information on its praxis that concerns public opinion. In this sense, it would appear that a better strategy for the democratisation of knowledge does not require the public to participate actively in practising it, but regards a better divulgation of the risks involved in its results and the possibility of directing its ends. This is the conclusion that has developed from what was discussed in § 2.2: the divulgation of scientific knowledge, though useful and fundamental for the economic and cultural growth of a nation, is not enough to attenuate the negative perception of techno-scientific practice on the part of society in general. Instead, it is necessary to inform the citizens of the effects on society of certain scientific practices, both public and private, and to guarantee their participation in the process of assessment without expecting them to have a technical grasp of scientific practice and a consequent rational assessment of social, cultural and environmental effects. One does not need to be a nuclear physicist or a geologist to understand the level of risk involved in the construction of an atomic centre in an earthquake zone or in an area with hydro-geological problems, for example; instead, honesty is required on the part of the policy-maker to inform citizens of factors that make this action risky, offering an analysis of the consequences that evaluate not only the economic impacts of a certain practice, but also the social, cultural and environmental effects.

Therefore, one could claim that the democratisation of knowledge does not require informed consensus on the construction of means; instead, it requires a common determination of the ends for which the means, techno-scientific practice, are merely the tools. Otherwise, the prospect of a technocratic society looms, within which only those who have a strong grasp of technology would be able to decide and determine its implementation.

To this regard, in 2.3 we have analysed strategies aimed at modelling the relationship between the public and science. In particular, we will analyse the model of "public co-production of knowledge" that tries to balance the relationship between experts and non-experts in the direction of a common orientation of means towards shared ends. Although these strategies of "interfacing" between the public and science assume that scientific divulgation is a necessary but insufficient condition for the democratisation of knowledge, it is necessary to stress the importance of the role of scientific divulgation as a tool with which to train citizens to develop a critical sense. In the concluding paragraph, § 2.4, we tried to show the educational role of science, that, apart from the transmission of contents, possesses the most intimate dimension of civil cohabitation: the formation of a system of shared values based on the free exercise of one's own rights but aware of the duties that guarantee a peaceful and fruitful cohabitation.

The Devolopment of HPSS Studies
(Chapter 3)

One of the tasks we set ourselves was to make a critical analysis of the models of interaction between science and society in the light of reflections and research carried out in the last decades in the field of the philosophy, history and sociology of science. This is what we have tried to do in Chapter 3.

Here we tried to show how the thesis has been consolidated among HPSS practitioners – whose evaluation we later discussed critically, from a methodological prospective (see Ch. 4) – that it is only by looking at extra-methodological, ideological motivations beyond methodology implementations that we may justify the efficaciousness of a given descriptive model as a means for a super-methodological objective: to employ the analytical and descriptive tools of HPSS for science policy.

We discussed in § 3.1 the twentieth-century historical background in which the relationship between science and society was instantiated. As we have seen above, or perhaps just because it is so close to us, the history of the twentieth-century is rich and complex. As a consequence, we tried to look as far back as the eighteenth-century Enlightenment in order to point out those basic tenets of modernity, concerning the relationship between science, democracy and society, that have been instantiated and opposed in equal measure in the context of the twentieth-century. This allowed us to explain the motivation beyond the methodological variation among orientations of HSPP by singling out historical-cultural diversification factors that would otherwise escape simple meta-methodological analysis. For instance, we discussed in § 3.2 and § 3.4 how the philosophy of science underwent a transformation in the 1960s which can be characterized as a debunking of the modernity tenets discussed in the previous section. Specifically, such a turning point in the philosophy of science is characterized by the return of a historical perspective which pays due attention to extra-logical and extra-empirical factors determining scientific consensus over rival theories.

The reintroduction of an historical perspective had opened the possibility of integrating historical, psychological and sociological themes into the framework of the philosophy of science. We discussed in § 3.3 how before the 1960s the history, philosophy and sociology of science were quite separate from one another. They both had the same subject – science practice – but each of them considered only one dimension of science. Specifically, the history of science was considered to be an activity primarily concerned with the "external," contingent development of science that had nothing to do with its "internal" development i.e. relative to the rational, intrinsic development of science contents. The philosophy of science was concerned with a logical reconstruction of the decision episodes of science, and therefore it simply represented the choice of one theory over a rival one as a matter of logical coherence and empirical correspondence. The sociology of science as put forward by Robert K. Merton, on the other hand, was only concerned with the institutional dimension of science.

This unproblematic division of labour broke down at the same time as the historicist turn of the philosophy of science. In fact, the protagonists of the historicist turn, who we referred to as the "post-positivist," by showing the underdetermination of theory by logic and evidence (i.e. the fact that the choice of one theory over another could not be decided by simply considering their logical and empirical virtues), implied that theories get selected because of "irrational" merits (such as group affiliation, prestige, financial gain and so on) and therefore the truth of a given theory was determined by those socio-historical factors that were before considered as extraneous to rational decision assessments. This gave rise to a more invasive sociology of science programme that would reject the division of labour established by Merton and henceforth we referred to as "post-Mertonian." This is the Sociology of Scientific Knowledge (SSK) that was first introduced in § 3.4 in connection with another important but somewhat different sociological approach, the Sociology of Knowledge (SK), and then it has been critically discussed in § 3.5.

A history of HPSS would not be complete without linking it to the more recent history of Science and Technology Studies (STS) that we tried to describe in § 3.6. After all, HPSS is the methodological hardcore of STS which in fact tolerate a great variety of approaches within their boundaries. The history of STS offers us the possibility to single out some of the historical contradictions within their often invoked methodological tolerance. For instance, STS scholars often embrace an anti-modernist, anti-scientistic perspective that they mistakenly refer to as "post-modernism." We have tried to show in § 3.7 that theirs is just an anti-scientistic perspective that does not assimilate the main methodological postmodernism as represented by the works of Lyotard. This helped us to clarify the ideological reasons beyond the methodological divergences of HPSS that are the basis for a better understanding of the methodological questions that have been tackled in the next chapters.

Multidisciplinary approach and modelling strategies
(Chapter 4)

Starting from the analyses carried out in Chapter 3, we have tried to achieve the first objective – understanding the role of HPSS with respect to science policy – by designing a "multidisciplinary" methodology for HPSS that would enable it to constitute an effective tool for science policy. Specifically: HPSS are mainly descriptive endeavors [in the Overview to Chapter 4, it is stated that STS are mainly descriptive. How can we reconcile the two things?]. They describe science practice and the relevant decision processes, such as why a given research programme is rejected in favour of a rival one, what kind of research is to be pursued in the face of empirically equivalent options, risk assessment with respect to both private and public sectors investments and general society. In brief, HPSS look for the causal factors effecting S&T decision process (see Chapter 3 for a full documented history of HPSS's methodological development). Such descriptive information is extremely valuable for science policy makers who should try to pursue their regulative and evaluative (i.e. normative) activities based on the best available knowledge on the financial, societal and environmental consequence of their decisions concerning R&D institutional design as part of a governmental effort addressed to the balance between the needs and wants of the private sector and those of general society.

HPSS has therefore to construct the descriptive narrative of R&D practice and how it interacts with government and civil society. But there is an obstacle to that. The methodologies and approaches employed within the HPSS field differ greatly. Specifically each methodology tends to privilege a specific aspect of techno-scientific practice, therefore each one of them singles out specific causal factors to explain the outcomes of the relevant decision outcomes while excluding others. For instance, the sociology of science explain decision episodes of science practice as the outcome of social interests; the philosophy of science employs mainly evidential factors (empirical support and logical coherence) as a causal unity of explanation; currently, the history of science privileges the sociological approach, but this is not always the case, as we have documented. To establish policy advice as the unitary objective of HPSS, helps to formulate an adequate strategy for their methodological integration. Specifically, we have outlined and defended a "multidisciplinary integration" of HPSS as opposed to their "interdisciplinary unification" (i.e. employing a single explanatory methodology as an umbrella discipline on which the others are methodologically reduced). On a multidisciplinary framework descriptive narratives are constructed so as to sacrifice "precision" (detailed analysis of specific causal connections) to "realism" (accounting for a process complexity) and "generality" (enlarged explanatory scope). On this framework each specific methodology of HPSS is employed independently from the others although they are all addressed on the descriptive analysis of the same process. Several causal factors are put forward to explain the same phenomena and the integration of results is postponed after the specific methodology are employed to the moment in which we look for convergence of results and try to solve out contradictions. We therefore sacrifice precision (we cannot focus anymore on the rule of specific causal factors), but we can account for the complexity of the factors determining the relevant process and, as a consequence, we can enlarge the explanatory scope to include more circumstances and consequences. With respect to policy makers' employment of HPSS narratives, through this strategy we construct more inclusive narratives – as a consequence of the elimination of mono-methodological perspectives – that are at the same time more intelligible for non-experts in specific techno-scientific issues – since to sacrifice precision imposes a relaxation of technical/specific HPSS terminology.

Once the conditions for multi-disciplinary approach had been set and defended, we discussed a special approach to the philosophy of science, the Modeling Approach to Science (MAS) which seems the right candidate among other approaches in the philosophy of science to facilitate the integration of the methodologically different contributions to STS towards policy objectives. In fact, besides offering a more realistic and descriptively complete picture of science practice with respect to its predecessor in the philosophy of science (§ 4.3), namely the syntactic view, MAS is also able to capture some aspects of science practice that elude even sociological approaches to STS, thus inviting different perspectives on the same subject matter (§ 4.4). Once we have shown the kind of contribution MAS can offer as a complement to other STS approaches, we articulated further its internal advantages and argued for its important role in the context of the disenchantment of the general public and experts towards science's quest for certainty (§ 4.5).

Finally, we tried to see whether STS can establish itself as a normative discipline beyond its primary descriptive nature (§ 4.6). We argued that it should not. STS can contribute to policy makers by offering, as we said above, informed descriptive narratives for policy making, specifically for science evaluation and regulation, and that in this respect it may suggest how to use this information without going beyond the threshold of policy "advising."

The main steps towards the recommendations
(Chapter 5)

What has been said in the previous chapters forms the historical and epistemological background of the premises that justify the steps made to reach the recommendations laid out in chapter 5.

In the first place, we have discussed the genealogy (§ 5.1.1), development (§ 5.1.2) and use of techno-scientific models of innovation in the area of European policy-making. Of the three models discussed here – the "linear model", the "Chain-Link Model of Innovation" and the models based on the "National Innovation Systems" (NIS) – we have above all highlighted the inefficiency regarding the two-fold objective of responding to the needs of both the private sector and civil society through technological innovation. In fact, the three models assume that economic growth is equivalent to the growth of civil society. The efficiency of the strategies set out to stimulate innovative processes is therefore measured on the basis of achieving merely economic-financial objectives, excluding the more general advantages such as the improvement of quality of life in terms of a better management of natural and human resources (see § 5.1).

Therefore, we have analyzed the connection between tacit knowledge and expertise, a fundamental connection to clarify the correct definition of the Knowledge-based Society. In fact, we believe that, in addition to the definitions currently in the literature, the best way to stimulate a greater opening and more widespread understanding of science is to modify the point of view of experts as well as that of the public. We think that this process is possible also through the recuperation of the concept of expertise, as suggested by the scientific epistemology of the twentieth century. This means encouraging the meeting of the implicit and explicit areas that are present within professional competence with that unexpressed knowledge that is incorporated in the knowledge of a biological-structural nature, from which the theoretical concept of tacit knowledge comes. In fact, expertise, as part of a wider perimetre represented by tacit knowledge, is still an incorporated part of knowledge. It cannot be separated from those processes of metaphorical representation of knowledge that everyone makes, whether s/he is an expert or a non-expert member of the general public. (see § 5.2).

In the following paragraph, we have analyzed the role of creativity in the shaping of the society of knowledge, highlighting how it is an essential tool for innovation in science and the humanities; and the EU is well aware of this (it declared 2009 the year of creativity). Creativity, present in all individuals and not only the privilege of a chosen few, should be nurtured from a young age, above all at school. We have also analyzed the creativity present in companies with the aim of innovation; to this end, it is essential to encourage an environment that is rich in stimuli and provide creative places in the company as in society. If companies take into consideration the well-being of their employees, giving them the possibility to express their creativity and fantasy, they would not only reap financial rewards, but would also get spin-offs in terms of personal, human well-being. A final aspect we have analyzed concerns widespread creativity. Today's society is bursting with creativity thanks to the presence of computerized tools that have changed our way of thinking. Knowledge on the Internet is increasingly an open system, in which everyone can create knowledge; Wikipedia is an example of this. We have dealt with the creativity present in the users of ready-made products, the so-called "producers", able to modify the products to adapt them to their needs. Companies are well aware of this and are creating forms of interaction with the users, whose creativity is necessary to re-design the products. Creativity is essential for a new way of company management, no longer seen as a vertical system, but a horizontal one, in which employees and users collaborate to create new products but especially new knowledge. (see § 5.3).

Considering these premises, the role of universities today and of knowledge in general seems to be crucial; universities are seen as being the engine of development for a society of knowledge that can evolve in the way we want it to: human, serious and critical. Naturally, it is not enough to make them expand or invest in them; we need to establish in a critical way, after due analysis, what needs to be expanded and what to invest in. In this sense, the human capital shaped in the universities and the new knowledge which depends on this human capital form the crux of these reflections. This is the our final objective in analyzing the most important issues of universities today and the challenges they have to face, in questioning ourselves about the role and mission that is most important for universities, in making comparisons with other university systems and in suggesting possible moves or proposals to revise. At the same time, the analysis of the concept of knowledge that is more valid today has the aim of justifying the objective to invest in a development of culture, knowledge, innovation and creativity as instruments, above all, of understanding of the real, of the cultural and civic training of citizens and subsequently also as real engines for a economic development that is human and sustainable. (see §§ 5.4-5]

Finally, we have outlined the general perspective in which we have framed our proposals and that we have defined as a "human scenario" characterized by greater investment in "human" capital rather than in technology and infrastructures. We have stressed the need: to privilege education as an essential factor for the growth of human capital and to stimulate greater creativity in schools and universities; to overcome fragmentation and specialist knowledge; to increase shared and interdisciplinary knowledge; to increase employment, opposing the tendency towards loss of jobs and out-sourcing; to attempt to replace GNP by an index of well-being that is not merely economic; and finally, to privilege the Scandinavian and Finnish model of innovation rather than the one incarnated in Silicon Valley (see § 5.6)

The recommendations
(Chapter 6)

Here we have laid out the recommendations that will be made to the EC:

Recommendation 1

In seeking descriptive narratives of scientific practice to support the descriptive activities of science policy-making (like funding policies for research which require a complete description of factors that can determine the expected results and risks, etc.) we suggest privileging those in which the diverse methodological approaches are integrated according to a multidisciplinary logic.

Recommendation 2

We suggest conserving the non-commercial aims of research financing its activities, even if the linear "science push" model has shown itself to be a failure on the level of increase of financial capital, as demonstrated byt he "European paradox", In fact, the model fails when mere economic growth is considered to be the objective, but the production of techno-scientific innovation is also useful to provide goods and public services besides carrying out the essential function of conservation, transmission and progressive organization (in the light of new discoveries and inventions) of the heritage of shared knowledge on which also the private sector can draw for the production of innovation for commercial aims.

Recommendation 3

It is essential for the policy maker to ensure the existence of independent scientific institutions – as the universities traditionally were – able to support themselves economically without having to answer to stakeholders and able to put into operation cognitive strategies that are only "curiosity driven

Recommendation 4
We suggest that basic research should be given more support on an EC level, inverting the trend that until now has privileged research of an applied nature, and that instead, the individual member states of the EU should be encouraged to invest more in applied research that is linked to the local community. This can take place both through traditional framework programs, and also by increasing and extending the network of scientific community institutions in which scientists from the different countries can participate.

Recommendation 5
It is essential for policy makers to ensure that scientific institutions are spread over the country in order to guarantee a general training of high quality, aiming at improving in quantity and quality the human and social capital available in society as a whole.

Recommendation 6
Policy makers must ensure that the scientific institutions spread over each country are governed in a democratic way, allow the widest freedom of research and have become models of a tolerant community, open with no linguistic, cultural, ethnic or racial barriers, in which success is based on merit and ability, so as to stimulate as much as possible the exchange of ideas, discussion and interaction between different cultures and experiences, primary sources of creativity and innovation

Recommendation 7
Policy makers must prevent an excessive polarization between universities for research and universities for mere post-school training, by trying to revitalize the "Humboldt model" based on the close correlation between research and teaching, which has assured the excellence of European universities and which was the basis of the success of the American university system

Recommendation 8
In order to balance the need for the accumulation of financial capital by the private sector and the safeguarding and better management of natural and human capital on the part of society in general, the EU should adopt a single platform of macroeconomic reform based on the environmental sustainability of production processes.

Recommendation 9
The spread of scientific culture and appreciation of it, with the consequent overcoming of unease and mistrust towards it, requires not only a generalized divulgation of scientific contents, but also better awareness of the humanistic content within it, and therefore the knowledge of the most vast human and historical context within which science builds it-

self

Recommendation 10
The diffusion of scientific culture and its appreciation on the part of civil society does not come about by the transmission of the contents of science, but requires also the shaping of intellectual habits, tributaries of that tacit knowledge that can be provided only by an effective scientific practice that must be implemented within all curricula of tertiary education

Recommendation 11
It is essential that within each specialist training at university level, hybrid areas of knowledge are created in which interaction between disciplines, and especially between the humanistic and scientific ones is possible. This would allow us to reduce the distance between the "two cultures" and would enable each researcher in each field to be in touch with the specialist jargons of others

Recommendation 12
In fact, it is important to encourage as much as possible a "diffuse expertise" able to promote the increase of democratic participation in decisional processes that are usually the privilege of experts. This can happen only when the scientific culture becomes explicitly part of a shared culture, based not so much on an encyclopedic vision of knowledge but rather on a common concept of reason that sees in logic and in scientific methodology the basis of a shared procedural modality of investigation.

Recommendation 13
We recommend avoiding a too early specialization of competences, both at the school stage and also in tertiary education , so as not to block the logical opening of the mind towards universes and worlds that are imagined but still not realized and to aim instead at the training of a flexible mind, able to face ever new problems

Recommendation 14
We recommend increasing the places and the ways of exchange of diverse competences in the specialist field (for example between the hard and soft sectors of science), and also by multiplying the places of interaction beyond R&D departments, since only the meeting of diverse and sometimes divaricating logics can ensure the creativity which is able to produce explicit new models.

Section one

0. Introduction:
From the age of "Posts" to the Knowledge Society

0.0 – Overview

We have introduced our analysis with a study of the main directions of reflection on society and its relationships with science and technology in the last 50 years. In particular, we have examined the set of subjects linked to the idea that we have entered an era characterised by the prefix "post": post-industrial, post-modern, post-democracy, post-positivism, post-structuralism, post-Fordism, post-Marxism, post- or trans-humanism and so on. Everything has been inserted, from a certain point onwards, within the complex framework of globalization, which in its turn has been made possible by the so-called knowledge economy, the centre and "nervous system" of which is the development of Information and Communication Technology (ICT). Having examined the key concepts of the post-industrial and the postmodern, we have tried to see how at the end, everything flows into the idea of a society of knowledge, which is the objective set by the EU with the Lisbon strategy. We have tried to trace the origins and development of the knowledge society, beginning with outlining the main characteristics of the well-known 1945 report by Vannevar Bush. Finally, we have tried to clarify in what sense one should speak of "knowledge" within the society of knowledge, distinguishing (in the wake of Lundvall) the the know-what, the know-why, the know-how and the know-who, underlining how this partition throws light on the dimension of "tacit knowledge", which will be subsequently investigated (§ 5.2).

0.1 – Beyond the age of "Posts"

It seems that in the 1960s, civilized Western society entered a new phase of its history, marked by a varied and widespread use of the prefix "post". In order to distinguish this phase, it is not enough to speak of "an advanced industrialized society" or the mechanization and automation of work, as indeed Marcuse did in his prophetic book One-Dimensional Man (see Marcuse 1964); but it seems necessary to point out a real break with the past, a watershed that indicates in a concrete way, or even in the collective imagination, the coming of a new model of society, of a new era of human history completely different from the previous one. Therefore, there is a profusion of definitions beginning with "post" that concern social, cultural and artistic phenomena: post-industrial, post-modern, post-democracy, post-positivism, post-structuralism, post-Fordism, post-Marxism, post- or trans-humanism, and so on, not to mention their linguistic variations ("pre-post-modernism", "post-post-modernism", "post-scientific society") or diverse denominations ("society or age of information", "flexible specialization", "liquid society", "alternative modernity", "hypermodernity", etc.) that in some way modify or give a different shade to already consolidated meanings, giving rise to new cultural aggregations, to new categorizations more adequate to feelings and to characteristics of certain intellectual or social configurations. Then everything often ends up flowing into an all-encompassing and all-explicative concept: that of "globalization" seen as

> a process (or set of processes) which embodies a transformation in the spatial organization of social relations and transactions – assessed in terms of their extensity, intensity, velocity and impact – generating transcontinental or interregional flows and networks of activity, interaction, and the exercise of power. (Held et al. 1999, p. 68)

In other words,

> globalization refers to a multidimensional set of social processes that create, multiply, stretch, and intensify worldwide social interdependencies and exchanges while at the same time fostering in people a growing awar eness of deepening connections between the local and the distant. (Steger 2003, p. 13)

There is no doubt that the nervous system of this new reality lies in the revolution that took place in Information and Communication Technology (ICT), in the rise of the "global network" and the "network society" – the most lucid analysis of which was provided by Manuel Castells (2000, 2000b, 2004) – «a society whose social structure is made of networks powered by microelectronics-based information and communication technologies» (Castells 2004b, p. 3). In fact,

> it is the global character of information, the "space of flows" that links people and places worldwide through the Internet and electronic communication, that gives it its decisive power. The "space of flows", the global network, complements and to some extent replaces the "space of places", the localities that were the predominant source of our experiences and identities. It is the integration of information in global networks, centred on "global cities" such as New York, London and Tokyo, that has brought about the supersession of the nation-state above all in the economic arena but also in culture and to an increasing extent in politics as well. (Kumar 2005, p. 7)

Nevertheless, even within such a vast globalizing process – more advanced in the domain of culture and imagination than in economics and even more than in politics (Nederveen Pieterse 2009), – it really seems that, apart from the various denominations, the basic characteristic of everything recognized by this epoch of ours is the importance of information, regardless of the fact that we see in it a totally new aspect that molds a kind of society that has broken away from the past (like Toffler 1981, for whom it represents the "third wave" of technological innovation after the agricultural and industrial revolutions); or rather a further modulation of organizational practices and forms with a longer continuity (Roszak 1986). And the heart of this new "information age" is without doubt linked to computers and the world-wide spread of the Internet, with all the well-known consequences that a vast literature has now amply illustrated and exalted (Masuda 1981) or demonized (Ellul 1990; Postman 1992). A series of changes derive from this that concern the field of economics (hence the term "information-based economy" – Machlup 1962, 1980, 1984; Porat 1977, 1977b): employment, quality of work and human capital, since economic well-being is derived not so much from the physical strength of traditional workers but from «ideas, knowledge, skills, talent and creativity» (Leadbeater 1999, p. 18) (this is the concept of the "post-industrial society", as we will see). These also involve the spatial dimensions within which the new society organizes itself, that do not have the previous limitations linked to distance and place, now minimized by "electronic highways"; finally, another consequence is the possibility to have at one's disposal information and cultural products in a measure that was unimaginable before, since we can say that now we live in a "media-laden society" (Webster 2006, pp. 8-21).

Without this surmise, it would not even be possible to speak of globalization. We will not go into detail here on the many interpretations and definitions regarding the concept of globalization (see Kumar 2005, pp. 7-16; Held & McGrew 2002b); it is enough to reveal, in a very synthetic way, that it represents a slow emergence from the condition of "modernity", the origins of which go back to the 16th century (Steger 2003, p. 8). It is an entry to the domain of the "post", the first step of which is to go back to the idea of the "post-industrial" society of Alain Touraine (1969) and even more of Daniel Bell (1973, but the concept had been put forward in the 1960s in an unpublished essay that was, however, widely circulated in diverse other articles – see Waters 1996, pp. 106-7) and also prepared by other sociologists and futurologists like Peter Drucker (1969) and Alvin Toffler (1970).

0.2 – Post-industrial and post-modern

In Bell's ideal-typical approach, the post-industrial society, that came into being during the 1960s, followed the industrial and pre-industrial ones. Unlike the latter – that is a "game against nature" to obtain the resources needed for survival — and the industrial one, that is a "game against fabricated nature" and is focused on the relationship between men and machines with the aim of producing tangible goods, the post-industrial society is a "game between people" in which technology-based information is developed and in which the transition takes place from a manufacturing-based economy (concerning the production of saleable products) to a service-based economy (concerning the production of services in terms of transport, distribution, promotion, and sale of goods produced by the manufacturing sector) characterized by the diffusion of capitalism on a global scale and consequent mass privatization (Bell 1973, p. 116). The manufacturing and service sector of the economy corresponds to the secondary and tertiary sectors; the primary sector is the transformation of natural resources into raw materials to be employed by industry for the production of goods. Because of these characteristics, Bell stresses the change in industry and economy in terms of an ever-increasing role of science as an exchange commodity and, therefore, as a mark of the economic wealth of nations and firms.

To this regard, the rising importance of professional figures with cognitive competences of a theoretical and technical nature has become more evident; at the same time, there has been a decline in the central importance of traditional workers, the so-called "blue collar" workers – workers involved in large manufacturing industrial complexes. In particular, in his book, Bell stresses the importance that information and knowledge have assumed in contemporary society (which, in essence, he considers to be equivalent to the post-industrial society and the society of information) (see Bell 1976, pp. 14-15).

> The phase of post-industrialism represents a shift in the kinds of work people do, from manufacturing to services (especially human and professional services) and a new centrality of theoretical knowledge in economic innovation and policy. […] The post-industrial society centres on the technology, the kind of work people do (though there are political implications in the relative decline of the working class), and the organization of knowledge. (Bell 1976, pp. 14-15)

Apart from the various specifications made by Bell regarding the fundamental dimensions that comprise his ideal type of post-industrial society, the nucleus of his proposal consists in indicating two fundamental dimensions that decide whether or not a society has entered at this stage: the centrality of theoretical knowledge and therefore the importance of science as a fundamental instrument of economic change (and so, he also uses the term "society of knowledge" – see Bell 1973, p. 212); and the expansion of the "quinary" sector, comprising the industries of health, education, research, public administration and entertainment (Waters 1996, p. 109).

However, for Bell, in line with his anti-holistic paradigm of the "three kingdoms" of social structure (technical-economic, political and cultural, each with its own dynamics that can operate independently of the others) (Bell 1973, ch. 2; 1976, pp. xvi-xvii, 10-12), the advent of the post-industrial society mainly concerns the technical-economic realm of society, which he calls "social structure"; therefore, it is possible for a society to enter the post industrial phase only regarding the technical-economic field, leaving behind politics and culture. That is, the internal mechanisms of the cultural and political systems, like their contents, may remain unchanged: for Bell, there is nothing to stop an Islamic post-industrial or even Soviet society from existing.

A more comprehensive vision that is mainly centered on cultural changes – not forgetting the political and economic ones – was provided by another version of "post", proposed at the end of the 1970s by the French philosopher Jean François Lyotard (1979). Through his conception of "post-modern" a perspective entered the western cultural debate that was to be very successful and would mark philosophical discussion in a particular way and would also end up having enormous repercussions in the field of epistemological reflection on science (see § 3.4). The various already elaborated "posts" entered quite easily within his all-embracing denomination: both the post-industrial one and the post-Fordian one, preferred to the previous one by thinkers with Marxist roots (Aglietta 1979), since the latter claims the paramount importance of factory and production relationships, that is work and capital, thus putting in the shade the central factor of contemporary industrial society, that is the production of knowledge and its circulation (Cerroni 2006, p. 104).

The post-modern designs the alteration of the status of knowledge once society enters the post-industrial age (Lyotard 1979, p. 3) and therefore involves several fields: from architecture (where it originated from) and from philosophy it extends to theology (see Griffin 1989; Vanhoozer 2003), to spirituality in general, to literary criticism (Lucy 2000; Carter 2003), to pedagogy and curricular training (de Alba et al. 2000), to anthropology and identity studies (D'haen & Vermeulen 2006), to geography (Soja 1989; Minca 2001), to the field of law (Douzinas et al. 1993), to the field of management and theory of organization (Boje et al. 1996), to science (Griffin 1988) and to a multitude of other sectors so that we can reasonably state that today there is no dimension of culture and society that cannot be interpreted or placed in a post-modern viewpoint (for a general picture see Sim 1998; Taylor & Winquist 2001; Connor 2004).

Post-modernism is first and foremost an analytical reflection and a critical stance regarding the notion of "modern", characterized by its most typically ideological manifestations, the most fundamental aspect of which is relying on the "great narratives" (the metanarratives) to give some meaning to history and indicate the place that humanity occupies in it.

1. The "metanarratives" which are spoken of in the post-modern condition are those that have left their mark on modernity: the progressive emancipation of reason and freedom; the progressive or catastrophic emancipation of work (a source of value alienated in capitalism); the enrichment of humanity as a whole as a result of the capitalistic progress of techno-science; finally, if modernity comprises Christianity itself (thus opposing ancient classicism), the salvation of creatures through the conversion of souls to the Christian narrative of love for the martyr. The philosophy of Hegel comprises all these narratives and in this sense we can find speculative modernity concentrated within it (Lyotard 1986, p. 27).

In brief, it is the rebellion against the idea of a society and a history founded on a "project" and on its legitimizing power. Therefore, «simplifying to the extreme, I define postmodern as incredulity towards meta-narratives» (Lyotard 1979, p. xxiv). As opposed to the unitary, progressive, rational view of history and culture, the postmodern constitutes «emphasis on the volatile, fleeting, mobile, ephemeral part of modernity: that which has lost the eternal part, the fixed nucleus» (Nacci 1995, p. 365). In a universe that is no longer seen in a compact way, it is not possible to conceive of a theory that embraces everything and is totalizing; instead, local limited concepts, language games and discursive formations each with its own rules and grammar are preferred. And when one does not arrive at such an "analytical" dimension of knowledge, it is the reflections of the central European intellectuals – from Heidegger to Junger, from Arendt to Jonas, from Spengler to Jaspers – who provide a deformed version of the concept of knowledge due to its illegitimate historical use, and also to the lack of trust in their capacity for social renewal. Also the enlightenment link between knowledge and science is swept away – taken up again in various ways in the context of European scientific philosophy: «knowledge [*savoir*] in general cannot be reduced to science, nor even to learning [*connaissance*]» (Lyotard 1979, p. 18). In this way, science ends up becoming a subset of knowledge, which in its turn constitutes a weakened knowledge reduced to a "set of denotative statements"; while knowledge «includes notions of "know-how", "knowing how to live", "how to listen" [savoir-faire, savoir-vivre, savoir-écouter]» (ibidem).

This is a wider vision of knowledge that – as we will see later when dealing with expertise and tacit knowledge (see § 5.2) – does not necessarily clash with the scientific one, but places itself as its necessary complement, as its further specification within a vision of science that is different and in many aspects is not in line with that criticized by Lyotard and by postmodernist critics in general, and they are not completely wrong in opposing it. However, from this diagnosis Lyotard pulls out a radical criticism of enlightenment and its idea of an increasingly rational domain of nature and society on the part of man and his science. In brief, he criticizes the project of making man master of his destiny, removing him from blind forces of nature, social slavery, also seen as something natural, ignorance that legitimizes and sanctions everything with the frills and perfumed garlands of religion and ideology. It is not only enlightenment that has lost every capacity of legitimation towards its own metanarrative, but the science that it places at its very basis shows itself incapable of legitimating anything:

> Science plays its own game; it is incapable of legitimating the other languages games. The game of prescription, for example, escapes it. But above all, it is incapable of legitimating itself, as speculation assumed it could. (Lyotard 1979, p. 40).

Therefore, science is – and here the lesson of Wittgenstein is decisive – knowledge without foundations (Gargani 2009), that cannot be justified by any epistemological strategy, if not by the science itself in its concrete praxis (and the naturalist turn of epistemology goes in this direction – see § 3.4-3.5).

It is from this basis that the postmodernist interpretation of science is derived:

> It is characterized by a belief that science is a socially constructed, "situated", historical product whose theories are generated by contextual factors such as class interest, ideology, or laboratory politics rather than nature. Moreover, instead of being a glorious and progressive achievement of the Western world since the seventeenth century it has been a deeply flawed enterprise which has degraded the environment, oppressed women, minorities, the Third World, and is presently a tool of corporate capitalism and the military industrial complex.

> These views are often joined to a profound anti-realism. Since nature cannot be interpreted independently of the conceptual structures scientists bring to the task, there is no "way the world is" apart from these structures. Scientific theories are not "caused" by nature. Instead, they constitute nature. So-called "scientific facts" do not correspond to mind-independent properties of the universe, but merely represent the biases of scientists. And since these biases inevitably reject class, gender, race, or other socio-political factors so does what we call "nature." It follows that vaunted "objectivity" of science is an illusion. Science is an ideology like any other. At best it may have some pragmatic or technological value, but there is no epistemological reason for it to be preferred over "other ways of knowing" such as religion and myth. (Brown 2009, p. ix)

This is not the moment to make an assessment of this approach (for this, see § 3.5); rather it is possible now to underline the common character in all the "posts" encountered until now: the central position of scientific knowledge as an essential base of technological innovation. Without the prodigious growth of scientific knowledge (basic and applied) in fact, the information revolution would not have been possible and without this we would not have seen the rise of the society of information – the common premise both of the post-industrial society and the postmodern one.

0.3 – The knowledge economy and the knowledge society

This section deals with the reasons why, from a certain point onwards, scholars have preferred to talk about "the knowledge economy" (Mokyr 2002) and, more in general, of "the knowledge society":

> The theme which unites what are rather disparate thinkers is that, in this information society (though the term "knowledge society" may be preferred, for the obvious reason that it evokes much more than agglomerated bits of information), affairs are organised and arranged in such ways that theory is prioritised. Though this priority of theoretical knowledge gets little treatment in information society theories, it has a good deal to commend it as a distinguishing feature of contemporary life. (Webster 2006, pp. 28-9)

The shift of attention to the society of knowledge not only has the advantage of moving away from the use of concepts "to differentiate", that find their raison d'être in the negation of something else, but also avoids identifying knowledge as information, a danger which all theoreticians both of the "information age" (Lyon 1988) and of the "new paradigm of information" come up against (Castells 2004b); in this way, these concepts do not adequately put into light the most characterizing and specific aspect of contemporary society, that distinguishes it in a radical way from all that preceded it. Besides, this lack of distinction runs the risk of under-evaluating the traditional centers of production of knowledge like universities and academic environments (Lyon 1988, pp. 107-108), that in our opinion, continue to have great importance (see § 5.4), and also risks diminishing the relevance that basic knowledge (encoded and implicit – see § 5.2) has for democratic participation in scientific choices, otherwise consigned to a restricted technocratic élite (see ch. 2).

Indeed, since the scientific revolution, the importance of knowledge for human progress and economic development has always been underlined, finding in Francis Bacon its most celebrated and symptomatic representative; some date the European tradition in this regard back to Plato (Kalthoff et al. 1997, ch. 1). However, the frenetic rhythm that has characterized scientific research and technological innovation in recent times (beginning from the end of the second world war), which has been placed along with the pressure of important socio-political changes, has imposed an in-depth reflection on the possibility that technological development can bring for democracy. As long ago as 1952, Russell was prophetically aware of what would soon happen:

> Man has existed for about a million years. He has possessed writing for about 6,000 years, agriculture somewhat longer, but perhaps not much longer. Science, as a dominant factor in determining the beliefs of educated men, has existed for about 300 years; as a source of economic technique, for about 150 years. In this brief period it has proved itself an incredibly powerful revolutionary force. When we consider how recently it has risen to power, we find ourselves forced to believe that are at the very beginning of its work in transforming human life. What its future effects will be is a matter of conjecture, but possibly a study of its effects hitherto may make the conjecture a little less hazardous.
>
> The effects of science are of various very different kinds. There are direct intellectual effects: the dispelling of many traditional beliefs, and the adoption of others suggested by the success of scientific method. Then there are effects on technique in industry and war. Then, chiefly as a consequence of new techniques, there are profound changes in social organisations which are gradually bringing

> about corresponding political changes. Finally, as a result of the new control over the environment which scientific knowledge has conferred, a new philosophy is growing, involving a changed conception of man's place in the universe. (Russell 1952, pp. 11-12)

In its modern meaning, the term "knowledge society" was first used by Robert Lane (1966) (who spoke of the "knowledgeable society" to be more exact) and then Peter Drucker (1969), and was later taken up again by Bell, even if in a way that was subordinate to the concept of post-industrial society (1973); however, it was Nico Stehr (1994; 2001, pp. 19-31) who gave it the autonomous dignity and the relevance that it has assumed today. He states that «present-day society may be described as a knowledge society because of the penetration of all its spheres by scientific and technical knowledge» and declares that he prefers this expression to many others to describe the characteristics of contemporary society (like those of "post-industrial society" and "information society"); and this is because «the transformation of the structures of the modern economy on the basis of knowledge as a productive force constitutes the "material" basis and justification for designating advanced modern society as a knowledge society» (Stehr 2001, p. 20).

The rise of the knowledge society implies first of all a profound transformation in the economy, since it is claimed that at the basis there is the birth of a "knowledge economy", which in essence means,

> economies in which the proportion of knowledge-intensive jobs is high, the economic weight of information sectors is a determining factor, and the share of intangible capital is greater than that of tangible capital in the overall stock of real capital. These developments are reflected in an ever-increasing proliferation of jobs in the production, processing, and transfer of knowledge and information. This evolution is not just confined to the high-technology and information and communication service sectors; it has gradually spread across the entire economy since first coming to light as early as the 1970s. Society as a whole, then, is shifting to knowledge-intensive activities. (Foray 2000, p. ix)

In the knowledge economy there is a shift from the importance that the input of a material nature has in the productive processes to the importance assumed by input that is symbolic or based on knowledge (Stehr 2001, p. 24). This can be seen in two ways: as the economy that incorporates more and more knowledge into the products that it puts on the market, since it can be stated that today we buy "frozen knowledge" (it has been calculated that the content of scientific and engineering knowledge of industrial products was about 5% in 1945, 16% in 2004, and will reach about 20% in 2020 – see MHLG 2004, p. 13); or as the economy in which knowledge becomes more like goods, and in which the economic activity is increasingly represented by production and the consumption of information, that is the «production of information in the form of goods» (Cini 2006, p. 370). In this way, the production of material goods, centered on the factory as the place of creation of social wealth, and the conflict linked to it between salary and profit for the division of the surplus have become increasingly less important. The dematerialization of the universe of goods has profoundly changed the productive process, diminishing the need to employ workers and raw materials; even where the production of material goods persists, it employs an increasingly reduced percentage of the human population (for example in agriculture) and there is an increasing tendency to substitute the work of humans with robots and computers: «the component of new knowledge will become more predominant; it is potentially limitless, because the new information that the human mind can create is without limits» (ib., p. 309).

Another characteristic of the knowledge economy is the speed with which knowledge is created. This is possible thanks to the formation of a new type of organization: knowledge-based communities comprising networks of people who «strive, above all, to produce knowledge and make it circulate, working for different organizations that are often also rivals» (OECD 2004, p. 14). This means that, along with traditional areas of research, productive systems of knowledge are on the increase, distributed through a set of new places and actors (see § 5.3.4); there are more and more innovators who emerge in unexpected sectors, like users and normal people, involved in the production of knowledge in sectors like health or the environment:

> Most knowledge communities cut across the boundaries of conventional organizations (business, research centres, public and government agencies, etc.) and members of the former are at the same time employed by the latter. So, the development of

> the knowledge economy has seen, inter alia, conventional organizations infiltrated by individual whose continuing attachment to an external knowledge community makes them all the more valuable to the organizations that Harbour them as regular employees. (OECD 2004, p. 24)

Regarding the places where the knowledge economy began, and the time (even if the originating process was gradual and not marked by radical breaks) it is generally recognized that the place was identified in the USA while the time varies from the end of the first world war (which for the first time saw the massive use of technology on the battlefield) (Block & Hirschhorn 1979, p. 368) and the immediate aftermath of the second world war, followed by the profound impact of the scientific and technological revolution of the 1950s (Richta 1969, p. 276). In particular, according to those who subscribe to the second date, a decisive drive in this direction was given by the great effort made by the USA at the end of the Second World War and during the Cold War. It was especially as a consequence of World War I and later, the technological competition between the USA and the USSR during the Cold War, that governments understood the importance of R&D for national security, or more appropriately for military and economic edge over other nations. Technological edge decided the outcome of World War II and it was the "cold" weapon, together with diplomacy, explicitly employed by the USA and the USSR that determined and increased their control and influence over other nations.

0.3.1 – Vannevar Bush and the consequences of his approach

We can place the actions of Vannevar Bush in this context; after overcoming the distrust that people first nurtured towards state intervention in financing scientific research (between the two wars, private funding through philanthropic trusts was preferred) he supported the need to radically innovate the system of public research, basing it fundamentally on the university structures. In his historical report – *Science: The Endless Frontier* – which went far beyond the expectations of President Roosevelt, who had commissioned it – he offered not only contingent solutions concerning specific objectives, but made «an extended and carefully reasoned justification of the key role of basic science» (Geiger 1993, p. 15), and therefore for the research carried out in «colleges, universities, and research institutes», held to be fundamental for the economic, social and democratic development of the country:

> Without scientific progress the national health would deteriorate; without scientific progress we could not hope for improvement in our standard of living or for an increased number of jobs for our citizens; and without scientific progress we could not have maintained our liberties against tyranny. (Bush 1945, ch. 1).

A real "new frontier" was announced for the American people, after that of the "old Far West": «It is in keeping with the American tradition – one which has made the United States great – that new frontiers shall be made accessible for development by all American citizens» (Bush 1945, ch. 1). The report is important also because it highlights the limits of private funding for research and therefore calls for strong federal commitment, that should have its own "national science policy".

With this document, the distinction between basic research and applied research was consolidated: in the pure reigns of science, developments take place that can lead to new products and innovative and driving processes for the life of society. And this was done with the awareness of the unpredictability and inevitability of a certain dispersion of funds:

> One of the peculiarities of basic science is the variety of paths which lead to productive advance. Many of the most important discoveries have come as a result of experiments undertaken with very different purposes in mind. Statistically it is certain that important and highly useful discoveries will result from some fraction of the undertakings in basic science; but the results of any one particular investigation cannot be predicted with accuracy. (Ib., ch. 3)

Nevertheless, Bush maintained that basic research should be encouraged in universities: this is the basic task of the federal government and public funds, paying attention not to privilege only natural sciences. In an unequivocal way that is extraordinarily relevant to our times, he stated that: «It would be folly to set up a program under which research in the natural sciences and medicine was expanded at the cost of the social sciences, humanities, and other studies so essential to national well-being» (ib., ch. 4). Not only that, but the report of the committee for the discovery and development of new scientific talents, directed by H.A. Moe (one of the committees created by Bush to contribute to the compilation of the whole report) underlines the importance of human sciences for the development of natural sciences: a disproportionate amount of investments in favor of the latter would not only damage the nation but would cripple science itself. There is also the conviction of the unitary character of research, for which excessive specialization and separation of scientists in sealed compartments would be quite damaging for it: «Separation of the sciences in tight compartments […] would retard and not advance scientific knowledge as a whole» (ib., ch. 6).

The report concludes with the proposal of the creation of an independent agency, the National Research Foundation, with the aim to «support scientific research and advanced scientific education alone», removed from the pressure to make research products immediately available for the market – as happens in industrial research. This agency must be devoted to basic research since:

> research is the exploration of the unknown and is necessarily speculative. It is inhibited by conventional approaches, traditions, and standards. It cannot be satisfactorily conducted in an atmosphere where it is gauged and tested by operating or production standards. Basic scientific research should not, therefore, be placed under an operating agency whose paramount concern is anything other than research. Research will always suffer when put in competition with operations.
>
> […]
>
> The National Research Foundation should develop and promote a national policy for scientific research and scientific education, should support basic research in non profit organizations, should develop scientific talent in American youth by means of scholarships and fellowships, and should by contract and otherwise support long-range research on military matters. (Ib., Ch. 6)

It is thanks to these indications that very soon, in the subsequent political debate, proposals were put forward to set up a National Science Foundation (NSF – this term was preferred to the one proposed by Bush), created in May 1950, after three years of heated debate (see the site of the NSF, http://www.nsf.gov/), to add to the preexistent agencies and institutions that were the main sources of f unding for scientific research (the Atomic Energy Commission, created in 1946; the Public Health Service, already in operation for some time, for medical research; the Office of Naval Research, set up in 1946 that, together with the Army and the Air Force, had a particular role in financing university research; finally the Department of Agriculture) (see Geiger 1993, pp. 18 ff.).

A further step that was quite important for strengthening the link between research and technological development aimed at the market was driven by the rising competition between the United States and Japan, whose winning model was determined, amongst other things, by the integration of the politics of research with the politics of industry. This led the American administration to put into operation a series of measures to encourage the integration of university research and industry. Among these, the most famous is the so-called Bayh-Dole Act of 12 December 1980: it had been noticed that little use was made of university patents on the part of the federal government, who possessed the property as it was the funding body; therefore, with the aim of bringing the fruits of university inventions to society as a whole, thanks to this law, Congress allowed the universities and research bodies (both public and private) to exploit the results of the research carried out by their scientists for commercial aims, through special Technology Licensing Offices that acted as intermediaries between the inventor and the industries, with the use of federal or public funds. In this way, Congress and the NSF encouraged the co-operation of the university with industry, enabling them to manage the fruits of their research in an autonomous way, and to create also numerous centers merging universities and industries, with the aim of exploiting innovations, especially in the field of biotechnologies and pharmaceuticals, the most likely to produce a remunerative economic return (Kenney & Patton 2009, pp. 1408-9).

However, the effect of this initiative lies not so much in the fact that it increased the opportunities for collaboration between universities and industries, which was already widespread since the beginning of the century, nor for having had a decisive influence on the contents of university research. Its impact is most felt in the commercialization of the results of research on the part of the university itself, encouraging the activity of patenting. What is more, the Bayh-Dole Act is important because it applies the “linear model” of the politics of science and contributes to its diffusion (see § 5.1.1); this was already present in Bush’s report, «assuming that if basic research results can be purchased by would-be developers, thereby establishing a clear "prospect" for the commercial development of these results, commercial innovation will be accelerated» (Mowery et al. 1999, p. 271).

Finally, this measure prompted an increasingly precise and interested defence of intellectual property of innovations on the basis of the conviction rooted among the politicians of the time that «a stronger protection for the results of publicly funded R&D would accelerate their commercialization» (ib., p. 274). Subsequently, numerous other legislative initiatives went in the same direction, such as the sentences decreed by the Supreme Court (for example, on whether new biotechnological products like organisms and molecules can be patented).

These are all significant moments that strengthen the relationship between the production of knowledge and its commercialization, and between basic scientific research and its incorporation in productive processes. They lead to the formation of a society of knowledge in which the value of research and innovation is not only the most important factor of stimulus for growth, but represents in itself the most precious and widespread asset and the principal element of connection and exchange between human beings.

0.3.2 – A new metamorphosis of "capital"

It is the twilight of the old "capital", as it had been imagined in the course of the first industrial revolution and had led to opposition between capitalists and workers. But can we say that the old tensions have vanished with it? That there are no new contradictions that have taken the place of the old ones?

It is true: now knowledge has become a real "intellectual capital" that manifests itself in information, news, entertainment, communication and services: no longer land and work, machines, utensils and systems, but a capital made up of knowledge (Stewart 1998). Unlike material goods that form part of traditional capital, the non-material goods that are the fruit of intellectual capital have the essential character of being intrinsically non rival, cumulative and not controllable. They are non rival in the sense that if one person uses them, this does not stop another from doing so; cumulative in the sense that every user can improve them, adapt them and therefore give them a new form that is available to others; finally they are not controllable since their very non-material nature and the means of transmission of the information available today, make it difficult for them to be contained and not diffused (Baker 2008, pp. 100-104).

This leads to the extremely delicate problem of the intellectual property of the products of knowledge: as the first industrial revolution was based on the exact definition of rights of physical property (think of the movement of the enclosures in England at the beginning of the industrial revolution), by analogy, according to Lester Thurow, the knowledge economy must have at its foundation the regulation of intellectual property rights, based on the thesis that knowledge does not come from nothing and in order to produce it, investment is required. These are the motivations that we have seen were at the basis of the Bayh-Dole Act: «Knowledge does not come free. Investments have to be made to extract it» (Thurow 2003, ch. 8). Since today we are witnessing a "second enclosure movement" that no longer has anything to do with material goods like land, but concerns non-material ones, the products of knowledge:

> Both overtly and covertly, the commons of facts and ideas is being enclosed. Patents are increasingly stretched out to cover "ideas" that twenty years ago all scholars would have agreed were unpatentable. Most troubling of all are the attempts to introduce intellectual property rights over mere compilations of facts. If Anglo-American intellectual property law had an article of faith it was that unoriginal compilations of facts would remain in the public domain, that this protection of the raw material of science and speech was as important to the next generation of innovation as the intellectual property rights themselves. The system would hand out monopolies in inventions and in original expression, while the facts below (and ideas above) would remain free for all to build upon. But this premise is being undermined. Some of the challenges are subtle: In patent law, stretched interpretations of novelty and non-obviousness allow intellectual property rights to move closer and closer to the underlying data layer; gene sequence patents come very close to being rights over a particular discovered arrangement of data – Cs, Gs, As, and Ts. Other challenges are overt: The European Database Directive does (and the various proposed bills in the United States would) create proprietary rights over compilations of facts, often without even the carefully framed exceptions of the copyright scheme, such as the usefully protean category of fair use. (Boyle 2003, p. 39)

Intellectual capital has another fundamental characteristic: it cannot be localized, nor circumscribed and its origins are rooted in that widespread and intangible asset represented by human capital and social capital: these are deposited – unlike what happens to the raw material of the old industrial cycle – in society:

> It is widespread, distributed knowledge that is the great laboratory that accumulates the raw material necessary for the non-material productive cycle […]. Therefore, the cultural level of a territory represents the most important mine to excavate in for new ideas, and at the same time, the most interesting market to supply in terms of use. (Bellucci & Cini 2009, p. 40)

What is important is not so much the availability of natural resources, but the growth of that intangible capital comprising two fundamental resources: the investments that are directed to the production and dissemination of knowledge (that is, education, training, and scientific research) and those that are indispensible to maintain the physical state of human capital (for example the expenditure on the health service) (OECD 2004, pp. 14-15); and everything that in its turn requires greater attention to the quality of social capital in which human capital is embedded, factors such as «networks and participation in public life, together with shared norms, values, culture, habits and practices, trust and understanding that facilitate co-operation within or among groups, to pursue shared objectives» (EC 2003g, p. 2). The importance of H&S capital to promote both economic growth and social well-being is now generally recognized in the literature, that is gradually increasing on this subject (see OECD 2001e; Keeley 2007; Castiglione *et al.* 2008; Bartkus & Davis 2009; Tinggaard Svendsen & Haase Svendesen 2009), and this is also an important acquisition that came to form part of the strategy of the European Union and recently was also one of the objectives of the Chinese government (see Simon & Cao 2009):

> the intrinsic link between human and social capital in the knowledge society rests on the fact that knowledge creation, storage, transfer, sharing and use are processes taking place between individuals within social contexts. A dynamic relationship links knowledge, human and social capital. Different societal and economic outcomes may depend on the different possible combination of these three factors in different interlinked given contexts. (EC 2003b, p. 16)

However if the "resources" at the basis of intellectual capital, that allow its very existence and the transformation into non-material goods to be put on the market, have an eminently social character, there is a glaring contradiction between their social nature and the ever pressing attempts to privatize their use through legislation on intellectual property (often detained by the corporations). It seems that the contradiction has been reproduced – hypothesized by Marx for the first industrial revolution – between the social character of production and the private property of the means of production. This is a problem that also bodies not directly concerned, like the OECD, have diagnosed exactly: the tension that arises between the need to guarantee intellectual property in some way so as to boost the production of new knowledge and the subsequent effect of blocking the growth of new knowledge that these limitations could cause (OECD 2004, pp. 31-33). More courageously, UNESCO has claimed that the «universal access to knowledge must then remain the pillar supporting the transition towards knowledge societies» (UNESCO 2005, p. 169); therefore, it is not only necessary to have a balance between the interests of producers and those of the users of knowledge, but also an effective work of support for the "public domain", which «contributes to the development of human capital and creativity in the knowledge societies that are definitely heading towards empowerment and development for all». Knowledge is a "common public good", and therefore not only can it not be «a marketable good like others, but also knowledge only has value if it is shared by all […]. Knowledge-sharing is the cornerstone of the practices and values that should be at the heart of knowledge societies» (ib., p. 170).

0.4 – The "knowledge" of the society of knowledge

A final but basic question should be faced, however briefly: what is meant more precisely by knowledge when we speak of economics and/or society of knowledge?

It seems to us that a good starting point is the distinction made by Lundvall & Johnson (1994; see also OECD 1996, p. 12) between:

- The *know-what*, that is the knowledge of relevant communicable facts as data and transformable in discreet units (bits).
- The *know-why*, or the knowledge of scientific principles and law of nature that allow us to understand and explain phenomena of any kind (from nature to the mind etc.)
- The *know-how*, or the practical competences that allow us to do something, translating the know-why into concrete operation, even if it is only knowing how to carry out an experiment in the laboratory.
- The *know-who*, that is the information that allows us to get hold of the person who is able to solve our problem, who has the know-how or know-why.

The first two are coded types of knowledge, accessible through scientific publications and data banks, and usually expressed in a universal, standardized language. The second are based on practical activity, on direct experience, on apprenticeship, since they are often defined as tacit forms of knowledge, according to Michael Polanyi, Ludwik Fleck e Thomas Kuhn (see § 5.2).

This distinction, well-known and accepted in the literature (Bell 1973; Sirilli 2005, pp. 15-6; Collins & Evans 2007, p. 28), so much so that it was also placed at the basis of official reports of International institutions (see e.g. OECD 2004, pp. 18-20; UNESCO 2005, p. 148) – allows us to make a fundamental distinction between knowledge and information: the former enables the person who possesses it to undertake physical or intellectual actions since it involves his cognitive capacities; the second, on the other hand, has the form of structured data that remain passive and inert until they are interpreted and restructured by those who possess the knowledge. In this way, while the replication of the information costs only the price of the copies made of it, the reproduction of knowledge is instead a much more expensive process as it involves cognitive abilities that are not easily articulated and transferred to others (OECD 2004, p. 18); in fact, in this case, the whole system of training and transmission of culture of a country comes into play. In brief, while the transmission of information requires only better performing technology, the production and transmission of knowledge takes place only if it has high quality "H&S capital" that has acquired a series of competences that slowly mature and that are the fruit of many factors linked to culture, the environment, cognitive tradition, capacity for innovation and the creativity of individual intellectuals:

> […] knowledge diffusion is not amenable to "transmissions" like data between computers; it is diffused by people reconstructing (or reinterpreting) it through complex social and cognitive processes. In other words, knowledge is diffused through communication and relationships. Knowledge is situated in relation to a greater interpretative context than data and information. […] Therefore, although we may each need to act differently upon receipt of new information, it is the knowledge we have that allows us to determine what the information means and that we have to act in this or that way. (Rooney et al. 2003, p. 3)

To use the language of Lyotard (1979, pp. 4-5), while information can always be translated into machine language and transferred in computer chips, knowledge is the fruit of Bildung and therefore it is something that cannot be immediately expressed in explicit, formalized language: often the narratives direct it better, with their images, metaphors and feelings. Therefore, in the viewpoint towards which we are moving, his thesis seems completely plausible, according to which science, before managing to legitimate itself according to the positivist canons, for a long period of time has not been able to avoid founding itself on procedures that depended on the narrative knowledge and this should not be seen as a superseded dimension of science (and this is even more valid today – see on this subject § 2.2 and Coco 2009, 2009b). Therefore, that tacit dimension (see § 5.2), also called "soft knowledge", is part of knowledge that can never be translated into explicit information and that together with the explicit one gives rise to a "knowledge array": knowledge is a continuum that goes from the explicit, formal and declarative one to the completely tacit and therefore procedural, intuitive and inarticulate one (see Rooney et al. 2003, pp. 6-8). «It is this type of knowledge that often provides the "spark" that leads to advances in science and technology by providing the combination of codified information and contextual understanding needed to create something new» (OECD 2010, p. 70).

However, there is a relationship of reciprocity between information and knowledge: the latter can sooner or later be translated – albeit never completely – into information; otherwise it would lose its main function of tool to enable humanity to act and transform the world, since it would become something private and no longer inter-subjective. However, for a certain portion of knowledge to be translated into information and made inter-subjectively available, it is necessary to possess a basic reservoir of knowledge that does not lend itself to translation. In fact, information and therefore communicable knowledge (the know-what and the know-why) are possible on condition that there is always new tacit knowledge (new know-how and know-who): the continual shift of knowledge towards the side of the explicit, recreates ever new space on the side of the implicit. Therefore, the thesis of those who maintained that the society of knowledge is distinguished by a progressive passage from tacit knowledge to encoded knowledge as a basis of organization and economy (Nonaka & Takeushi 1995) may be considered true only in the extent to which it highlights this necessary aspect of the translatability of one to the other, but it would be deceitful if it entailed a supposed disappearance of tacit knowledge, so dissolving within the explicit one, and becoming simple information.

It is in the relationship between this unarticulated, unexpressed, tacit basis of knowledge, and the cognitive and coded way in which man relates to the world – expressed in the history of philosophy through a series of dual conceptualizations of great value (such as dialectic/not-dialectic thought, lateral/central thought, divergent/convergent conceptualisation, left/right hemisphere, mystical/rational and so on) – that the capacity of individuals and humanity lies, to find again the essential resources to produce in a creative way; it is what explains that inventive act that the philosophy of traditional science has wanted to send back to the irrational realm of the psychology of research (see § 3.1). As is recognized today, «wisdom, curiosity and creativity, the very foundations of all future advances for humanity, rely heavily on our tacit faculties in the form of imagination, insight and so on» (Rooney et al., 2005, p. 2).

This is the perspective that has profoundly motivated our research and has been stressed in all its parts; it is deeply rooted in the conviction that a correct understanding of the way in which science is constituted (in its theoretical and explicit parts) does not clash with tacit, unexpressed knowledge; on the contrary, it is a theoretical and epistemological justification of its function. Only from the contribution that can come from the new philosophy of science, and from Science and Technology Studies (STS) in general, can theoretical motivations be found that – without falling into forms of postmodern nihilism – allow us to conceive of the relationship between democratization and scientific innovation in a new way and therefore help to overcome the public's mistrust of science. Finally, it is always in the heart of scientific theorizing that we can find the justification of a science policy that is inserted in that humanistic tradition again that makes the "old Europe" a unique place in the world and that can constitute its trump card, able to make it shift towards a society of knowledge that is also a society of men and their most authentic values.

And in the light of what has been said in this report, as STS scholars called to the difficult task of advising on science policy, we could not abandon our primary descriptive vocation and set aside the material and cultural contradictions that impede the realisation of a democratic European knowledge-based society. The enlightenment ideal of a science for and with society faces the delusionary path that Lyotard has so strongly warned us against: the science for/with society ideal may serve the purpose of legitimatising beliefs and acts that are otherwise functional to other interests of a private and egotistical nature.

For the last 30 years, STS scholars have employed their descriptive methodology to spot this kind of delusionary imbalance of means/goals. Most of them have spotted the main imbalance in the coexistence of an enlightenment goal of a knowledge society able to meet society's needs, and the operative ideal of a knowledge society that would obtain social well-being by simply fostering economic growth. STS cannot solve this tension by its own methodological means, and for a good reason at that. History, philosophy and sociology of science (HPSS) – the main fields of STS – are descriptive disciplines and should leave evaluation and regulation to policy makers. Of course, policy needs complete descriptions of decision scenarios of science practice in order to apply conscious and informed reformation strategies based on a good estimation of ethical, societal and environmental relevant outcomes.

There is, therefore, a limit to the kind of contribution STS can give to science policy, making a normative threshold so to speak (see § 4.6). Any attempt to overcome this limit would lead to technocracy, which is in sharp contrast to with the hope of making Europe a "democratic" knowledge-based society.

So, HPSS scholars, with respect to science policy, encounter the same limitations as scientists themselves. Scientists must make their choices clear to anyone as their actions involve more of the relevant community they belong to; in fact, they involve the environment and the social life of the entire "interconnected" planet. STS may help scientists to better assess risks and advantages of their work and may help them to democratize their practice.

0.5 – A short overview of the following chapters

In Chapter 1 we used the descriptive methodology of STS to critically discuss the attempts to implement the Lisbon Strategy, its development and its future prospects. The economic, social, and political environments in which normative proposals for the creation of a democratic European knowledge society have been set and tentatively implemented can be better understood as constraints on the implementation of the Lisbon Strategy which has informed the work of science policy makers in the last decade. In fact, despite its failure and defects, the Lisbon Strategy functions as a regulative ideal. The Strategy has given us a common working platform: decision processes in S&T practice need to be democratized and as a consequence, only the consensus of the majority of citizens should decide on choices involving the relevant community.

The democratization of science is a slow, difficult process. There is no guarantee of successful outcomes, and this is a lesson we have learnt from history. But there is no single recipe and, like natural evolution, most of the time we proceed by trial and error. So, in Chapter 2 we have tried to disentangle the difficult issue of the democratization of science and, fully aware of the kind of limitations stated above, in the following chapters we have tried to understand the kind of descriptive contribution that STS can offer normative policy making.

In Chapter 3 we have presented a history of STS, which is interesting in itself. For our purposes, this history highlights the strong methodological differences in the descriptive practice of science in the heterogeneous field of STS in order to attempt a methodological integration in Chapter 4. It is important to achieve such an integration not just to give STS a professional identity. We envisage a methodological integration especially designed for the purpose of science policy advising and we conclude that "interdisciplinary unification" (the methodological reduction of different disciplines to the heuristics of a dominant one) should be rejected in favour of a "multidisciplinary integration" (which allows for different methodologies to employ their own basic assumptions to describe the relevant phenomena and so to postpone the integration moment to the level of results in order to critically discuss contradictions and achieve descriptive completeness).

We have tried to employ this last integration strategy in Chapter 5 to face what we believe are among the "hot topics" of the science policy of today, such as the relationship between techno-scientific innovation and economic growth (with a special emphasis on funding policy), specialization and professionalization within a unified European education system, and the role of industry and the private sector for the increment of public goods and, vice versa, how the public may modernize the private sector itself; we shall also discuss issues of a more conceptual nature such as the relationship between expert and tacit knowledge, creativity, and the role of the humanities for science curricula.

Finally, in Chapter 6, we have proposed our science policy suggestions.

1. In the beginnings there was Lisbon

1.0 – Overview

In this chapter we have tried to summarize the economic, social, and political environments in which normative proposals for the creation of a European knowledge society are set and attempts are made to implement them. Several means have been put forward in the last decade, all of them addressed to the implementation of a common objective: to make the Lisbon Strategy a reality.

We have critically discussed the cultural and practical conditions that led to the formulation of the Lisbon Strategy (§ 1.1) and its development during the last decade (§ 1.2). The Lisbon objective has not been fully implemented by 2010 as expected, but a good deal of sub-objectives have been fulfilled; first and foremost, we argue that although the Lisbon Strategy could not have been effectively implemented in certain areas of Europe, it has served the purpose of mobilizing intellectual and material resources toward democratization and modernization. Specifically, the failure of the Lisbon Strategy has helped to create a new environmental awareness that seems to be able to unify the "modernizing" needs of the private sector with the "democratizing" needs of general society (§ 1.3).

Today the Lisbon Strategy has further postponed its objectives, but it has also qualitatively improved them in perspective. The main aim is no longer simple economic growth, with the consequent idea that it alone would suffice to meet society needs. Rather, it is undergoing a transformation towards sustainable development strategies and a greater attention towards the preservation of public goods (including knowledge) that we see as the right platform towards the construction of a truly democratic knowledge-based society (§ 1.4).

1.1. Old Europe needs to wake up

1.1.1 – *The roots of "Lisbon Strategy"*

For a long time now, there has been widespread awareness in the European Community of the importance that research has for economic development, generating from 25% to 50% of growth, and so contributing to the increase in the number of jobs and an improvement in their quality. The European Commission (EC) is aware of the tradition of excellence that it can boast of in that field (in 2000, one third of the scientific knowledge developed in the world came from its researchers) but, nonetheless, it is worried about the condition of the research, with the risk of an increase in the gap between Europe and the other technologically advanced countries, and a postponement in the transition towards the knowledge economy: «Europe would be quite wrong to reduce its investment in this area» (EC 2000b, § 3). There is a relative weakness of the funds coming from the private sector that, even amounting to over the half of the total, have seen less growth than the amounts registered both in the U.S.A. and in developing countries from Asia, due for the most part to the greater incidence that small and medium-sized enterprises have on the European economy.

In this framework, the European Commission considers the instruments used nowadays by Europe to sustain R&D to be insufficient; these were substantially put into practice in various framework programs, that nowadays comprise only 5.4% of the total funds for non-military public research. The individual Nation States provide the rest of the money, in an inconsistent way, to fund research, and that is why «The European research effort as it stands today is no more than the simple addition of the efforts of the 15 Member States and the Union» (EC 2000b, § 5). The result is an avoidable fragmentation, isolation and segregation of the various research systems, discouraged from interacting by the divergences among the regulative and administrative systems in the various Member States. Unfortunately, this tendency has not been stopped yet, as it is shown by both documents produced by the EU (that will be thoughtfully employed in this work) and "external" reports such as the recent Blanke & Geiger 2008 of the World Economic Forum, in which it outlined both the heterogeneity among the member states in pursuing the Lisbon Strategy and, especially, the severe insufficiency of their research policy (except for some north European states such as Sweden, Denmark, and Finland).

In order to create a concrete European research policy, the Commission decided to request, by a Communication to the Council (18/01/2000), the

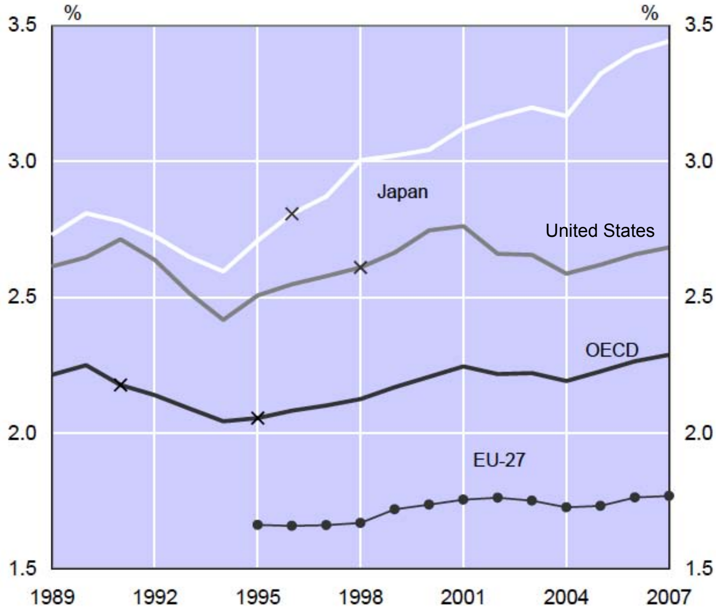


Fig. 1 – Gross Domestic Expenditure on R&D
Source: OECD, *Main Science and Technology Indicators 2009-1*

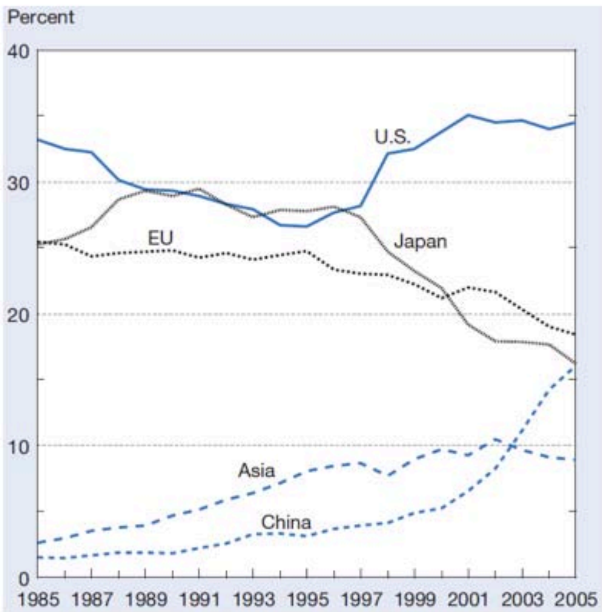


Fig. 2 – World share of high-technology manufacturing, by region/country: 1985–2005
Source: National Science Foundation, *Science and Engineering Indicators 2008*

creation of a European Research Area (ERA) (see also the recent document EC 2007n), the task of which is to set up an area with no frontiers for research. Thanks to this, scientific resources can be better used in order to increase occupation and competitiveness. The ERA consists of three concepts:

- the creation of an "internal market" of research (a true space for a free circulation of knowledge, researchers and technologies) destined to reinforce cooperation, to motivate competition, and to optimize the allocation of resources;
- a renovation of the European research web, that consists essentially of the coordination of the activities and national research policies (the latter represent the greater part of research carried out and funded in Europe);
- the development of a European research policy not limited only to the mere funding of research activities, but also comprising all aspects of the other national and European policies linked to the research sector (EC 2000c).

These three concepts form a series of measures and specific actions, such as the idea to link the centers of excellence in order to create some virtual research centers too; to improve and coordinate the efforts to arrange research infrastructures, which are usually very expensive; to exploit better the opportunities given by electronic nets and by the Internet (extending broadband, for instance); to coordinate better the realization of national and European research programs, strengthening the relationships between the scientific and technological cooperation bodies; to favor private investment in research with direct and indirect support tools; to improve the protection of intellectual property, passing from a patent system on a national basis to a single European patent that is standard over the entire European territory; to stimulate investments thanks to venture capital and entrepreneurial initiative by researchers themselves (as happens in the U.S.A.); to increase the mobility of researchers, and to introduce a European dimension in scientific careers (liberating them from the exclusive national reference); and to increase the attractiveness of Europe for researchers in the rest of the world (inverting the "brain drain"). Finally, there are some recommendations about the more general aims to encourage the participation of women in science, to conceive of a science that takes into account the needs of politics and to tackle the questions relating to the relationship between science and society in a European dimension, taking into account the specific tradition that is based on a «combination of a market economy, a high level of social protection and quality of life and a number of principles, such as free access to knowledge» (EC 2000b, § 7.1).[1]

The indications already seen in EC 2000 were taken into account during a special session of the European Council held in Lisbon on 23-24 March 2000, the results of which were put into writing in the *Presidency Conclusions of the European Council*. In this document, that indicates the birth of the so-called Lisbon Strategy,

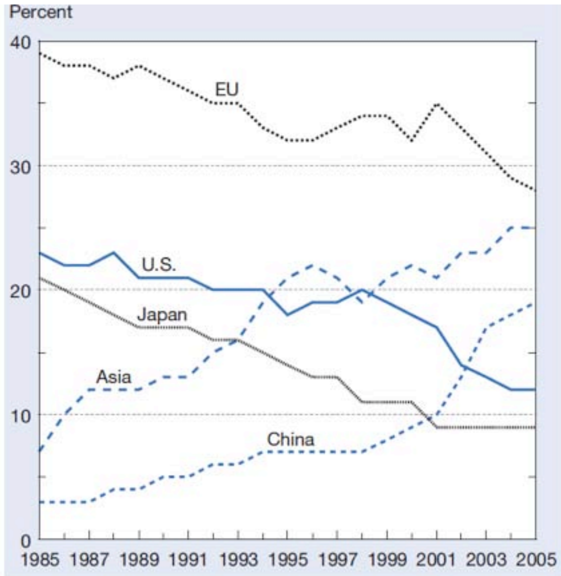


Fig. 3 – World share of high-technology manufacturing exports, by region/country: 1985–2005
Source: National Science Foundation, *Science and Engineering Indicators 2008*

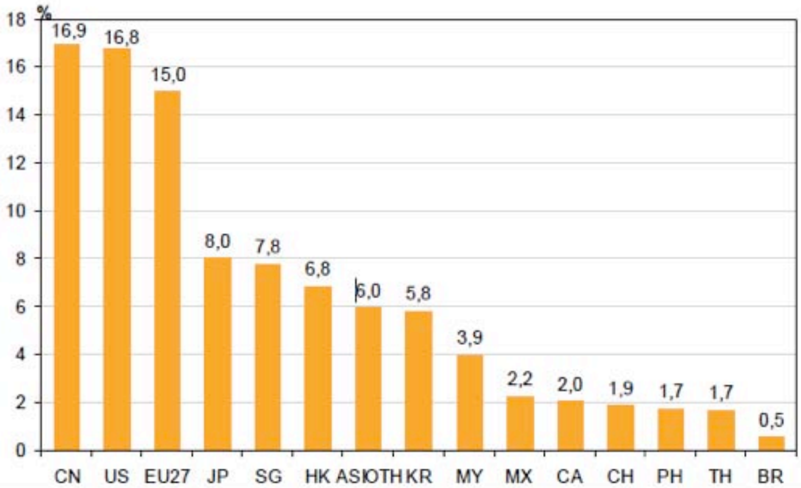


Fig. 4 – World market shares of high-tech exports, main exporters - 2006
Source: Eurostat, *Statistics in focus* 25/2009.

it was stated right in the first point that the EU:

> is confronted with a quantum shift resulting from globalization and the challenges of a new knowledge-driven economy. These changes are affecting every aspect of people's lives and require a radical transformation of the European economy. The Union must shape these changes in a manner consistent with its values and concepts of society and also with a view to the forthcoming enlargement. (EC 2000b, §1)

[1] Regarding the European Research Area, the realization of EIROforum is worthy of mention; it is a European intergovernmental organization that comprises the following partners: CERN (European Organization for Nuclear Research), EFDA-JET (European Fusion Development Agreement), EMBL (European Molecular Biology Laboratory), ESRF (European Sinchrotron Radiation Facility) and ILL (Institue Laue-Langevine). This scientific platform was created in 2002 with the aim to support European science in order to encourage its full development. EIROforum wants also to facilitate and simplify both relationships between European Commission and the principal European institutions and between national governments, industries, science teachers, students, journalists and so on. One of its most remarkable documents is, surely, *EIROforum's Response to the Green Paper "The European Research Area: New Perspectives"* of September 2007 (see EIROforum 2007), a sort of response to EC 2007n, where, in addition to the six points or elements proposed by the European Commission (an adequate flow of competent researchers, world-class research infrastructures, excellent research institutions, effective knowledge sharing, well-coordinated research programs and priorities and, finally, the opening of the ERA to third countries), EIROforum proposes a seventh goal: "excellent education and training, at all levels, in science and technology" (EIROforum 2007, p. 5). In this document, as in the previous EIROforum 2005, both the importance of ERA and the need for research policies to favor the goals set by the Lisbon Strategy are reiterated; according to EIROforum, all this can be done only thanks to the essential basis on which it is possible to build the knowledge-based society, that is: well developed research, education, training and innovation (see *ibid.*, p. 14).

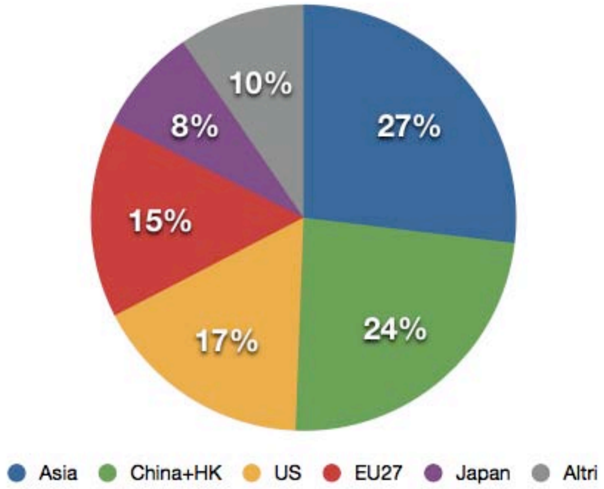


Fig. 5 – World market shares of high-tech exports, main area exporters - 2006
Source: Our elaboration from Eurostat, *Statistics in focus* 25/2009.

marginalization (EC, 2000b, § 5 – see also EC 2001b, EC 2003b, EC 2005, EC 2006). The fundamental instrument used by EU in order to reach this goal – besides the interventions that have to be put into practice by the single Member States – is the sixth Framework Programme until 2006 and the seventh from 2007 to 2013.

1.1.2 – *The reasoning behind the worries*

The worries concerning the origin of this strategy come from the real data concerning the European economic development of the last decade, especially in those fields with a "high intensity of knowledge" typical of con-

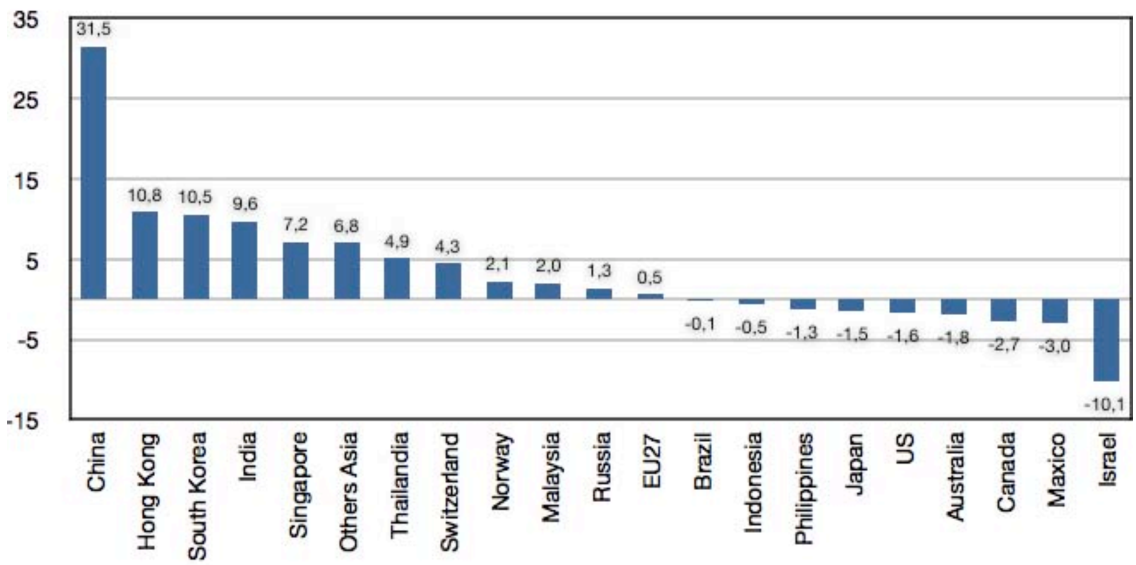


Fig. 6 - Annual average growth rates (AAGR) in high-tech exports - EU27 and 20 main exporters
Source: Our elaboration from Eurostat, *Statistics in focus* 25/2009.

Hence the fundamental aim is to make Europe «the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion» (EC, 2000b, 5). The EU, aware of the radical global change in the economic and social field, has tried to put into practice a strategy aiming to increase investment in R&D to 3% of the GDP, in order to improve the policies in the field of ICT and investing more in human capital and at the same time fighting social temporary society; that is, in the field of high technology, that is fuelled by scientific research and from investments for this aim.

In fact, in the document that proposes the institution of ERA, we can see that in Europe the investments in R&D amount (with remarkable differences between the various member States) on average (in both the public and private sector) to 1.8% of the GDP, compared to 2.8% in the USA and to 2.9% in Japan; that each year the deficit for the European trade balance increases by 20 billion

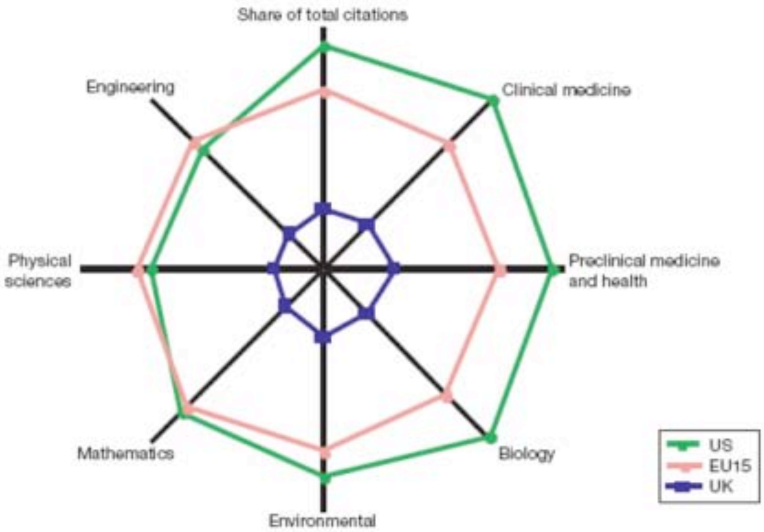


Fig. 7 – Comparison between EU 15, USA and UK in some primary Sectors
Source: G. Dosi, P. Llerena, M. Sylos Labini, "Evaluating and Comparing the innovation performance of the United States and the European Union", Expert report prepared for the TrendChart Policy Workshop 2005, 29 Giu 2005.

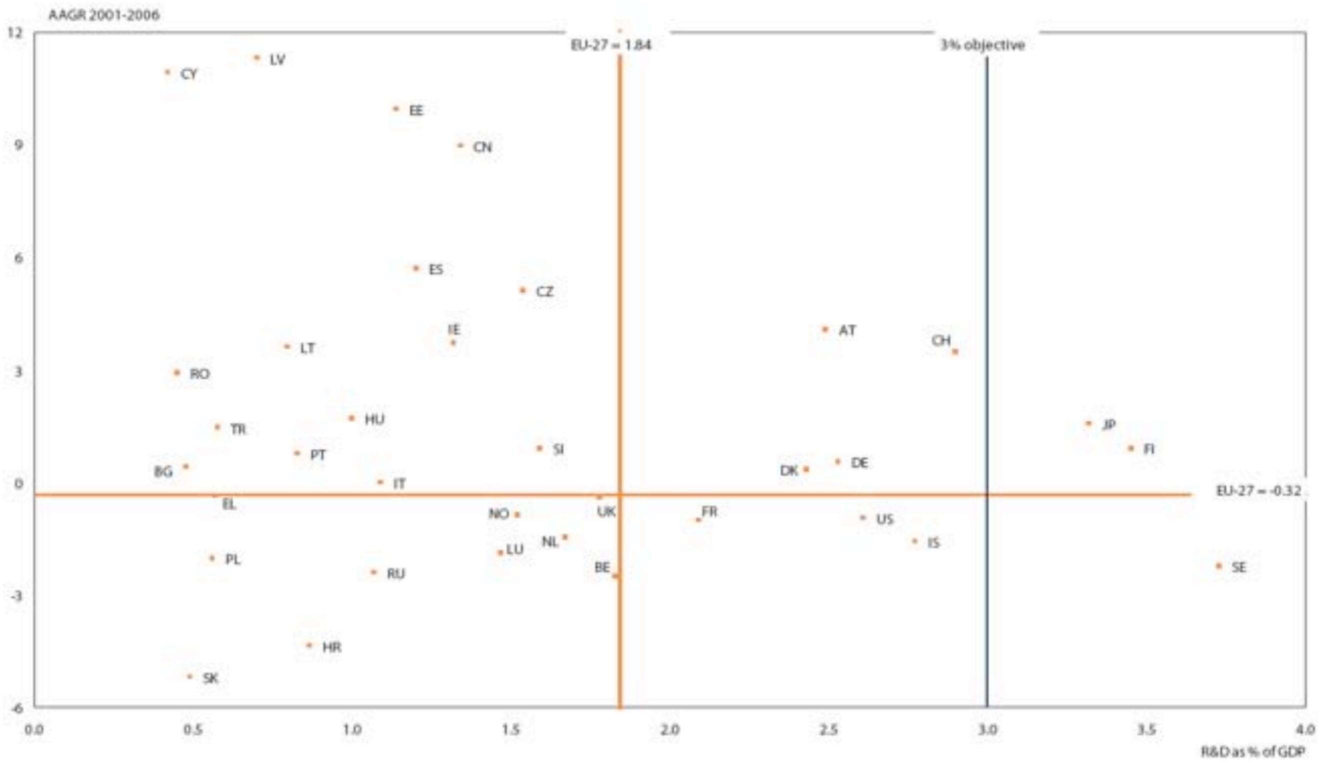


Fig. 8 – R&D expenditure as a percentage og GDP in 2006 and average annual growth rate (AAGR) 2001-2006, alla sectors, EU27 and selected countries
Fonte: Eurostat, *Science, technology and innovation in Europe*, 2009.

euro for high technological products; that the percentage of the workforce represented by researchers is lower than that in the USA and Japan (2.5 per 1000, compared to 6.7% in the USA and 6% in Japan); finally, the document shows that there is a consistent migration of undergraduates from Europe to USA (EC 2000b, § 1). This discrepancy from Japan and USA is evident in **figure 1**, showing that the situation in the 27 countries of the EU has not improved since 2000, and this gap has remained practically unchanged.

The backwardness of Europe is particularly evident in the high technology sector. The graph in the **figure 2** shows clearly how over the years, the EU has seen a progressive decline in the productive capacity in this sector compared to the new competitors that have appeared on the scene of globalised economy, such as China (Hong Kong included) and Asia (that includes countries that have seen greater development in recent decades - India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand.). Only in Japan have things been worse than in Europe.

This framework becomes more critical if we turn our attention (**figure 3**) to the amount of exports in this field (see NSB 2008, fig. 0-12), where the European decline (like in America and Japan) is more evident in relation to the progress of Asia and China, where the latter has grown exceptionally from 7% to 28%, while the USA has declined from 23% to 12% and Japan from 21% to 9%. In 2006 (the last data we have) China became the leader in the amount of exports in the framework of an annual growth of 5%, from 2001 to 2006, in the global amount of the exportation value in high-tech. In particular, in the field of telecommunications, sound and video equipment (especially mobile telephones) the imports of EU27 increased by 61% over 2000-2008, recording trade deficits for these products every year. China was the major world trader in these products in 2008, followed by the United States. So, «although in 2005 the EU was the leader in high-tech exports, China took over the lead in 2006 followed by the USA, the EU-27 and Japan» (Eurostat 2009). Regarding the internal situation in the EU, Germany reached first place, followed by the United Kingdom, France and the Netherlands.

In a more disaggregated vision, the situation in 2006 is illustrated in **figure 4**, that shows how 97% of world exports are provided by 15 exporters. If we group the Asian countries together (except Hong Kong, that we can consider as belonging to the Chinese economic system, and of Japan too) we can see that their share is 26.9%, much higher than the USA and EU-27 share. The combined share of China and Hong Kong is 23.7%. So, the total scenario of 2006 is well represented in **figure 5**.

However, what is most worrying is the growth rate in exports of the period 2001-2006, shown in **figure 6**, where it is clear how EU-27 is progressively losing ground compared to the main new competitors, where China stands out. If we check out the separate data within EU-27 in order to evaluate the individual performances of the EU Member states, we can see that Ireland (-7,8%), France (-5,2%), Italy (-2,1%), Estonia (-0,5%), and Malta (-0,4%) reported a decrease in their exports of high-tech products between 2001 and 2006. Instead, many new Member States experienced rapid growth in high-tech exports, most notably Cyprus (+63%), followed by Bulgaria, Latvia, Lithuania and Slovakia (all over 30%). In the world scene, four nations of the EU have a larger amount of exports in this sector: Germany (7.68%), the United Kingdom (5,86%), France (4,73%) and the Netherlands (4,18%); the others follow at a certain distance (Italy is in 7th place with 1.31%).

The Lisbon Strategy has also taken note that – contrary to what was stated by the European Commission (*Green Paper on Innovation*, 1995) when its attention was more focused on applied research and on technology-transfer university-industry – even in the field of basic research and of its productivity the EU lost ground compared to its competitors. This weakness can be seen in **figure 7**, that groups the various fields of research in seven broad categories. As we can see, the sciences in which Europe excels are mathematics, physics and engineering.

Taking into account the current state of European economy and society, it is clear that the goals have not been reached. According to the News release n° 127/2009 published by Eurostat on September 2009, in 2007 EU27 spent 1.85% of GDP on R&D, practically the same amount as in 2006 (1.84%) and essentially the same as 2000, the year when the Lisbon Strategy was conceived in order to increase this amount. Only Sweden (3.73%) and Finland (3.45%) exceeded the 3% target set by the Lisbon Strategy. The situation can be summarized in a very efficacious and analytical way in **figure**

8, where we can see the shortfall from the aim of 3% of GDP in 2006 (calculated for all sectors: government, business, enterprises, higher education, private non-profit) but even how the average annual growth rate in the period 2001-2006 was even below zero (-0,32%). Besides, it is possible to appreciate, apart from the various global averages of EU27, also the position of single member states and those of some of the most remarkable national economies of the world: «At a global level, the EU share of GDP devoted to R&D in 2005 was significantly lower than that of Japan (3.32 %), Switzerland (2.90 %) and the United States (2.61 %)» (Eurostat 2009b, p. 20).

Before trying to understand the reasons for this, and before proposing possible implementations and corrections, within the heuristic framework of our research, it is necessary to analyze the various phases in which the Lisbon Strategy is articulated and also the various documents linked to it

1.2 – The development of the Lisbon Strategy

In 2000, the year the Lisbon Strategy was launched, a positive trend in the economy was registered, during which there was a tangible reduction of the amount of unemployment, due also to the strengthening of the euro. But on the front of innovation (see also the recent document EC 2009b) and research, the weaknesses noted above were registered, and this happened despite the fact that Europe is a vital cultural reality and rich in human capital. Even the goal of social cohesion seems to be very hard to reach, since «poverty and exclusion persist within the European Union – compounded by substantial regional variations in employment and the standard of living. Social protection systems need to be modernized and improved» (EC 2001b, p.3).

1.2.1 – *The close union of economics and research*

In order to face these problems, the EU decided to intervene on the following ten priority sectors:

- more and better jobs;
- new European job markets: open and accessible;
- economic reforms for goods and services;
- integrated financial markets;
- adapted regulations;
- eEurope 2002;
- more qualified workers in the information technology sector;
- research, innovation and enterprise;
- cutting-edge technology;
- efficient social protection for an ageing population.

However, it was soon evident that it was necessary to place the field of education at the centre of the reforms and proposals to be put into action, an area that would soon show itself to be the primary source of the Lisbon Strategy. In this respect, on 20 November 2001, an important document was written, regarding the European benchmarks for education systems and training (see EC 2002d) to be allocated within the aims of the *lifelong learning* program. Fundamental for the knowledge society, the European system of education (see also EC 2009c) has led the EC to set some goals in that field, including:

- to reach a school drop-out rate of an EU average equal or lower to 10% by 2010;
- to halve the gender disparity among math, science and technology undergraduates;
- to increase by 2010 the UE average of participation in *lifelong learning*, to reach at least 15% of the adult active population (aged between 25 and 64).

On 15 January 2001, the EC published another document (EC 2001b) entitled *The Lisbon Strategy – Making Change Happen*, in which both the importance of the Strategy and the positive fulfilment of some goals on a strategic level are underlined. This document states also the intention of the EU to extend the Lisbon Strategy to all sectors considered to be fundamental; it also maintains that it is essential to direct more energy to the three so-called priority areas (see EC 2002b, p. 3) – employment (see also the recent document EC 2009d), market and knowledge («multiply investments in knowledge to guarantee future competitiveness and jobs»). In the conclusions some assessments have been made about the consequences that the American economic crisis (after September 11) had on the European economy. Instead, the data concerning research and innovation are seen as positive even if a lack of energy expended by researchers and enterprises in the sectors of biotechnology and natural sciences has been registered. However, the framework of the efforts made to strengthen the basic knowledge in the EU is more negative (later on, as we shall see in §§ 1.2.2, 5.6, this is of fundamental importance in order to improve the quality of "human capital", a decisive factor also for economic and productive growth).

Regarding innovation, on 11 March 2003, the EC published a document (EC 2003f, that bases its analyses on the previous 2002c – regarding this, see the previous EC 2000c and the recent EC 2008), in which it is stated that innovation policies must not be necessarily concentrated exclusively on the relationship between innovation and research. In fact, besides *technological innovation*, we can also speak of *organizational innovation* of job models and of their components, of *innovation concerning commercial models* and of *innovation of the presentation*, that is in sectors concerning design and marketing (EC 2003f, p. 8).

It also reaffirms, on the one hand, the national sovereignty of each member state in the choice of strategies useful to reach the goals of the Lisbon Strategy, and on the other hand the fact that they must integrate themselves within a supranational coordination, in particular in all the sectors considered strategic in such a way as to assure the interconnection of policies on a community, national and regional level. In this way, the need to put into practice tax incentives is stressed, not only for investments in research and development but also for investments concerning technological innovation (as is happening in Spain, for example), strengthening at the same time the regional dimension of the innovation policy.[2]

If in the field of innovation there are some encouraging signs, in the field of education things are diametrically opposite. In fact, in the document EC 2000c, we can see that the EC has started to be aware of the fact that in the member states: «the reforms undertaken are not up to the challenges and their current pace will not enable the Union to attain the objectives set» (EC 2003c, p. 3).

There have been insufficient efforts to reach the goals of the Lisbon Strategy and there has been no increase in the investment in human resources that represent, as we will see, the most essential factor for the development of a knowledge-based society. Nevertheless, 2003 was the year in which, for the first time, the EU started to see the University as a strategic sector for the creation of what was later called *human capital*: with the publication of the document entitled *The Role of the Universities on the Europe of Knowledge* (EC 2003b), the university is seen as a central element for the parallel development of the Lisbon Strategy and the Bologna Process – in order to create a common and shared European area of instruction and training alongside the already mentioned ERA (see EC 2000b). The University is recognized for the first time as the place that stands at the centre of that virtuous mechanism, thanks to which it is possible to create and spread new knowledge: «Given that they are situated at the crossroads of research, education and innovation, universities in many respects hold the key to the knowledge economy and society» (EC 2003b, p. 5). That way, we must attribute to the European university in general, even in its great heterogeneity and with its numerous problems, the prerogative to spring from the Humboldtian model and to represent a greater union between research and teaching. At the same time, given the awareness of the financial limitations and of the structural shortfalls of the university system, we can identify the possible solutions and propose ways of modernization that, if carried out within a few years, can allow us to bridge the enormous gap that divides our system from the American one (often taken as a model). This is an essential point to which we will return (see § 5.4).

However, the EU understood very soon that the goals set for 2010 were very hard to realize within that date. That is why on 14 July 2004, the EC published a document entitled *Financial Perspectives 2007-2013* (EC 2004b): the year within which Europe has to become the most dynamic and competitive economy and knowledge-based society is set further into the future with each document.

Nevertheless, the EC returns once again to the

[2] On this issue see also EC 2003e (in which the validity of the Lisbon Strategy is reasserted) and EC 2006. See also EC 2008b, in which at "point 6" it is argued how, in order to fulfill the objectives of the Lisbon Strategy, it is essential to involve local and regional institutions in the decision process.

issue of innovation, allocating it at the centre of the Lisbon Strategy (see EC 2005). At this juncture, the EU puts emphasis on an effort of coordination at a triple level: national, regional and European. Given the high level of competitiveness of the USA, Japan and other emerging economies like China and India, the EC highlights the need for transnational synergies if we want to make Europe competitive now and in the future. The EC also states – and this is the most important point of the document – that research and innovation «are needed to make the EU economy more sustainable, by finding win-win solutions for economic growth, social development and environmental protection» (EC 2005, p. 4). This point is reaffirmed in EC 2005b, where the EC states that

> **the realisation of a knowledge society, based upon human capital, education, research and innovation policies, is the key to boost our growth potential and prepare the future.** Sustainable growth also requires greater demographic dynamism, improved social integration and fuller utilization of the **potential embodied by European youth** as recognized by the European Council in adopting the European Youth Pact. (EC 2005b, p. 5, bold in the text).

In order to do so, the EC considers it to be of primary importance to guarantee economic stability in order to increase growth potential and occupation. Other objectives and measures are, for instance: to safeguard the sustainability of the economy in the long term because of the ageing European population; to promote an efficient allocation of resources and coherent macroeconomic and structural policies; to enlarge and improve the internal market; to guarantee the opening and competitiveness of markets inside and outside Europe; to improve the European community and national law in order to reduce costs due to the inefficiencies of the market; to increase and improve investments in R&D; to promote innovation, the diffusion of ICT (see EC 2005n and the recent EC 2009e) and the sustainable use of resources; and to contribute to consolidating the European industrial basis.

1.2.2 – *Human capital – beyond the economy*

All these measures are, doubtlessly, very important in order to reach the goals of the Lisbon Strategy, but without efficient and clear policies to sustain human capital, it is unlikely that Europe can be the most competitive and dynamic economy and knowledge-based society.

The subject of human capital is tackled clearly by the EC (2005c). Here we can find three key words on which European knowledge is based: *education, research* and *innovation*; and the relevance of human capital – the quality of which is measured by the average of EU working-age population that has achieved tertiary education – is closely tied with the innovation performance. It follows that the EC reiterates once again the importance of one of the main actors of policy innovation, that is the European university system. In fact, in this document, universities are seen as the engine of the new knowledge-based paradigm, even underlining the fact that universities now are not fully capable of putting into practice their potential in the service of the Lisbon Strategy because of a series of limitation and critical points, including: the small number of centres of excellence; the trend towards uniformity and to egalitarianism that rule out those that do not conform to standard models; the isolation of universities from the industrial and economic system; the excess of legislation of their internal life (that is seen as an obstacle to their modernisation and to their efficiency); insufficient funds (and in any case at a lower level than those assured in the USA, Canada and South Korea), and so on.

Therefore, the problems listed in this document are considerable and very serious, and to this regard, the EC has announced a series of measures, including attractiveness, seen as an imperative to attain quality and excellence. In the document, the EC states, quite rightly, that excellence is not an acquired data and for that reason it must always be called into question; but the EC recognizes also that centres of excellence must not be the only ones to benefit from funds: funds must be distributed even among those centres that have the potential to reach a high level of efficiency and excellence, that places emphasis on the need to encourage young innovative companies to carry out high-risk projects and to pursue radical innovation, helping them to overcome the start-up phase (this indication was raised again by ERA 2009 in the recommendation n. 9).

That is why universities must become more attractive, both at a local and global level and to do so it is necessary to revise curricula in order to promote the integration of graduates in the professional life. Seen from this viewpoint, the EC hopes that study programs can allow students «to encompass transversal skills (such as teamwork and entrepreneurship) in addition to specialist knowledge» (EC 2003h, p. 6); besides, the EC hopes for an increase in university access even for the socially weak groups, thus removing the correlation between social origin and level of the academic title reached.

The focal point of of EC 2005 concerns the improvement of human resources, that «are a core determinant of quality in higher education and research»; they can reach a high level of excellence only where there is a favorable professional environment based on open, transparent and competitive procedures; besides, in the document the importance of research is stressed. The document states that they:

> should be treated as professionals from the early stages of their career. Physical and virtual mobility (whether across boundaries or between university and industry) and innovation leading e.g. to university spin-offs should be encouraged and rewarded. Compensation should reward quality and achievement in the performance of all tasks, including a share of income from research contracts, consultancies, patents, etc. These measures would over time reinforce world-class excellence at European universities, thus reducing the attractiveness gap with other world regions and benefiting all of Europe - through highly qualified graduates moving or returning to more regional universities, whether immediately or later in their careers. (*ib.*, p. 7)[3]

Regarding the importance given by the EU to attractiveness, we think it is appropriate to quote also the recent Expert Group Report (see ERA 2009), that contains very important policy recommendations including attractiveness, the realization of which can be favoured by a global circulation of knowledge (recommendations n. 5 and 6).

The importance of the quality of human capital is highlighted by another circumstance on which a subsequent document insists (see EC 2006h): the existence of rapid technological and economic change, followed by an ageing population; according to the EC., this realization necessitates a strengthening of *lifelong learning* strategies. In fact, the document states that the wealth and the variety of European education and training «can be seen as an important asset and something which makes it possible to react rapidly and efficiently to technological and economic change» (EC 2006h, p. 3). In this respect, the EC recommends, on the one hand, the promotion and improvement of participation in *lifelong learning* both at a national and European level, and on the other hand, the request to outline a *European Qualification Framework* (EQF), the aim of which is

> to act as a translation device and neutral reference point for comparing qualifications across different education and training systems and to strengthen co-operation and mutual trust between the relevant stakeholders. This will increase transparency, facilitate the transfer and use of qualifications across different education and training systems and levels. (*Ibid.*, pp. 2-3)

With document EC 2007i, the EC returns to the issue regarding education and *lifelong learning*; the interesting point of this document lies in the indicators used in order to supervise the progress made in that field.

However, giving importance to human capital means being aware that innovation has many facets and not only the one regarding technological products which we are more familiar with: it shows itself in many ways (service innovation, organizational innovation, and so on). Besides – and this is the most important thing – innovation must base itself on a solid education system that, in theory, should promote the creativity and talents of students at the beginning of their careers: this is a very important first indication that was always to be highly privileged by the EU – 2009 was declared the year of creativity – and it would also prove crucial in the considerations and suggestions that will be discuss later (see ch. 5). It is no accident that even in 2007, the EC made the clarification/recommendation according to which, in order to strengthen both research and innovation it is necessary to invest in human capital (EC 2007l, p. 2).

Besides, the improvement of the quality of human capital has had an economic effect that cannot be ignored. In fact, in many studies (see, for instance, de la Fuente & Ciccone 2002, Cingano & Cipollone 2009, Visco 2009) it has been verified that there is an appreciable and significant economic return from the investments in education and that is, obviously, proof of the need to invest more in human capital.

The importance of human capital and of in-

[3] The role of the universities is discussed in great detail in § 5.4

vestments that must be addressed to it, is stated once again in report EC 2008g. The starting point of this report consists in the realization of a certain economic recovery but, unfortunately, it has not been followed by the hoped-for reduction of the youth unemployment rate:

> Youth unemployment remains a severe problem in many Member States. The overall youth unemployment rate did decrease over the last year but this was mainly attributable to significant reductions in a small number of Member States. The unemployment rate amongst young people has actually increased since 2004 in a number of other Member States. So far, young people have not benefitted enough from the favorable economic environment; they remain more than twice as exposed to unemployment as the overall work force. Finally, many Member States still fall short of the new activation targets. Despite also being a Lisbon priority since 2006, and given the importance of the young generations in addressing the future demographic challenges, these trends remain disappointing. (EC 2008g, p. 5)

The negative data is registered even concerning the quality of jobs, which can only be rectified by lifelong learning and by massive investment in human capital:

> Also the efforts made to increase quality at work again have not given good results, and the implementation of policies to further this aim are limited. In-work poverty still affects 8% of workers in the EU. While 2006 saw some further improvements in youth education levels there has been limited progress in other elements of quality at work, including in particular the transitions from insecure to secure jobs, and the issue of reducing labor market segmentation, the level of which is currently on the rise in many Member States. Adult participation in lifelong learning, one of the key indicators for quality at work shows stagnating or even declining trends. (*Ib.*, p. 8)

Recently, in EC 2009o (pp. 6-7) the need is stressed again to avoid dismissals and the loss of human capital by reforming education and training systems and ensuring a better fit between education, skills and the labour market. For these purposes the funding of lifelong learning is seen as a crucial aspect, together with measures to target resources towards higher education.

1.2.3 – *The economic requirements for innovation*

No innovation is possible without the basis of a strong economy able to invest in research and knowledge. This is expressed in a document that aims to lay out the guidelines for the re-launch of the Lisbon Strategy (see EC 2005d). In this document President Barroso and Vice-president Verheugen, express three points to be realized:

- Make Europe more capable of attracting investments and jobs;
- Make knowledge and innovation the fulcrum of European growth;
- Elaborate policies that enable European enterprises to create new and better jobs (*ib.*, p. 5).

If we turn our attention to the document of 2000 (see EC 2000b), the aims are the same, except that in the 2005 document the EC concentrates on the economic aspects as if the EC wanted to demonstrate, in a Marxian way, that it is necessary to operate on the economic structure to modify the political and legal super-structure. Barroso and Verheugen also talk about the “Non-Europe costs”, referring to the inefficient and inactive policies that have obstructed or delayed the process towards the goals of the Lisbon Strategy.

That is why Barroso and Verheugen wanted to review the Lisbon Strategy focusing on three fundamental aims: European initiatives must be more specific, they must raise support for the change, and they have to allow for the Strategy itself to be simplified and rationalized. But the economic aspect is once again the most privileged one: in a subsequent document of 13 February 2006 (see EC 2006g), the EC states that the two main tasks of the Lisbon Strategy have to guarantee a stronger and lasting growth and to create a higher number of jobs of better quality. If we turn our attention once again to the Barroso-Verheugen document, we can see that the second point has disappeared, the one according to which knowledge and innovation must be the fulcrum of European growth. So, the “knowledge factor” sometimes appears and sometimes disappears. In this case, they have preferred to put the stress on the “entrepreneurial factor”, considered essential for social cohesion (see EC 2006g, p. 3).

In order to make this factor take root in the European youth spirit, the suggestion has been made to the effect that it is appropriate to «make people aware of the benefits of basic entrepreneurship learning for society at large and for learners themselves, even at the early stages of education» (*ibid.*, p. 6; on economic issues see also

EC 2006b, 2006c, 2006d).

The issue regarding knowledge goes back to document EC 2006h. In it, we can see the existence of rapid technological and economic change, followed by an ageing population; according to the EC., this realization necessitates a strengthening of *life long learning* strategies. In fact, in the document, the EC states that the wealth and the variety of European education and training «can be seen as an important asset and something which makes it possible to react rapidly and efficiently to technological and economic change» (EC 2006h, p. 3). In this respect, the EC recommends, on the one hand, the promotion and improvement of participation in *life long learning* both at a national and European level, and on the other hand, the request to outline a *European Qualification Framework* (EQF), the aim of which is

> to act as a translation device and neutral reference point for comparing qualifications across different education and training systems and to strengthen co-operation and mutual trust between the relevant stakeholders. This will increase transparency, and facilitate the transfer and use of qualifications across different education and training systems and levels. (*ibid.*, pp. 2-3)

Another important document among those dedicated to the aims of the Lisbon Strategy is EC 2006i, entitled *Putting knowledge into practice: A broad-based innovation strategy for the EU*. After the recent changes in the socio-economic structures (cf. EC 2007c), the EC looks at innovation as an instrument that is useful to face the great challenges such as climate change[4], the demographic evolution, and so on. In this document, the EC reiterates once again the essential concept expressed previously in EC 2003f: it is necessary to avoid reducing innovation to technology alone, since innovation shows itself in many ways (service innovation, organizational innovation, and so on.). But innovation must base itself on a solid education system that, in theory, should promote the creativity and talents of students at the beginning of their careers: this is a very important first indication that was always to be highly privileged by the EU – 2009 was declared the year of creativity – and it would also prove crucial in the considerations and suggestions developed by the MIRRORS Research Project.

However, the remarkable and continuing drop in the total number of graduates in scientific disciplines and engineering can seriously compromise the capacity to innovate (this situation is even worse given the fact that the same trend is present in countries like Italy, Germany or Austria). Another measure to be carried out in this sphere is the mobility of researchers, that should be intensified through a transnational mobility between universities and industries.

These problems, in effect, are also the result of the state of crisis of the internal market (see the recent EC 2008c), characterized by some barriers that have hit both worker mobility and availability of venture capital; that is why the EC, in this document, states the importance of setting some more concrete priorities for future policies, aiming at the creation of an internal market that is more favourable to innovation. To this regard, the EC hopes not only for the approval of a European patent, but also for a strengthening of the "cluster" policy (see EC 2008d, 2008e); according to the EC, clusters:

> help to close the gap between business, research and resources, thereby bringing knowledge faster to the market. Successful clusters promote intense competition along with co-operation. They enhance productivity, attract investment, promote research, strengthen the industrial basis, and develop specific products or services and become a focus for developing skills. World-class clusters attract brilliant minds that sustain innovation – Silicon Valley is the best-known example. (EC 2006m, p. 7)

At this point, the EC reaffirms the need for universities to have sufficient autonomy in order to develop their strategies and to strengthen their role in society. To these clarifications, that continue in the document entitled *Delivering on the Modernisation Agenda for Universities: Education, Research and Innovation* (cf. EC 2006l), the EC adds the recommendation concerning more investment in research and innovation (year after year, in fact, the aim of 3% of GDP in R&D seems to be a chimera). According to the EC, research policies have taken on a more specific character thanks to the creation of technological platforms that, though not instruments of either the research framework program or technological development, will nevertheless be taken into account for the seventh

[4] Regarding this issue, see GMES 2009 of the Global Monitoring for Environment and Security expert group, founded by the EU in order to supervise the principal questions concerning the environment.

framework program of 2007-2013 (in which MIRRORS is inserted).

On 23 October 2006, the EC published a document entitled *Community Lisbon Program: Technical Implementation Report* (see EC 2006l). In this document, the EC listed the main results realized in the sphere of the Lisbon Strategy but also the next actions that the EC wants to put into practice in order to implement some of its aspects. The EC focuses on four priority areas for which action is required: knowledge and innovation; business environment; employment policy; and energy policy.

In the following document (see EC 2007g), the EC returns to the issue of research and innovation. Once again, this communication aims to provide a valid support for the improvement of knowledge transfer (that involves the processes aiming to capture, collect and share both tacit knowledge and explicit knowledge) between public institutions of research and, for instance, industries, civil society, and so on.

In this document, the EC notes once again the gap between Europe and USA regarding the investments spent in R&D; everything that obstructs the application of an efficient knowledge transfer – legal barriers, the lack of incentive, and cultural differences between the market and the science community (see EC 2006e); all these negative factors, obviously, become serious obstacles both for European growth and for the creation of jobs. The EC, in this respect, states that in order to put into practice the activities regarding knowledge transfer, research institutions need sufficient autonomy to recruit *knowledge transfer experts* on a competitive basis.

Regarding competitiveness, the EC recalls also the importance of an entrepreneurial mindset, considered to be the main element to remedy the cultural watershed between scientific institutions and industry. In order to realize that, the EC stresses also another recommendation proposed in previous documents and reports, concerning the joint work between member States and the European Community: the importance for member states to put their research institutions within ERA and the Lisbon Strategy. A very important aspect, in this respect, is the foundation of the European Institute of Technology, established in order to favor and promote the interactions between research institutions and industry and also to favour knowledge transfer. A first significative achievement of EIT is the creation of the first three Knowledge and Innovation Communities (KIC) that are «highly integrated partnerships, bringing together excellent higher education, research and business around the topics of climate change mitigation and adaptation ("Climate-KIC"), sustainable energy ("KIC InnoEnergy") and the future information and communication society ('EIT ICT Labs') respectively» (EC 2009p). The need to proceed in these directions had already emerged in previous document (see EC 2006i) in which, referring to the recent changes in the socio-economic structures (see EC 2007c), the EC looks at innovation as an instrument that is useful to face the great challenges such as climate change (see GMES 2009), the demographic evolution, and so on.

These positions have been repeated in EC 2007h, where we can find the concept of *flexicurity*, «an integrated strategy to enhance, at the same time, flexibility and security in the labour market» (*ib.*, p. 4). This concept tries to respond to two essential needs that the EU has to satisfy: those concerning the labour market (characterized by a faster technological development) and social patterns (engaged in favoring social cohesion, solidarity and social protection). The first factor, *flexibility*, is useful not only to face the fast change we are currently undergoing in the economic field, but also to improve the workers' capacity to change jobs during their lifetime (but on the basis of a strengthening of their skills and competences); while the second concept, *security*, is essential for workers in order to plan their future and careers. In connection with these needs, as we will see later, there is a double responsibility: on the one hand, in fact, the training has the task of providing the adequate tools so that workers can achieve flexibility and capacity of adjustment to the ongoing change; on the other hand, we must recognize the enormous responsibilities of the political choices that will be realized in the social and working fields in order to guarantee a less precarious working environment (see § 5.6).

The issue of growth and employment is also at the center of EC 2007l: according to the EC, only through promoting the knowledge-based economy (and this, in turn, is feasible only through research, technological development and innovation) is it possible to improve them. An interesting point of this document is, in our opinion, the one concerning the importance of the regional dimension of innovation («Innovation is most effectively addressed at a regional level, as physical proximity fosters the partnerships between actors in both public and private sectors», EC 2007l, p. 2).

In the following communication EC 2007m, the EC on the one hand indicates some of the actions it intends to put into practice for the period 2007-2013 and on the other hand, it makes an assessment of the progress made in the sphere of the Lisbon Strategy in the period 2005-2007 (see also EC 2007f and EC 2008f). The interesting data of this document can be found in the emphasis that the EC puts on the potential of the investments in knowledge and innovation. The importance of investments aiming at the improvement both of energy policies and energetic resource management is also stressed; but we must not forget the EC recommendations addressed at the improvement and modernization of public administration and services at a national, regional and local level.

In a subsequent document the EC underlines once again the importance of investment in research (see EC 2008h). But if Europe wants to reach the goals set by the Lisbon Strategy, more and better investments must be made. Despite the initiatives carried out by the EC in R&D, the situation outlined in this document is almost alarming: «Europe is still under-investing in research, and R&D spending – by both the public and the private sector – has generally stagnated over the past decade» (*ibid.*, p. 4). The weaker point of research policies and of the investments in R&D depends on the merely national dimension of the R&D activities, whose results on an economic level are not encouraging (too high costs and too low economic returns); that is why the EC recommends that member States do some cross-border collaboration, because otherwise, mobility, researchers training and research development could be (and in fact they are) obstructed.

In order to tackle this negative situation, in this document, the EC has tried to apply a new approach, the already mentioned *joint programming*, that, involving the member States on a volunteer basis, could lead us either to the coordination of different national programs already existing or to the institution of new community programs; the aim of this is to increase the cross-borders research publicly funded in specific strategic sectors (see *ib.*, p. 10). According to the EC, the adoption of this approach could give us some important advantages:

> by supporting cross-border project collaboration, Joint Programming facilitates the pooling of data and expertise scattered across several countries or throughout Europe as a whole, enables the rapid dissemination of research results, promotes cross-border mobility and training of human resources, and increases the scientific, technological and innovative impacts of every Euro invested in public research. (*Ibidem*)

The following point concerns the pragmatic methodology that must be used to make the joint programming really effective, that consists of three starting phases: a) the development of a common vision for the agreed sector, that should «set the longer term objective(s), to be defined by authoritative experts in the field and politically endorsed»; b) once this common vision is defined it must be translated «into a Strategic Research Agenda (SRA), entailing specific, measurable, achievable, realistic and time-based (SMART) objectives»; c) the realization of the strategic research agenda to which all participating public authorities must direct their programs and funds.

In order to realize all this, some coordination measures are necessary between member States and EU and it is the insufficient coordination capacity and the lack of synergies between member States and the EC that obstruct the reaching of the goals of the Lisbon Strategy, especially in the scientific field. This problem was tackled by EC 2008i, in which the EC stated that the cooperation of the nations in the fields of science and technology can really contribute to the stability, to the security and to prosperity in the world only through the strengthening of the partnership between member States and the European Community.

To this we should add the need to expand the boundaries of European research to extend it also to collaboration with non-European partners; this last recommendation should help to realize not only the mobility of researchers, but also the circulation (and not drain) of brains.

These are the measures that according to the EC we need to put into practice in order to make Europe an attractive research partner. This strategic framework for international cooperation on science and technology should be able, according to the EC, to strengthen the coordination actions between member States and the EC: the aim should be to create additional synergies between public authorities, industry and civil society, and also the capacity to facilitate the access to knowledge and to world markets, to exert a positive influence on scientific and technological activities programmed at a world level combining together the resources necessary to reach a critical mass and underlining the democratic values of the world information society (in particular freedom of speech and the right to access information); finally, all this should provide universities and European researchers with more chances to work with the best scientists and in the best research infrastructures of the world.

The importance of economic factors for an effective research policy has been underlined in one of the most recent documents, that is a kind of assessment that contains some recommendations to be put into practice in order to complete the actions scheduled by the European plan for the economic recovery (see EC 2008l). The list of the steps towards the great goals already made by the Lisbon Community Program (LCP) 2008-2010, aims at the following goals:

- investing in people and modernizing labour-markets;
- exploiting the potential of companies;
- reducing administrative costs by 25% by 2012 (see also EC 2009f);
- strengthening the single market;
- making investments in knowledge and innovation;
- reducing gas emissions by 20%;
- promoting an industrial policy aiming to favour sustainable production and consumption (see also EC 2009g), and so on.

1.3 – Beyond GDP: the environmental turn

Although in the past, since 2001, the EU had singled out the necessity to pursue sustainable development by following several actions (see EC 2001d, 2002e, 2004f, 2005q, 2005r, 2005s, 2006o, 2006p, 2007o, 2007p, 2008n, 2009g), a turning point for the Lisbon Strategy came with the communication *GDP and Beyond* (see EC 2009h), by which the EC called for the elaboration of indicators complementary to GDP: this is the coherent development of a commitment already undertaken in November 2007 with the conference *Beyond GDP*, held in Brussels and organized with the help of OECD and WWF.

For long time now, the gross domestic product has been seen as the fundamental magnitude of macro-economy and is considered as the main indicator of economic prosperity and of progress in general. It has traditionally responded to the need for the creation of new policies of growth and of identifying tools able to measure its efficiency. GDP is the indicator traditionally used up to now to measure the quality of life and economic growth – it is the sum of the value of all goods and final services produced in a country during a fixed period of time. In fact, GDP is generally considered to be the main indicator of economic prosperity and of progress in general.

The use of this indicator is due to two factors in particular. First of all, the underlying idea that there is a firm correlation between income and well-being; this notion arose in the last century – a period in which the growth of western economies was transformed into improvements of well-being for the respective populations. Secondly, it has the advantage of reducing several different aspects to a single number.

1.3.1 – *The unheroic history of GDP*

We owe the first attempts at measuring the wealth of a nation to Sir William Petty who, at the end of the 17th century was responsible for measuring the capacity and productive force of England. Subsequently, at the beginning of his work *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith tried to define the wealth of a nation and identified it as the quantity of goods produced by work, or the goods that work enables people to purchase from other countries (Smith 1776, p.10). Therefore, starting from the idea that the more productive work is, the richer a nation will be, the search for well-being has ended up coinciding with the search for the reasons for the economic prosperity of a nation and this has driven people to look for forms of organization of economic activity that are able to maximize work productivity.

With the rise of the modern political economy in the 1930s, the promotion of growth became a real political need and it became essential to measure it as a tool of promotion, control and correction of the actions of the government. The Great Depression and the threat of a new war that would put the production systems of the different states in competition with each other, reinforced the need for a system of measuring economic activity.

The final affirmation and international diffusion of modern accountancy and its disclosure tool, the GDP, took place on the occasion of the Marshall plan. Companies that intended to take part in reconstruction programs had to produce development plans using new balance sheet models. From the start, the system developed by changing the criteria of company accounting which required the registration of formal financial transactions. The metaphor "country = large company" and the need to measure the value of transactions limited the system to transactions that generated a flow that could easily be measured in monetary terms. The advantages of this system lay in the possibility to gauge the political action of a country and to compare the economic strength of one's own country with that of other nations, which turned out to be essential during the Cold War, with the stand-off between America and the Soviet Union (see Chiappero-Martinetti & Pareglio 2009, p. 20).

However, despite this power of reduction, the capacity for integrating with other aspects of accountancy of a country and to reflect macro-differences in development, the GDP has shown itself to be very limited from the beginning.

Simon Kuznets, the father of the concept of GDP, noted as early as 1934 in his first report to the Congress of America, how it was not a tool for the assessment of well-being of a country (Kohler & Chaves 2003, p. 336). However, the most well-known and influential criticism of GDP was expressed on 18 March 1968 by Robert Kennedy in a speech at Kansas University, three months before he was assassinated:

> We will never find a purpose for our nation nor for our personal satisfaction in the mere search for economic well-being, in endlessly amassing terrestrial goods. We cannot measure the national spirit on the basis of the Dow-Jones, nor can we measure the achievements of our country on the basis of the gross domestic product (GDP). Our gross national product counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage. It counts special locks for our doors and the jails for those who break them. It counts Whitman's rifle and Speck's knife, and the television programs which glorify violence in order to sell toys to our children. It counts napalm and the cost of a nuclear warhead, and armored cars for police who fight riots in our streets. Yet the gross national product does not allow for the health of our children, the quality of their education, or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages; the intelligence of our public debate or the integrity of our public officials. It measures neither our wit nor our courage; neither our wisdom nor our learning; neither our compassion nor our devotion to our country; it measures everything, in short, except that which makes life worthwhile. And it tells us everything about America except why we are proud that we are Americans. (Kennedy 1968)

For the first time, in a public and visible way, by highlighting all the partialities and distortions of an index that takes account of the worst things and neglects those that make life actually worth living (see Mirovitskaya, Corbet & Swibold 2002, p. 28), this accusation brought to the forefront of public opinion a subject that until then had been reserved for limited academic debates.

The many criticisms that have been made since then focus mainly on two aspects. The first concerns the partiality of the registrations: the GDP only records transactions made in the markets, therefore is not able to account for all the activity that does not undergo formal transaction, like in the case of domestic work that, though essential and representing a fundamental aspect of the well-being of a family, is not taken into consideration in the national accounting and is therefore not registered. The simple act of formally registering it could make the GDP rise though leaving the well-being of a country unaltered (Pallante 2009, p. 8).

In the second place, the GDP does not take account of the qualitative difference of the transactions. Since all production and all expenses contribute in a indiscriminate way to the GDP, including destructive ones and there is no distinction between an effective production and one aimed at neutralising the effects of another production (Ellul 1998, p. 76), the GDP marks the same values for the construction of a hospital, either built from scratch or rebuilt following an earthquake. Likewise, a fire caused by arson that destroys a forest with the consequent expenses for extinguishing it, reconstruction and the normalisation of the territory registers a growth in GDP.

The petrol crises of 1973 and 1978 showed how impossible it is to exclude the finite nature of natural resources from productive accountancy and the measure of well-being. In the same years, the Rome Club (see Meadows *et al.*, 1972) foresaw a dramatic growth in pollution and fast exhaustion of natural resources.

It is clear that these are the criteria conceived of to explain the economic growth in the years and in the countries in which it took place, mainly, through the accumulation of production capacity in terms of industrial plants, infrastructures and with the shift of productive resources from informal sectors to highly productive ones. Energy was once considered to be limitless, but as soon as the effects of the lack of energy began to make themselves felt, the concept of the economic value of natural capital emerged.

Therefore, the theoretical elaborations began that highlighted other factors and questioned the close dependence between the growth of GDP and the growth of well-being over long periods of time.

Using the Hicksian Income (Hicks 1946, p. 172), that is the maximum amount of goods or services that an individual can consume in a fixed period without prejudicing the possibility of future consumption, Erik Lindahl introduced the Net National Product (NNP), in which the depreciation of the stock of physical and human capital is subtracted from the Gross National Product (Chiappero-Martinetti & Pareglio 2009, p. 24). In 1972 two Yale economists, William Nordhaus and James Tobin (1972) composed the Measure of Economic Welfare (MEW), in which the depreciation of capital goods, investments and the so-called non discretionary expenses (for example, the costs incurred in travelling for work purposes, or getting about in big cities). They calculated the MEW of the USA from 1929 to 1965 and although they obtained growth rates that were inferior to those recorded for the GDP (1.1% a year rather than 1.7%) nevertheless, the GDP did not present a view that was excessively distorted from the evolution of well-being enjoyed by the country.

In line with the limitation often attributed to GDP that it does not represent a measure of well-being, and going also beyond economic well-being, in 1972, the King of Bhutan Jigme Singye Wangchuck coined the term Gross National Happiness (GNH), which he considered to be more important than GDP for the construction of an economy coherent with the traditional Buddhist culture (Brooks 2008). The Dalai Lama is one of the supporters of GNH – he was convinced that happiness and the end of suffering is coherent with Buddhism. Many others have made happiness a subject of study in economics courses.

In 1993 David Pearce and Giles Atkinson presented the Genuine Saving, which is the saving from which the degradation of natural resources is deducted; it appears from this, that many countries are following unsustainable paths of development, unable to replace the depreciation of technical and natural capital (Pearce, Hamilton & Atkinson 1996).

The energy crisis, the definitive affirmation of the problem of sustainability and the slowing of the growth of industrialised countries has led to a re-working of the old paradigms of development, and models of growth like those of Solow and Ramsey-Cass-Koopmans show how the maximisation of well-being in the present time can be detrimental to the reaching of the maximum level of wealth over longer time spans (Chiappero-Martinetti & Pareglio 2009, p. 25).

The solution to the problem in the long term is sought in technological progress. In the works of Paul Romer (1986), Robert Lucas (1988), Philippe Aghion and Peter Howitt (1992), technical progress, which already emerged as a basis element in the 1960s (Arndt 1987, pp. 84-98), is considered to be essential to contrast the tendency of the system to stagnate. In this perspective, the role of human capital and technological innovation becomes central, with the consequence that knowledge is seen as capital to be used according to criteria that are valid for the market: expenditure in research and development is essential and the indicators in the rate of education and research will proliferate.

With the works of Robert Solow and John Artwick on the depletion of non-renewable natural resources, in the area of what is defined the Solow-Hartwick model, and with other contributions and improvements, the Green Net National Product was defined, which «includes corrections for the depreciation of the stock of non-renewable resources and registers the rise or reduction of the quality of the environment» (Hartwick 2000).

In 1994 Clifford Cobb and John Cobb defined the Index of Sustainable Economic Welfare (ISEW), by changing some aspects regarding the distribution of income and the growth of net capital and a country's debt position towards abroad. This index corrects the GNP attributing an economic value to natural resources, environmental damage, free time, unpaid domestic work, education and health (Cobb 1994; Cobb & Cobb 1994). The loss of the value of natural resources and the reduction of non-renewable biological diversity is estimated to be equal to the savings necessary to compensate the future generations for lost natural capital. A sign of the end of energetic optimism, the loss of natural capital, considered to have no remedy, has a much greater negative influence than the MEW.

In the 1990s, several research institutions and international organisations elaborated tools for measuring particular aspects linked to depletion of resources and well-being. The FAO made available a collection of indicators for sustainable development. The United Nations Development Programme, UNDP, published the Human Development Index, (HDI), inspired by Amartya Sen's approach to quality of life. In 1994 Herman Daly, John Cobb and Philip Lawn tried to find a substitute for GNP. Starting from the ISEW they elaborated the Genuine Progress Indicator (GPI) which, by analogy to the difference between the total turnover and the net profit of a company, distinguishes between positive development, which increases well-being, and negative development, which includes the costs of crime, pollution etc. (Lawn 2003, pp. 105-118).

Although there are many methodological difficulties due to the quantification of biodiversity or the measure of the effects of climate change, also the index of economic development proposed by the United Nations (with the collaboration of the World bank and the OCSE) represents an indication of a change of paradigm, as it takes account of the consequences on the environment of economic development, the enviromentally Adjusted Net Domestic Product (EDP) (Pellizzari 2008, p. 47).

1.3.2 – *Europe towards sustainable development*

These are the historical and theoretical premises that help us to understand the recent stances of the EC. In 2007 the EC with the European Parliament, the Rome Club, WWF and OECD organized the conference "Beyond GDP" and in the document that came out of it (EC 2009h), starting from the general agreement on the need to identify some parametres for the assesment of well-being in addition to GDP, the EC states that, considering its nature and aim,

> GDP has also come to be regarded as a proxy indicator for overall societal development and progress in general. However, by design and purpose, it cannot be relied upon to inform policy debates on all issues. Critically, GDP does not measure environmental sustainability or social inclusion and these limitations need to be taken into account when using it in policy analysis and debates (EC 2009h, p. 2).

In this text, in order to measure progress in a better way, the EC proposes five actions that can be even extended or re-worked during the revision scheduled for 2012. The first action consists in completing GDP with social and environmental indicators, because up to now, the GDP has not taken stock of the situation regarding issues linked, for instance, to the environment or to social disparity; so,

> to bridge this gap, the Commission services intend to develop a comprehensive environmental index and improve quality-of-life indicators. There is currently no comprehensive environmental indicator that can be used in policy debates alongside GDP. Such a single measurement for the environment would help foster a more balanced public debate on societal objectives and progress. (*Ib.*, pp. 4-5)

The second action consists in giving fast and well-timed information about phenomena and consequences linked to globalization and to climate change. This implies the use of social indicators that must be more topical because, as is known, the time lapse between the data-gathering and its publication is too long.

The third action concerns giving more precise information about the distribution of wealth and disparity:

> Social and economic cohesion are overarching objectives of the Community. The aim is to reduce disparities between regions and social groups. In addition, far-reaching reforms – such as those required to fight climate change or to promote new patterns of consumption – can only be achieved if efforts and benefits are felt to be equitably shared among countries, regions, and economic and social groups (*Ib.*, p. 7).

The fourth action consists in the elaboration of a European schedule of evaluation of sustainable development, since this is a general objective of the EU. This strategy aims at a respect for natural resources that cannot provide us with renewable energies and cannot absorb polluting agents indefinitely. That is why scientists «are seeking to identify related physical environmental threshold values and highlight the potential long-term or irreversible consequences of crossing them. For policymaking it is important to know the "danger zones" before the actual tipping points are reached, thereby identifying alert levels» (*ib.*, p. 8 – see also Eurostat 2007).

The fifth action, that concerns taking into consideration the social and environmental questions in national balance sheets, returns to the issue regarding the elaboration of complementary indicators to GDP that must show data linked to social and environmental questions in a sustainable development perspective:

> As a foundation for coherent policy-making, we need a data framework that consistently includes environmental and social issues along with economic ones. In the conclusions of June 2006, the European Council called on the EU and its Member States to extend the national accounts to key aspects of Sustainable Development. (*Ib.*, p. 9)

With this document, the EC, obviously, does not mean to reject the validity of GDP, but proposes to integrate it with other indicators that must take into account factors that the GDP does not incorporate; the EC conclusions on this point are more than explicit:

> Gross Domestic Product (GDP) is a powerful and widely accepted indicator for monitoring short to medium term fluctuations in economic activity, notably in the current recession. For all of its shortcomings, it is still the best single measure of how the market economy is performing. But GDP is not meant to be an accurate gauge of longer term economic and social progress and notably the ability of a society to tackle issues such as climate change, resource efficiency or social inclusion. There is a clear case for complementing GDP with statistics covering the other economic, social and environmental issues, on which people's well-being critically depends. (*Ib.*, p. 10)

In conclusion, we cannot ignore the report commissioned by the French President Sarkozy and written by Joseph Stiglitz, Amartya Sen and Jean Paul Fitoussi (see Stiglitz, Sen & Fitoussi 2008, 2009, and 2010), and the communication entitled *Consultation on the Future "EU 2020" Strategy* (see EC 2009i), that has postponed the goals set by the Lisbon Strategy to 2020, casting shadows on both the Strategy results and on the political intention hitherto shown by member States. Anyway, this communication also provides a continuation to what has emerged recently in the European scenario and to what maturated during the last decade, especially regarding the issue of the environment and a less economy-oriented measure of collective wealth.

The beginning of the communication is not encouraging, especially when the EC states that, although economic collapse has been avoided, the Union's defences have been weakened; it postulates the coming out of the recession of the last two years which, according to the EC:

> should be the point of entry into a new sustainable social market economy, a smarter, greener economy, where our prosperity will come from innovation and from using resources better, and where the key input will be knowledge. These new drivers should help us tap into new sources of sustainable growth and create new jobs to offset the higher level of unemployment our societies are likely to face in the coming years. However, we will only succeed if we design and implement a bold policy response. Otherwise, the risk is a period of low growth which can only make it harder for Europe to tackle the major challenges we face today. (EC 2009i, p. 2)

In this text all the negative factors coming from the present economic crisis are mentioned, and the repercussion has been very harmful for workers. Besides, the EC acknowledges the centrality, both for competitiveness and innovation, of energy saving and of environmental resources, stressing that environmental problems must be solved in parallel to economic ones.

In this *Consultation* the EC sets the following three key drivers, considered to be fundamental for the EU Strategy 2020:

- Creating value by basing growth on knowledge (see also EC 2009n).
- Empowering people in inclusive societies.
- Creating a competitive, connected and greener economy (see EC 2009i, p. 4).

Regarding the first factor the EC states that:

> Knowledge is the engine for sustainable growth. In a fast-changing world, what makes the difference is education and research, innovation and creativity. Strengthening education is one of the most effective ways of fighting inequality and poverty. The high number of low achievers in basic skills (reading, mathematics and science) needs to be addressed urgently to enhance the employability of young people and to bring them into the world of work after school. Preventing early school leaving reduces

> future exclusion from the labor market and the threat of future social exclusion. A greater emphasis on vulnerable groups, gender equality and social cohesion is needed to ensure that no one is excluded from knowledge. (*Ib.* p. 5)

Regarding the second one, the EC takes note of the loss of many jobs because of the present economic crisis and recommends the creation of a greener economy, that is more intelligent and competitive, able to create new jobs in the EU. However, this implies also a change of the traditional model "study-work-retirement", which should be substituted with another model that is more suitable for the present global economic situation (a return to the concept of *flexicurity* we have seen before).

Also regarding the third factor, the situation seems to be inadequate for the objectives that the EU wants to reach: an economy that is greener and more environment-friendly could provide a drastic change in the European industrial organization and also in its modernization (which has been slowed down, among other things, by the present economic crisis).

Therefore, given the situation outlined in this document, it is obvious that in order to overcome this present economic crisis it will be necessary to find a balance between the need, in the short term, to sustain the demand with budget measures and the need to restore the public finances in a sustainable way guaranteeing, at the same time, macro-economic stability. The risk is that a slow recovery cannot favour the occupational growth necessary to reduce the high levels of unemployment (*ibid.*, p. 9).

These aims can be reached by 2020 only by recognizing, first of all, the high level of interdependence existing among the member States, caused by indirect effects (positive or negative) of national interventions, especially in the euro-zone; interdependence between the different levels of intervention (EU, member States, regions and so on); interdependence between different policies and between policies and instruments, and from that the importance of political integration in order to reach the general objectives; finally, the interdependence at a world level (no member State is able to withstand emerging economies or to undertake the hoped-for transformation alone).

Later, it will be necessary to set the EU 2020 strategy in a world context, to sustain growth through the treaty of stability and growth, to translate the political priorities into monetary commitments and finally, to outline a clear governance in order to contribute to the efficiency of the new strategy. In short, the path we have to travel is very long and difficult, even though the goals are, for the most part, desirable and sharable by every member State; however, the extent to which national and community political institutions will have the will to cooperate in order to implement what we have outlined here remains to be seen.

Moreover, we do not know yet the extent to which the new scenarios opening up in Europe, with the most recent positions and indications, are compatible with the objectives – set by the Lisbon Strategy in 2000 – that seem to assume a merely quantitative approach to economic growth, all based on the increase of GDP and on a linear vision between R&D and development. It is on this front that our researchers have developed their reflections, as we will see in the following chapters.

1.4 - Keep on trying once again, old Europe!

If we try to make an assessment of the history of the last decade – characterized by the effort to put into practice the Lisbon Strategy – we can only note a negative result: the goals set by the Lisbon Strategy (to make Europe the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion, aiming to increase the investments in R&D to 3% of the GDP, creating new and better jobs, and so on) have not been reached for several reasons. The main one is, surely, the lack of political commitment on the part of most of the member States that, with some exceptions in the North of Europe, have not made sufficient investments in education and research. If this can be justified in the light of the present economic crisis, it is also true that most member States have not been able to make the necessary efforts to reach, even approximately, the goals set by the conference of 2000. In our opinion (and we shall explain this later), a particularly serious shortcoming was the lack of far-seeing investments in what in our reflections, and not only in ours, is the main resource of all the complex socio-economic systems: human capital and research (see also EC 2009o, p. 7).

All this happened despite the fact that in 2005, the Commissioner Janaz Potočnik formed an expert group of notable economists – called "Knowledge for Growth" (K4G) – with the aim to re-launch the Lisbon Strategy and to receive suggestions about the contribution that knowledge can provide for growth and sustainable prosperity, on the best policies able to promote the creation, dissemination and use of knowledge and the role that the various social actors can play in order to stimulate the training and the coming of a knowledge–based society in Europe. Although the K4G group demonstrated, during its activity and with a lot of documents and *policy briefs* (see K4G 2009), how fundamental it is to invest in research even during the period of recession, since scientific research is the very factor required to get out of recession, in many member States the trend was just the opposite: during the period of recession, investment in research and development is seen not as a categorical imperative but simply as a luxury. This trend must be abandoned if we are really to reach – in a renewed framework and with the modifications that this report has tried to suggest – the goals set by the Lisbon Strategy. Otherwise, Europe will lose not only its economic potential but also its human one.

The impression that we get, giving a comprehensive look at the EC documents and at the many reports and studies commissioned by the EU, is a sort of enlightened vision of Europe's future – elaborated more or less by many studies and specialist scholars – which is not matched by an equally enlightened policy by the national States. It is as if the relative absence in the EC of the need for a direct relationship with the electorate and with concrete national needs – inevitably tied up with many mediations of interests, lobbies and social parties, besides cronyism and local interests aiming at the achievement of a consensus that is immediately operable and short-lived – protects Europe from the immediate conditioning of local interests and so can give her the chance to "think in general", to outline optimal strategies that are rationally planned.

However, these noble drives are not matched either by the will to put them into practice or by the real conviction of the single member States, of their urgency. Until we manage to build a bridge between a kind of "powerless Jacobinism" orientated in an enlightened way, and the effective capacity to touch the realities of the single member States, every initiative in the field of knowledge and research will be only the expression of good intentions and an ideal of "beautiful souls". From this deficiency, already diagnosed and well known, the new European Constitution should save us.

Now the very recent "Europe 2020 strategy", put forward on 3 March 2010 – while we were writing this report – proposes three priorities that consist in a "smart, sustainable and inclusive growth" that aim to react to the recent economic recession by relaunching the programme of development to enable us to come out it, by hypothesizing the possibility of a new economy. This must be smart, since it proposes to develop "an economy based on knowledge and innovation"; sustainable, because it aims at "a more efficient, greener and more competitive economy"; inclusive as its objective is "fostering a high-employment economy delivering social and territorial cohesion" (EC 2010, p. 3). And among the objectives needed to reach to realize the aforementioned priorities, there is the return of the aim to reach 3% of GDP in investments for R&D, especially in the private field: a clear admission of the failure of the Lisbon strategy but also a renewed conviction of the fundamental need to invest in research and innovation. Besides, the strategy for 2020 also proposes to raise the level of school education (the objective is for 40% of young people to reach tertiary education, i.e. get a degree); to favour these two objectives the initiatives "Innovation Union" have been launched, among others, «to improve framework conditions and access to finance for research and innovation so as to ensure that innovative ideas can be turned into products and services that create growth and jobs; and "Youth on the move" to enhance the performance of education systems and to facilitate the entry of young people to the labour market» (*ib.*). A programme that is not lacking in optimism and that will try to maximise the strong points that Europe has traditionally been credited with:

> Europe has many strengths: we can count on the talent and creativity of our people, a strong industrial base, a vibrant services sector, a thriving, high quality agricultural sector, strong maritime tradition, our single market and common currency, our position as the world's biggest trading bloc and leading destination for foreign direct investment. But we can also count on our strong values, democratic institutions, our consideration for economic, social and territorial cohesion and solidarity, our

> respect for the environment, our cultural diversity, respect for gender equality – just to name a few. Many of our Member States are amongst the most innovative and developed economies in the world. But the best chance for Europe to succeed is if it acts collectively – as a Union. (EC 2010, p. 7)

Will “old Europe” succeed this time in its effort to keep up with countries who are guiding the knowledge economy? Will it effectively manage to orchestrate a unitary, collective policy rather than falling victim to the egoism of the individual nations?

We can only hope that the patient will not die before the doctors decide to carry out the treatment, and that Europe could still have another chance in the new decade that has just begun. At the end of the day, it is not too late to keep on trying once again, learning from the mistakes of the past and treasuring the experiences already made. Keep on trying once again, old Europe!

2. Society, Democracy and Trust in Science

2.0 – Overview

In this chapter we have discussed the strategies needed to democratise techno-scientific praxis, focalising our attention on the difficult question of the perception of techno-scientific activity on the part of public opinion.

To this regard we have begun by analyzing the changes in the perception of the role and function of science in society. In the Modern Age, science has always played a pivotal, instrumental and beneficial role. The eighteenth century is characterized by its "scientific" revolution that also implied a change in the way mankind would perceive the world and organize social life. In the eighteenth century, for Enlightenment thinkers, science – in itself and as a paradigm of impartial reasoning and inter-subjective agreement – became the instrument to achieve individual emancipation from religious dogmatism and political despotism. The same applies to the nineteenth century with "positivism" investing all areas of cultural thought as well as institutional arrangements. There again science would serve the purpose of emancipating man from superstition and ignorance. Furthermore, industrial modernization was perceived as a beneficial, material instantiation of the emancipatory powers of science.

Up to the first decades of the twentieth century, science enjoyed unconditional support from the general public and political institutions until the two World Wars showed the bad side effects of its powers. After that, in the midst of the Cold War, pollution, overpopulation, economic disparity, and suchlike prompted many to call for a critical discussion about the main tenets of positivistic modernism. This was the conclusion everybody could agree on: in the postmodern age, science cannot be left uncontrolled. Its display of power during the two world conflicts had led governments to take up the role of controllers. Here, in the aftermath of World War II, the prestige of nations (or factions) during the Cold War depended on their economic and military edge, which, due to the paralysis (to some degree) of material conflicts within Western civilization ultimately depended on the techno-scientific edge – while ethnic and political aggressiveness was played on the outside in the form of economic coercion, cultural advertising, espionage, and suchlike. It was especially with the official end of Cold War in 1989 that a radical change in the way the perception of science of both professionals and the general public occurred. All the techno-scientific resources accumulated during those thirty years could be directed towards public, social and civic purposes. It is at this point in history that public opinion entered an area of social organization that was previously held only in government quarters and discussed within university walls: science policy. Once the thirty-year threat of a nuclear and final conflict between the (then) two poles of the planet had stopped exercising a sort of coercive assent towards public expenses for techno-scientific development for defence purposes, the general public's risk perception was turned entirely towards other potential and real effects of government control over science. The environmental and social effects of industrial modernization became the object of public debate and it still is today.

We have subsequently analysed the development of the research policies promoted by the EC since the 1980s and we have tried to show how the negative perception of science, linked to the risk of the annihilation of our species during the Cold War by destructive technological apparatus, has given rise to the search for ways of involving society in general in the decisions concerning the use of research for non-bellicose aims and for broader public interest, especially in the light of a growing environmentalist awareness. We have concluded by sustaining that it is the use of techno-science, not the specific information on its praxis that concerns public opinion. In this sense, it would appear that a better strategy for the democratisation of knowledge does not require the public to participate actively in practising it, but regards a better divulgation of the risks involved in its results and the possibility of directing its ends. This is the conclusion that has developed from what was discussed in § 2.2: the divulgation of scientific knowledge, though useful and fundamental for the economic and cultural growth of a nation, is not enough to attenuate the negative perception of techno-scientific practice on the part of society in general. Instead, it is necessary to inform the citizens of the effects on society of certain scientific practices, both public and private, and to guarantee their participation in the process of assessment without expecting them to have a technical grasp of scientific practice and a consequent rational assessment of social, cultural and environmental effects. One does not need to be a nuclear physicist or a geologist to understand the level of risk involved in the construction of an atomic centre in an earthquake zone or in an area with hydro-geological problems, for example; instead, honesty is required on the part of the policy-maker to inform citizens of factors that make this action risky, offering an analysis of the consequences that evaluate not only the economic impacts of a certain practice, but also the social, cultural and environmental effects.

Therefore, one could claim that the democratisation of knowledge does not require informed consensus on the construction of means; instead, it requires a common determination of the ends for which the means, techno-scientific practice, are merely the tools. Otherwise, the prospect of a technocratic society looms, within which only those who have a strong grasp of technology would be able to decide and determine its implementation.

To this regard, in 2.3 we have analysed strategies aimed at modelling the relationship between the public and science. In particular, we have analysed the model of "public co-production of knowledge" that tries to balance the relationship between experts and non-experts in the direction of a common orientation of means towards shared ends. Although these strategies of 'interfacing' between the public and science assume that scientific divulgation is a necessary but insufficient condition for the democratisation of knowledge, it is necessary to stress the importance of the role of scientific divulgation as a tool with which to train citizens to develop a critical sense. In the concluding paragraph, § 2.4, we have tried to show the educational role of science, that, apart from the transmission of contents, possesses the most intimate dimension of civil cohabitation: the formation of a system of shared values based on the free exercise of one's own rights but aware of the duties that guarantee a peaceful and fruitful cohabitation

2.1 – Science, democracy and society in the history of modern culture

The close link between science and democracy has been one of the foundations of Western culture. In fact, the development of science in the Western world has been favoured by a democratic environment and by the possibility of a free exchange of ideas (Corbellini 2009, pp. 181-213; Taverne 2005, pp. 250-283). However, it must be said that it is the consolidation and diffusion of scientific rationality which allowed the embedding of democratic institutions. The founding fathers of the USA, for instance, who formulated the first world democratic constitution, had been strongly influenced by the environment and concepts of eighteenth-century science (Cohen 1997). The West has learned several important things from the ideal of rationality incorporated in scientific procedures: to place moral authorities and established cultures under critical scrutiny; to tolerate the convictions and ideas of others; and to believe in a united effort aiming at the progress of knowledge.

The method put forward by eighteenth century science – during the religion wars – allowed for the rejection of established authority. But such a rejection could not be established by further authoritarian claims, that is without a public debate. Eighteenth-century scientific rationality had also legitimised the idea that knowledge cannot be the privilege of a restricted elite. That is, eighteenth century thinkers were opposed to the idea that only a small group of "privileged" people could access knowledge through procedures that could not be made available to those who did not have the necessary spiritual prerequisites. Rather, knowledge started to be seen as something everybody could access and achieve through reason, which every human possesses and which is equally distributed among the population. Descartes' idea – according to which the power of judging well and distinguishing truth from falsehood, that is what we properly mean by "common sense" or reason, is naturally equal in all men – can be considered as a sort of "null hypothesis" which gives each man an equal starting point. From there, each individual can demonstrate the validity of his own convictions through his ability to put forward argumentations and defend them in a public debate, in which nobody should have a superior authority or rationality over the other participants and other people's argumentations. Kant's motto – "Sapere aude!" – is not just the motto of the Enlightenment; it is also the guiding idea of modernity that, by adopting it, has challenged established authority on behalf of a concept of knowledge which saw its model in Newtonian science. In fact, the latter was the paradigm of knowledge acquisition that best suited the modern idea of instrumental reason that established a continuity with the concept of rationality of the ancient Greeks.

As efficaciously argued by Yaron Ezrahi, in the modern age, metaphors drawn from science constituted the starting point for arguments, calling upon the idea of political freedom and the need for a model of social organization based upon a de-personalization of power. In fact, as with science, the power had to adopt forms of control which were analogous to those adopted by science; that is, it had to be employed according to common rules that would ensure transparency, inter-subjective agreement, and, consequently, growth by common assent and cooperation by public (at least in theory) debate (Ezrahi 1990).

The link between science and democracy has been underlined by many intellectuals, from Bacon to Karl Polanyi, from Weber to Merton, and from Dewey to Popper. Nonetheless – as we shall see – this link has taken unusual forms in recent times, during which the demands of democracy sometimes take precedence over the acknowledgement of the intrinsic rationality of science, which modernity received as a legacy from the Greek *logos* and from scientific Enlightenment and which had traditionally been scientists' common ideological framework.

In addition, the idea of an implicit agreement between science and society has always been part of the "received tradition" inherited from the Greek *logos* and thereafter followed up by modern science and the Enlightenment (Coniglione 2008, pp. 14-41). This harmonious agreement between science and society is so entrenched in Western thought, starting from the eighteenth-century Enlightenment, that it needs no justification. Therefore, scientists have not always thought it necessary to clarify and justify their choices and discoveries to a wider general public. It is even more true during the twentieth century that was a century of rapid technological advances in which people experienced the most drastic changes ever seen in the history of the world and in which the endless succession of industrial revolutions has radically altered both our perception of reality and our lifestyles, since electricity, TV, radio, and more recently the computer, the Internet, and finally biotechnology have become part of the everyday lives of Western citizens. This has helped science to gain widespread social acceptance since, with its technological implications, it has been mainly regarded as a resource for the continuing improvement of society.

Political institutions and governments quickly understood the importance of science for economic development and for their own political power, especially regarding innovation in the field of armaments; therefore, they have sustained the progress of science and technological research by providing unconditional support for scientists, thereby helping them to increase their prestige and importance in society. This has favoured a general circulation of a benevolent public opinion towards science, which has been sought as the main instrument for solving the problems mankind has always been subjected to, such as illness, poverty, and famine. Such an agreement between public opinion and science ruled over ideological differences, since even the most radical opponent to capitalist society – Bolshevik communism – saw with Lenin the future of socialism as consisting of the diffusion of both the soviet and electric energy. Marx himself understood how industrial development would have incorporated ever more knowledge, and he believed that science would bring about the reduction of work time and a consequent increase in the time (and space) that people could use for artistic and scientific development. According to this line of reasoning, it was techno-scientific development itself, if we understand it as instrumental to the production of society goods which cannot be reduced to private goods, that caused the overthrow of capitalism and the consequent advent of communism (Cini 2006, pp. 367-8).

Nonetheless, in time science has also shown its "demonic" face, so to speak, especially as far as scientists' commitment to the creation of war technology goes. Although it had already happened in a distant past (consider, for instance Leonardo da Vinci), the negative outcomes of science practice became a more evident problem in the twentieth century. Let us consider, for instance, the production of chemical weapons during War World I and then the creation of the atomic bomb with its effects of mass destruction, well represented by the annihilation of Hiroshima and Nagasaki. Hence it became evident that it was no longer possible to convey an image of science as an impartial endeavour free from human whims and cruelty. As Robert Oppenhaimer argued in the aftermath of Hiroshima, even «the physicists have known sin»; and the anguish caused to them by being responsible for the awakening of a Leviathan able to potentially destroy humanity led scientists to adhere to a manifesto promoted in 1955 by Albert Einstein and Bertrand Russell which was later countersigned by eleven other scientists. From the manifesto, the Pugwash (as the Pugwash Conferences on science and World Affairs, from the homonymous Canadian village of Nova Scotia) movement would emerge. The movement has thousands of subscribers today. Its main aim consists in reducing armed conflicts and looking for peaceful means for global security.

The importance of the movement mainly lies in the role its supporters ascribed to scientists who should not be considered as merely machines for the production of knowledge, unable to consider the consequences of their actions. Rather, scientists, according to the supporters of the Manifesto, must take part in public debates concerning the employment of scientific inventions and discoveries. This was a brand new role for scientists (Boutwell & Ionno Butcher 2009). To the idea of an unstoppable progress (no matter what), the Manifesto counterpoised a different concept of scientific development: that of going forward for the common interest of the human species. «Remember your humanity, and forget the rest. If you can do so, the way lies open to a new Paradise; if you cannot, there lies before you the risk of universal death»: with these words, the Einstein-Russell Manifesto would show its intention of taking into account the human factor in science decision processes as well as the necessity for evaluating scientific progress not just in terms of intrinsic criteria of rationality, but also in terms of the increase in public benefit. In this respect, the Manifesto marks the end of a sort of "pre-established harmony" going on between techno-scientific development and the wellbeing of mankind, between the increase of knowledge and the betterment of the human condition, since the essential requirement of the harmony, namely the equation "techno-scientific development = increase of market goods = social betterment", has been shown to be a delusion. And as has happened to governments in the past and to the Catholic church, the scientific establishment is progressively losing its sacred social role, since it has to account for its choices not only to those political (and military) institutions that had previously supported it, but also to the general public.

The end of the Cold War, with the decline of big military-industrial corporations and of their scientific teams in military-oriented projects seemed to determine radical changes: not only did these historical events seem to push away the spectre of an atomic war, but they also allowed for the conversion of military industry into civil industry which would free up resources that would enable mankind to face some of the more pressing (and traditional) challenges of humanity, such as food production, poverty, and public health.

Nonetheless, the "society-friendly" development of industrial modernization as described above has created new challenges which seem to be the direct consequences of the new technologies and their mass distribution through a somewhat deregulated market. It is those very successes of science that have generated new societal "alarms:" global warming and a indiscriminate exhaustion of natural resources; the reduction of biodiversity and thus the need to create instruments for its preservation; new ethical challenges such as the correct employment of biotechnology, the demarcation between life and death, that was once taken for granted. These are challenges that directly involve citizens not only as taxpayers but also as agents responsible for their own actions, and they cannot be solved by simply recurring to expert knowledge. They require the assent of the entire civil society which feels compelled to participate in the decision process and desires to do so. Policy makers cannot ignore the ever increasing tension between science and the public and the need to solve it for a positive cooperation.

During this "second modernity", there is a general awareness that we live in a risk society in which science and technology seem incapable of controlling the consequences of their activities as they give rise to new circumstances that cannot be dominated by old and traditional means and procedures (Beck 1992): so the scientist has become the metaphor for Goethe's Sorcerer's Apprentice, namely that of a person who practices powers that s/he is not fully able to master and thus is likely to cause collective and irreversible disasters involving all mankind. In fact, there has been a change in the way the public manifests its mistrust towards science, as shown by the environmentalist movement with the publication, in 1962, Rachel Carson's *Silent Spring*. There Carson exposed the possibility of the extinction of insects due to the overuse of insecticide, with the consequent massive disruption of the ecosystem (as in the case of DDT, which was subsequently banished). This increase of public mistrust in science in the late twentieth century is also a consequence of the increased awareness of the consumption and indiscriminate use of natural resources which should be available to everybody (Hardin 1968). To this regard, we should also mention the influential report by the *Club di Roma*, "The Limits of Growth" (Meadows *et al*. 1972); another important aspect is the growing awareness of the problem of overpopulation (Ehrlich 1968); and of course the very recent "global" awareness concerning global warming as the most pressing collective challenge of the new millennia.

The existence of a form of hyper-rationalism derived on the one hand from the exaltation of scientific reason as incarnated in both processes of production and their results, and on the other hand, of an hypermodern culture that has overestimated the traditional values of modernity (individualism, democracy, free trade, and techno-scientific development) to a state of paroxysm (Charles 2009), has as a counterbalance widespread mass irrationalism. This irrational attitude goes hand to hand with a typical narcissistic way of conceiving one's own existence. The coexistence of science and irrationality – of the internet and horoscopes, of iPhones and tarot cards, of technological medicine and Father Pio – has its root in the feeling of alienation and self-destruction which afflicts mankind nowadays. A sense of being defenceless against suffering and deprivation and of living in a contradiction between the idea that everything can in principle be possessed and the sad reality of our limitations in that respect (Lasch 1979).

In recent times, the irenic, reassuring view of science that was widely held by the public at large, and the paradigmatic role of rationality and knowledge traditionally attributed to it since the times of the scientific revolution, have become progressively splintered and questioned. This has not only happened because of the growing divergence between the science experts and those who are uninitiated in scientific matters; nor is it the result of the usual indomitable metaphysical philosophers, who, from the outside, have opposed science with methods of alternative theorizing, held to be more authentic. There has been, in fact, a deep transformation of critical awareness within scientific areas by the very people who should have guarded its virginal purity. In fact, there has been a progressive questioning and transformation of the epistemological frameworks within which attempts have been made to place scientific practice, in order to ground scientific research as the most disembodied and disinterested application of rationality, whose only aim was knowledge of reality (see ch. 3).

It is around this point that one of the most distinctive topics of our research revolves: in the fulcrum that holds together scientific modeling and research practices, epistemological awareness and politics of science. There is a growing conviction that it is impossible to understand and articulate a strategy with the aim of the construction of a "knowledge society" without first clarifying the ways, types, and levels of articulation of that scientific knowledge that will be placed as a cornerstone of a new, more democratically advanced society. Philosophy of science and sociology of science are the complex areas from which we have to start, in order to be fully aware of how models of scientific rationality have undergone a radical transformation in the past thirty years, a transformation that cannot be ignored if we do not want to condemn to unproductiveness every research policy that aims to keep up with the times.

But at the same time – and this is one of the convictions that we have nurtured during our study – it is necessary to find a point of equilibrium in which the "received tradition" of science that has been at the heart of western culture is not swept away by a radical questioning of it that, while quite rightly indicating the crisis points, at the same time abandons it completely, rejecting the elements that are authentically cognitive and progressive. And it is in the rift between the epistemological image of science and the concrete practices of research, between philosophical awareness of scientists and more and more elaborated scientific theories that must – in our opinion – be seen as one of the fundamental reasons for that crisis of the image of science in the world that many deem irreversible.

2.2 – Public opinion and science

For a few decades, National governments and International institutions have had an interest in the field of scientific research that is not limited to the mere promotion of culture but has been translated into concrete, direct actions that are more explicitly addressed to solutions to social problems and the improvement of the quality of life of society in general (see Gottweis 1998; Beckwith 2002).

The Lisbon Strategy shows awareness of the need to reaffirm the links between democracy, the public and science, because of the decreasing amount of resources invested for the progress of knowledge, and the fact that «the image that Europeans have of science is also less positive than it was. Scientific progress seems to inspire as much anguish as hope, and the gap between the scientific world and the people at large is growing» (EC 2000, § 1). Moreover, over the years, many other international institutions have underlined the importance of the democratic participation of citizens: the Aarhus Convention (see UN ECE 1998), Agenda 21 of 1992 of ONU (see NU 1992), the Biosafety Protocol of Carthage of 2000, to name but a few of the most important ones.

What are the reasons for this distrust in science? This feeling of distrust has become stronger and stronger because of the rise of new kinds of problems that have brought to the fore the notion of the "social acceptability of technology", that refers in particular to issues such as nuclear waste, genetically modified crops (see Borbone 2009) or experimentation using stem cells. The debates arising from them have been political, ethical and economic; and if we consider the active role carried out by citizens regarding topics in which human life on earth is at stake, it would be a great mistake to consider their reaction to be secondary or exclude them from scientific and technical matters.

> […] the great issues concerning health, the relationship with one's own body, illness, and the borders of life and death have become more open and problematic and concern individuals more closely, requiring a definition and public discussion. The redefinition that concerns the space of the competence of medical science seems then to have assumed a more general character and has become an indicator of a deeper redefinition of the relationship between science and public space, between science and personal experience, and between scientific knowledge and profane knowledge. (Melucci, Colombo & Paccagnella, in Guizzardi 2002, pp. 102-103)

The EU has long recognised the importance of a relationship of trust between public opinion and science in order to implement an effective science policy in Europe, in relation to the increasing importance this has for civil and economic progress, and this aspect has gradually gained weight in EU scientific and technological policy. Since 1977, the EC has carried out a series of projects on the topic "European Society and its Interactions with Science and Technology" (ESIST); in this framework, a survey was made on the relationships between scientific research and public opinion for the first time on an EC level. The first public report (see EC 1977), regarding the nine member states at that time and 9000 people interviewed, focalised on four main aspects:

- the advantages that Europe can offer for the future of research;
- the scientific activities that are considered to be priority
- the impact of these activities and their image in European society;
- public interest in science and scientists.

The conclusions were quite optimistic and homogeneous regarding age, level of education and political convictions:

> the poll reveals a very favourable climate of opinion towards science and scientific research. The general public see science as a central factor in the improvement of daily life and would readily endorse the statement by Francis Bacon at the end of the 16th century: "The true and lawful goal of the sciences is none than this: that human life be enriched with new discoveries and powers" […]. This confidence is neither naïve nor blind the general public believes that scientific discoveries can have dangerous effects but its general awareness of the risks does not shake its conviction that research must be supported because "there are still good things left to discover in science". (EC 1977, p. 85)

There followed almost unanimous support for funding of scientific research (81%) and greater EU commitment in this sector. Therefore, it can be stated with certainty that «as far as principles are concerned, there is no crisis of confidence with regard to science in European public opinion» (*ib.*, p. 87). The dissent and worries emerge only among certain groups of people (the natural pessimists, the intellectuals with ecological tendencies, those who expect only personal benefits etc.) and in any case, concern only specific, limited aspects that have no bearing on the general image of science and its essentially rational nature, favouring well-being.

However, over time, the concerns revealed in this first report increased and expanded, which became evident in the following report (see EC 1979) and subsequent ones that were published by the Eurobarometer (1990, 1993, 2001, 2005, 2005b, 2008) which were enriched by more specific surveys regarding the environment, energy resources, the society of information and so on.

The survey that marked a watershed and the beginning of a new movement of opinion was the one commissioned in 1985 by the Royal Society to a group of experts guided by W.F. Bodmer on the *Public Understanding of Science* (PUS) (see Royal Society 1985). The conclusions of the report, which noted the elements of distrust that already existed among the public and fearing that this could get worse, suggested a series of measures:

> A basic thesis of this report is that better public understanding of science can be a major element in promoting national prosperity, in raising the quality of public and private decision-making and in enriching the life of the individual. These are nationally important long-term aims and require sustained commitment if they are to be realized. Improving the public understanding of science is an investment in the future, not a luxury to be indulged in if and when resources allow. (Royal Society 1985, p. 9)

In essence, the conclusion was that «scientists must learn to communicate with the public, be willing to do so, and indeed consider it their duty to do so» (*ib.*, p. 6).

The PUS movement, which was created in the wake of the report of the Royal Society, was very lucky and had an interesting and articulated history that even today has profound repercussions in the debate on the relationship between science and the public. It triggered a great effort of popularising scientific knowledge (with the COPUS – Committee on Public Understanding of Science in England and the movement "Scientific culture and technique" in France). Besides, a magazine called *Public Understanding of Science* has been published since 1992 which deals with the relationship between science, society and citizens; the institutions of research are making their results more and more accessible; and there are more and more programmes of public involvement on the part of National and International institutions (conferences of consensus, science and technology weeks, science festivals and so on). In brief, it has become clearer and clearer that, for science and those involved in it, the relationship with society represents an area of interest and intervention as fundamental as the research itself.

The Royal Society report highlighted three fundamental dimensions at the basis of the PUS: culture, economics and politics. They all revolve around a common problem: how can an individual citizen, a lay person, knowledgeably intervene in issues of undeniable complexity that are usually the sole prerogative of scientists and experts in general? How can these people decide on issues that no longer concern abstract knowledge in areas that may have some tenuous link to everyday life (as in the case of research into fundamental particles or quark or esoteric matters like the unification of fundamental forces in nature, the theory of strings and so on), but affect the everyday quality of life, with tempting promises but unknown risks? Everyday we hear of climate disasters, highly technological pandemics, the destruction of the natural environment and – even more worrying – of the fundamental requisites for a healthy life, like clean drinking water, good food or pure air which are increasingly becoming luxury goods. In brief, there is the possibility that the perception of possible risks of new technological applications may also lead to a refusal of the reasoning that is at their basis and may therefore trigger a real movement of rejection of the scientific world and scientists: under indictment – not only by religions as usually happens, but also by the lay culture – the cognitive *hybris* that, unrestrained by opportune "moral values" would lead to the dehumanisation of man himself. In brief, the lack of an adequate understanding of science and its methods generates the danger of a return to irrationalism and fundamentalism, to trust in dogmas and ideologies and this is no less dangerous for democracy than the excessive power of experts.

> Reason is one of the foundations of democracy. If irrationality prevails and respect for evidence is rejected, how can we resist religious fundamentalism and chauvinism and racism and all the other threats to a civilized society? We become a credulous society ready to believe charlatans and risk sinking back into superstition and the savagery that

> prevailed before the Enlightenment. The building blocks of today's liberal democracies were laid in the seventeenth and eighteenth centuries, in the period celebrated by Roy Porter in his wonderful book *Enlightenment Britain and the creation of the modern world*. It is no coincidence that this was the time when modern science was born. Indeed, science was the chief progenitor of the Enlightenment. Both science and democracy are based on the rejection of dogmatism, and whenever and wherever ideology rules, freedom as well the evidence-based approach is suppressed. (Taverne 2005, p. 10)

The failure to understand the limits, but also the cognitive value of science, carries with it the risk that at the end what will prevail will be the constraints of politics and the market, that not only have little to do with disinterested research, but often assume a post-modernist vision of science (on this see § 3.5) as a tool to support lobbying interest or political options in the form of religious or ethical fundamentalism.

To this we can also add the danger revealed by Bourdieu (2001) when he refers to science as a dog that bites its own tail: having yielded to external pressures that require ever newer tools and new knowledge able to transform the world, science has ended up by becoming dependent on the logic of the market, making commercially exploitable patents the cornerstone of its activity, and in doing so threatening the development of scientific knowledge (regarding this see § 3.5).

This has led to a transition from PUS to PEST, that is Public Engagement with Science and Technology. It has been realised that considering that in actual fact, the citizen is not directly in contact with "science" in itself but with its products, the important thing is not so much communicating scientific information, but having trust in science and scientists. Especially if we think how science has become a dispenser also of uncertainties and how it risks being subordinate to the constraints of politics and the market. The consequence of all this is that the fears of the European public regarding science and its derivatives can compromise not only innovation but also the economic benefits that can derive from it. The consequence of all this is that the fears of the European public regarding science and its derivatives can compromise not only innovation but also the economic benefits that can derive from it.

> In the first place, the public is unaware of the countless cutting-edge breakthroughs that science has made and its methods of research and investigation. Secondly, people tend to assimilate only what interests them most, what they like and what is immediately useful. Following these tendencies, it is quite understandable that the public may also accept some suggestions with no scientific basis or, on the contrary, may reject outright some aspects that have, instead, a strong scientific basis. (Dulbecco 2004, p. 68)

Despite the efforts made by the various nations to try to overcome this diffidence, citizens often continue to mistrust information that comes from the various scientific agencies, though they appear to be above suspicion. In this sense, the Chernobyl episode is significant and its effect was the reformulation of the problem with new and richer questions on the new scenarios proposed by science. We only have to think of the new actors who intervene in scientific debates, normal people who see their own interests damaged and feel the right to speak out in order to change the existing situation.

The EC is also more sensitive to this issue and believes it should intensify its efforts in this area: on 16 November 2000 the EC Commission, referring to its resolution concerning the constitution of ERA (see EC 2000b) and previous documents (see EC 2000e, 2000d, 2000f), pronounced a resolution in which it,

> SUPPORTS the need to make the debate on the role of science in society more profound and to assist public decision-making by strengthening links between research policies and the needs of society, including the ethical dimensions of progress; REITERATES the importance of the Commission setting up an independent advisory body to boost the effectiveness of European RTD policies; NOTES the essential contribution of the human and social sciences and the need to improve tools for the dissemination of scientific and technical information and to enhance scientific and technical knowledge. (CEU 2000, § 11)

The White book on governance recalls, in general terms, the importance of these issues (see EC 2001), which raise the question of the opening, participation and responsibility of the citizen, mentioning the problem of people's trust in experts, particularly regarding moral problems created by technology. «The importance of informing people and policy makers about what is known and where uncertainty persists» is highlighted since:

> Public perceptions are not helped by the opacity of

> the Union's system of expert committees or the lack of information about how they work. It is often unclear who is actually deciding – experts or those with political authority. At the same time, a better informed public increasingly questions the content and independence of the expert advice that is given. (EC 2001, p. 19)

An Action Plan follows on the subject of the relationship between science and society (see EC 2000f, 14 December) presented on request of the Research Council in June of the same year, also intended to contribute to the Lisbon Strategy, as one of the pillars of EC strategy is to «promote scientific and education culture in Europe» so that people can acquire greater familiarity with science and technology; to this end, it «is also necessary to to promote dialogue between science and society» and that

> the relationship between science, technology and innovation, on the one hand, and society, on the other, must be reconsidered. Their activities need to centre around the needs and aspirations of Europe's citizens to a greater extent than at present. In particular, in future, women must be able to participate more fully in science, and science must anticipate tomorrow's issues. (EC 2001f, p. 5)

To this end, a series of actions aimed at favouring a better dissemination of scientific information have been proposed (including the institution of "Science weeks") and improvement in the education in the scientific field, in the dialogue between the scientific community and citizens, in the involvement in civil society in choices through public debate, forums and so on. To respond to the increasingly insistent demand for greater dialogue between policy makers and civic society on topics linked to science policy, the EC subsequently commissioned also a study on governance (see Banthien *et al.* 2003).

There are two aspects that we can add to these studies and official documents: concrete support for research that gives further indications to this regard or provides further elements of knowledge, and also the afore-mentioned constant monitoring of a statistical nature carried out by Eurobarometer on the relationship that Europeans have with science and technology and their attitudes.

To this regard, we should mention the qualitative survey carried out for the EC by the Eurobarometer in the 27 Member states, which brought to light the opinion of the so-called "profane" on R&S, providing new ideas for the communication of science in the near future (see Eurobarometer 2008). The result of this is that most Europeans interviewed confirmed what had emerged out in the previous investigations: the image of science that comes out is that of a "two-faced Janus". This can be summed up in the words of a Greek citizen: *"science is a potent tool that can be beneficial or catastrophic*"; or in the words of a Bulgarian: "*It is not scientific results that frighten me but their application…*". In general, research tends to be read as "positive" when it is aimed at the progress of medicine or the environment, and "negative" when it brings risks, as in the case of GMOs. The economic implications must not be ignored, as science is not immune to them: *"the problem is not research in itself, but the capitalist spirit that does not provide for anything that is not aimed at profit"* (Lithuanian citizen). But what counts more for our ends is that almost all those interviewed maintained that the content of communication must be as close as possible to the everyday life of the person, that is, it has to deal mainly with topics such as health, medicine and the environment and be presented in a concise, practical and comprehensible form, avoiding specialist jargon and institutionalised language. *"The key point is to give information in language that is clear and interesting even for lay people*" is the conclusion of a European from Latvia.

Another particularly interesting aspect for the EC regarding these issues is represented by the research on science and governance it commissioned in June to a group of experts in STS, led by Bryan Wynne (see Wynne *et al.* 2007). As Mariachiara Tallacchini, member of the nominated Expert Group claims, «the mandate of the Director general for Research of the EC was to analyse the rising sense of unease that pervades the interactions between science and society and to explore ways to develop constructive relationships between techno-scientific expertise and the fears of the public in order to establish the most effective governance in Europe» (Tallacchini 2008b). Besides providing a clarifying and at the same time provocative reading, this report is important because for the first time in a European setting, the conceptions of STS scholars are set out in a systematic way:

> in the cultural panorama of the EC, the viewpoint of STS was missing; no report had ever explicitly dealt with the perspective of Science and Technology

> Studies. […] the idea was to present at the same time a variety of subjects that were set out as STS and to respond to the questions contained in the mandate of the Commission: why citizens are seem so averse to science, why they do not trust science and scientists and what can be done about it. On the one hand, we have tried to appeal to the principle of auto-reflexivity of institutions. Our thesis, in fact, is that the public's fear of science is not the fruit of a knowledge deficit but the perplexity that citizens nurture towards institutions; the problem, therefore, concerns more the policy and the way in which the discourse between science and society and science and institutions is imposed. (Tallacchini 2008b).

With this the prevailing limit of the conception of PUS emerges: that in order to explain the nature of the distrust of public opinion towards science, the so-called "deficit model" has been accepted, according to which it is the absence of familiarity and knowledge that nurtures an irrational feeling towards science and its technological applications. There follows, as a remedy, a massive operation of divulgation and acclimatization of scientific contents and the presentation, in a favourable light, of the researchers and their work, so as to dissipate the idea that they are "dangerous" (as suggested in the title of the work by Corbellini 2009).

As regards the first aspect, the report *Taking European Knowledge Society seriously* (Wynne *et al.* 2007) stresses the fact that mistrust of science is as much due to a deficit of knowledge on the part of the public as to a lack of trust in the institutions responsible for managing science policy. This conclusion was reached in Italy with the recent report *Observa*, which refutes the idea that «adhesion to a positive vision of the scientific world is directly connected to an elevated level of exposure to science in the media» and that, despite the positive judgements on science, the most critical point concerns not so much trust in science without further explanation, «but rather the organisation of scientific activity and the practical ways with which the priorities are defined and the resources managed» (Arzenton & Bucchi 2009, pp. 16-17), since one Italian in two is convinced that the world of research is significantly governed by the logic of the market and economic interests (*ib.*, pp. 19-20).

Research has shown that, though the public has a rich knowledge of snippets of science, and they are able to distinguish between applications that are useful and those that are not, the seed of distrust is nurtured not so much by the results of techno-scientific innovation but by the ways in which these innovations are carried out and the behaviour of institutions responsible for the innovations, the management of risks and the involvement of the public (Wynne *et al.*, § 5.5). The most shocking example of bad management of risk and its presentation to the public comes from Great Britain with the case of Bse or "mad cow disease". Though the British government had been aware for some time about the risk of the virus spreading, also among other species including humans, they avoided divulging the news; it was held to be essential to hide the risk because the economy of the country was at stake. So, if on the one hand, in May 1990, the then Minister for Agriculture John Gummer considered putting down all infected herds, on the other hand, he spread good news about the health of those very same herds through the media, and images of his daughter eating British meat were broadcast on live TV. «His performance combined two old repertoires of trust: a father who feeds his daughter and the state, *in loco parentis*, that reassures its citizens through public demonstration of trust» (Jasanoff 2005, p. 305). Obviously, when this ambiguous behaviour became known, the consequence was the collapse of trust of the British in the institutions that should have provided guarantees. It took a long time to rebuild that trust; people became to have faith in the government again only after the investigation opened by Blair in 1997, with which it was discovered that the British experts involved in Bse «had behaved like an unforthcoming community with limited vision» and had been «very reluctant to reveal their uncertainties to citizens that they considered to be irrational and prone to panic» (*ib.*, p. 150). A different way of behaviour would certainly have alarmed the population but that would have been preferable to hiding the truth, also because panic rises not so much for a fact that is dangerous in itself (when the information about it is verified) but from the fear that there is a hidden truth that has not been said and is much more serious than what is known, causing a "precautionary" reaction, exaggerated and often without a motive. Panic is always the fruit of an irrational reaction to an impending danger, threatening and unknown and therefore terrifying.

From these investigations it follows that the traditional distinction between science and the use of science is endorsed by public opinion; a distinction that instead is hotly contested by STS theorists and critics of postmodernist and relativist scientific rationality. Besides, this gives substance to the theory already expressed by Stilgoe, Wisdom & Wynne (2005), according to which another reason for mistrust is linked to the fact that too much weight is given to the "hardware" assuring the participation of people (methodologies, focus groups, citizens' juries etc.) with the inevitable "industrialisation" of its functioning, while instead:

> The focus should shift more to the "software" – informal codes, values, norms – that governs scientific and policy practices. This software or cultural dimension is more pervasive, less visible, escapes design, and is harder to change, but nevertheless seems to be a key to the issues involved. (Wynne *et al.* 2007, p. 60)

Finally, the fact is underlined that consent should not be seen as the determining element of participating exercise, since dissent could also be seen not so much as failure of agreement, but as «a vital form of keeping public engagement with science authentically alive and not under the control of agents whose own culturally embedded assumptions, imaginations and practices may well be part of the problem» (*ib.*, p. 61).

The conclusion according to which the problem has shown itself to be not only the scant acquaintance with science, but instead the scarce trust that the authorities of policy and scientific matters have in the public, has led to substituting the "paradigm of scientific divulgation" (that of the PUS) with that of "dialogue and participation" or the so-called "Public Engagement with Science" (PES). However, the modalities and types of involvement of the public are still unclear – at least in the field of directives and initiatives of the EC (*ib.*, § 5.3).

However, we believe that it is not possible to overlook the problem of divulgation and scientific communication.

2.3 – Divulgation and communication of science

As we have seen, the immediate consequence that derives from the model of "knowledge deficit" of the PUS is the need for an energetic operation of divulgation and presentation of results of science to a lay public. The report of the Royal Society was full of recommendations and proposals to this regard: better teaching of scientific subjects in schools; intervention of the mass media (with more and better quality programmes on scientific matters and an increase in the number of scientific pages in papers and magazines); the organisation of public conferences in museums and libraries; the involvement of industries to improve the level of preparation of their employees and researchers; and above all, a pressing invitation to the scientific community to take on the task of communicating with the public in first person, and to learn the techniques and the most opportune ways for an effective transmission and understanding of their research:

> Communicating science effectively to the public can and should be taught formally to all professional scientists. **Opportunities should be provided throughout the formal education period for gaining experience in explaining science simply, without jargon and without being condescending. Every Ph.D. candidate, for example, should explain the essential background and nature of his or her thesis work to a lay audience in the form of a short written article or lecture**. (Royal Society 1985, § 9.42 – bold characters in the text)

Cerroni recommends a change in the mindset and professional figure of the scientist which still exists today:

> the training of the scientist must now go beyond the reproductive paradigm ("for the scientist") in which it was centred on the traditional pre-requisites, such as the transmission of specialised knowledge, the trustworthy replica of professional figures, the complete diffusion of accumulated information, the certainty of the techno-scientific expertise of the teacher, the correspondence to professional requisites of the explicit formulated demand (perceived) and so on. The scientist's training must always move more towards a *paradigm of innovation* ("for the citizens"), and go in the direction of focusing on creativity, on a critical/autocritical spirit, on responsibility and awareness of the role of science in the economy, the society and culture. The new training must start from the idea that also the scientist is a citizen (and therefore needs an adequate civic education) and a citizen who is institutionally given a key task in society, that is, in the life and work of everyone, to generate new knowledge that must be shared. (Cerroni 2006, p. 153)

Considering what has been said, are these measures sufficient for the aim that has been fixed? Or do they constitute only one necessary element that must be further integrated with other provisions and interventions?

Further reflections arose from the analysis of reports produced after 1985, particularly recent ones, such as the third report on Science and Society prepared by the House of Lords (2000), which underlines the limits of scientific information seen as a flow in one direction, from science to the public, without a corresponding listening to the needs and the sensibilities of this public of users. In fact, despite the efforts made to raise scientific literacy in the UK – for example, through special funds and organisations like COPUS, not only do people continue to have scant scientific knowledge but there has actually been an increase in aversion to research.

However, issues of method were dealt with at the *Science Communication Conference* (14-15 May 2007), organized by the BA (British Association for the Advancement of Science) and the Royal Society. At the conference, seven crucial points were identified with which to open the debate on the issues in question (see Wild *et al.* 2007). One of these stands out in particular: the important role attributed to the media, considered in this historical phase to be the best way to stimulate the social commitment of citizens, as they promote the "dissemination of ideas" and the development of debates. However, these possibilities have been left to their own devices since – as shown by the panel of scholars consulted by the Royal Society and the BA – commitment and participation in the cultural life of a country seems to have been dismissed by many scientists who «see research and scientific discovery as a first priority followed by teaching. Knowledge transfer is somewhat important, but public engagement is low on the agenda» (*ib.*, 2007, p. 4).

However, the work we have carried out over the past two years has allowed us to make some observations and work proposals (see Coco 2009). In fact, we are convinced that if we want to carry out a series of reflections and especially a serious work that will make a difference, regarding the problem of science and society it is important to set up a *laboratory* for the investigation into the problem and its modeling. This is because this kind of work cannot remain on a purely theoretical level but must exist in a continual counterpoint between what is estimated by the models and what is experimented with in practice. The theoretical actions undertaken so far have not had – at least in most cases – effective results because insufficient experimentation has been carried out in the context in which they should have operated. In order to produce useful actions starting from theoretical models, they should ideally pass through a phase in which planned actions can be tested and corrected from a methodological and procedural point of view

2.3.1 – *The many faces of a relationship*

The promotion of a "harmonious interaction" between science and society constitutes a general task. However, so as not to create confusion, it should be articulated in such a way as to identify the ideal ways to realise it. In fact, the relationship between science and society shows different aspects and lines of intervention.

1. *Consensus and financial support*. The idea that science needs a good dialogue with society in order to obtain the required funding is now pretty well rooted. Mistrust and scant participation on the part of the citizen slow down (and can even block) scientific activity, making it difficult to find funds and encourage the legislator to place vetoes or involuntarily favour economic lobbies. The presence of institutional or private subjects that set themselves up as the moral authority by dedicating themselves to intensive propagandist proselytising (in fact, they are able to recruit a vast consensus) means that scientific operators and their protectors (democratic forces present in the political and administrative fabric) need to produce and sustain opportune information to counterbalance the irrational wave that in some cases animates protest movements. Consider, for example, the issue of stem cell research or recent regulations that, by allowing laboratory techniques to be patented, in fact favour limited economic groups and make basic research in other contexts more expensive and difficult.

2. *Democratic participation*. The pressing need on the part of the citizens for a democratic participation in the choices regarding scientific activity cannot be put in practice without correct scientific information; otherwise they will be marginalized from the debate and if they are not, they risk having a negative effect. But, as a matter of fact, the citizens are not well informed: their positions often revolve around sparse journalistic notions and not on real knowledge of the objects of study

which they called on to intervene. For example, what percentage of the public are correctly informed about the real possibilities and risks of energy sources: solar, wind, nuclear power or fossil fuels?

3. *Economic development*. A good relationship between science and society creates economic development: this is the idea behind the entire Lisbon Strategy. An up-dated society and a higher quality of human capital (see § 1.2.2 and 5.6) generates enterprises that are more nimble and flexible, less polluting and more productive. But how can a citizen "invent" an enterprise that, for example, puts video material produced by Internet surfers online (as in the case of YouTube) if he or she does not know that today the servers and the latest generation software allow you to do so very cheaply? This is just a banal example as it deals with a kind of scientific information – information technology – that is among the most widespread, unlike many other forms of scientific information. But the same can be said of many others. The general sense, apart from the example, remains valid: how can a citizen create a business that requires scientific or technological progress if he or she is unaware of it? How could Thomas Alva Edison have set up the *Edison Electric Light Company* in 1878 if he had not invented the light bulb himself? As we will see (§ 5.3.4) when a discovery leaves the laboratories it is more likely to become an economic resource or development factor thanks to the spirit of initiative and creativity of the citizens

4. *Science as culture and human capital*. By becoming culture, science contributes to the development of human capital: as we shall see better later, this is a precious resource (see § 5.6). Phenomena such as the non-development of talents or insufficient expenditure on cultural and scientific activities, the brain drain or the absence of social recognition are among the causes of the impoverishment of human capital of a country; the inevitable consequences of this is a negative effect on economic development, quality of life and the interpersonal or public social relationships of a territory (Becker 1964; Foray 2000). However, it must be added that science is not a cultural object that is widespread in itself but becomes so through a process of sharing and transformation that equips it to respond to the social and intellectual requirements of the country. To this regard, there have been some interesting efforts made to integrate modern theories on genetic and evolutionism (that may discredit the previous views stirred up by a genetic reductionism of the radical matrix) in the policies of multi-ethnic cohabitation and integration fostered by the EU and the individual states (Coco 2008).

5. *Science as a narrative heritage* Each society has used narratives of reference to some degree to construct shared values. The lives of exemplary figures, experiences of famous people, history in the near and distant past and even news stories form narrative material starting from which the subjects can testify their personal scale of values, comparing it to figures who appear to merit our trust and are appealing. In particular, young people tend to imitate figures who, in their opinion, have a story that is rich in values and success (economic, social, existential, etc.). For some time now, publicists and politicians have been aware of the importance of offering the public the history of the product when in search of supporters (buyers, voters etc) (Salmon 2007). For example, the popularity and esteem that Edison enjoyed among the young Japanese is due to the wide diffusion of biographies that – in the form of books, news articles and even cartoons – transformed him into a real idol to be imitated and a reference point: «Thus, several generations of Japanese children have had numerous occasions to become familiar with stories of scientists and engineers» (Shigeo 1999, p. 125). By no means static, the construction of Edison's biographies in Japan followed an evolution adapting the story of the inventor of the light bulb to the evolution of the times and society. The biography of the man of science thus became a mirror of the society in which it was constructed, but also contributed to the construction of a certain sensitivity, of a way of seeing science, of a more or less widespread image of science:

> Biographies of scientists or engineers can effectively communicate to the public the value of science and technology and the reason why science and technology should energetically be promoted, in a quite concrete hence impressive way, that is, through describing how the scientist or engineer studies and works, and how he or she spends every day with family and friends. The value and significance of promoting science and technology, which are expected to be learnt by the public, crystallise in the life of a hero or a heroine. A number of people are hence inspired with a new image of science and technology, and are encouraged to support the new

> science and technology policy. Furthermore, some are encouraged to be scientists or engineers by reading biographies. (*ib.*, p. 133)

2.3.2 – *The "construction" of the public*

When faced with the many different aspects of the relationship between science and society, we have to carry out a series of strategies that cannot be simply reduced to divulgation in the classic sense of the word, as imagined in the report of the Royal Society or in the subsequent EC documents and publications.

As regards information and democratic participation, we must underline the need to abandon the old single directional model of *education of the public* in favour of the development of a two directional interactive model of *dialogue and public participation* (see Callon *et al.* 2009; Felt 2002), in which science is open to dialogue/debate with public authorities, industry and citizens: the so-called model of *public coproduction of knowledge*, that has different names and has been widely diffused in recent times, especially in the STS literature. The following expressions are common: "citizen involvement", "stakeholder engagement", "participatory technology assessment", "indigenous people's rights", "local community consultation", "NGO intervention", "multi-stakeholder dialogue", "access to information", or "access to justice" (Einsiedel 2008, p. 173).

However, in this relationship, we must underline that the concept of "public" cannot be characterised in a monolithic way: it takes on different meanings depending on the contexts, times, places, and interests that the citizens express and can make them part of the diverse "publics" depending on circumstances and situations. And this is important in the extent to which models of analysis are elaborated, on which to build concrete actions (political choices, cultural and educational products etc.), that depend both on the objectives that are fixed (and therefore the objects and tools that are set) and also on the public to which it refers. It seems to us that the most relevant types of heterogeneity are formed by the *variables within a geographical area* (the public varies according to age, tastes, abilities and so on) and *the variability between different geographical areas* (despite the process of cultural integration promoted by the EU for several years, we must not underestimate the diversity between citizens of different member states). The action models proposed should consequently be thought of as general models to be adapted from time to time to the context in which they should operate.

Clearly, if – within an approach that is still traditional (uni-linear and diffusionist) of the public-science relationship – the model to which we refer is a prototype of the *Hollywood style romantic film* we do not need to make a lot of adaptation to make it perceived by a transversal, heterogeneous public. Now, this public shares a wealth of references and tastes that allow everyone to understand and appreciate a brilliant show. However, when we construct an *object* that has not yet been tested (for example, an interactive exhibition or even better, a TV programme with debates on scientific issues), then we have to consider the possible diversities in the audience; a problem that forces us to structure the programme in a different way. For example, it is clear that British viewers are much more accustomed to prime-time documentaries and cultural investigations than Italian ones. For this reason, the question of the audience is very important and must be given due consideration.

Still on the question of the public, it should be noted that no kind of interaction is possible, either unidirectional or bidirectional, if the citizen is not in tune with the subject. This is an obvious premise but absolutely necessary when people are faced with scientific statements that may be antithetical and contradictory. The risk is in these cases that they may find themselves faced with what the pragmatics of communication call a *paradoxical injunction*, as the community of scientists itself is divided in some areas by opposing arguments (for example: *GMOs are dangerous/ GMOs are not dangerous*). The citizen who does not have critical tools at his disposal and who is unable to contextualise epistemologically the different opinions (assessing the level of approximation, the area of application, the advantages and disadvantages and the level of risk associated with it) risks falling into a condition of stalemate, from which he can come out, as in the homologous cases seen in psychotherapy, in three different ways: he may withdraw into himself, paralysed by the fear of not being up to the task; he may succumb to a violent reaction caused by stress due to the contradiction; he may pull himself out of the paradox by critically intervening in what is happening.

Worse still, he may choose one of the options present in the field on the basis of a fideistic option for that part of the scientific community that best fits his vision of the world and political preferences. In this case, he would privilege the opinion of the group of experts that adapts best – through a selective mechanism of a Darwinian type – to his own convictions, or even worse, to his own interests (economic, cultural and religious). Indeed, this happened with the Bush administration in the USA, as numerous studies have shown (Grant 2007; Shulman 2006; Mooney 2005). It is not a matter of hypothesizing a conscious, voluntary distortion of "facts" on the part of scientists and experts in bad faith (that may indeed happen, but that is not the point), but we want to underline the need of the awareness that the more complex the issues, the more they have the character of "frontier science" (see Nickles 2009; see also § 5.1); indeed, the methodologies of assessment and the underlying epistemologies have wavering borders and allow a wider dispersion of opinion amongst experts. There have always been scientists who support unorthodox theories (and sometimes they are essential for the progress of science), but today, in fields such as global warming and GMOs, it appears difficult to reach a unanimous or even majority viewpoint since it is not difficult for the policy-maker to select – even in good faith – the positions that he prefers, perhaps supporting his choice with the most up-to-date and culturally equipped conceptual postmodern and post-positivist tools (see Di Tommasi 2009).

The experience of the *science wars* of recent years (see J.R. Brown 2001) gives pause for though; they lead to a debate on the limits of the reliability and correctness of scientific theories and the possibility of trusting the predictive models that, because of their abstract nature and necessary simplification, seem to be too far from the concrete evolution of complex systems that are their object of study (and this happens in particular in the field of assessment of climate change). This is a very delicate question because it moves on a narrow, slippery ridge from which one can fall into either an a-critical and unreflective acceptance of the new postmodern philosophy of science and of the new sociology of postmodern science (the danger pointed out by us in § 3.6), with the consequent possibility that any political choice is justified through epistemological and sociological backing that is made legitimate thanks to the most up-to-date acquisitions of meta-scientific knowledge; or, one could fall once again into a claim for the need for scientific progress and investment in R&S, a-critically entrusted to the power of scientists and therefore any possibility of public discussion has been removed, creating the dominion of technocracy and thus justifying the accuses of "scientism" that are more and more frequently made by intellectuals and philosophers fearful of an overturning of traditional values and identity.

As we will see in § 4.5, a more balanced view of science cannot – in our view – ignore an adequate appreciation of its modeling and idealising character, the profitable effect of which could be seen recently in that discussion on the epistemological and cognitive value of the previsional models in the area of environmental sciences effectively begun by Naomi Oreskes (1998, 2004; Oreskes & Belitz 2001; Oreskes *et al.* 1994). And this has revealing consequences on the way in which society, the public and policy-makers must face crucial choices for the lives of the citizens and the well-being of society: the awareness of the prescriptive and previsional limits of the models must not form an alibi for what has not been chosen. The times of politics cannot wait for the times of the formation of universal consensus among scientists, if indeed such a thing is possible; political decision cannot hide its own fears or its own interests behind the need for a mythical "sound" science with no uncertainties. Then, it is necessary that on such controversial issues one intervenes with knowledge of the cause and the public should be accustomed to conceive not of a *"scientia triumphans"*, able to celebrate only its own successes and honours, but a knowledge that is substantially imperfect, with limits of application and areas of uncertainty that present risks and advantages and whose choices are not neutrally subject only to the judgement of Minerva, but must also take account of interests, values, hopes and future prospects of those who are directly called on to suffer the consequences. For these reasons, the task of intellectuals and scientists should be, in the words of Oreskes, to «feel obliged to invite people to discuss uncertainties openly. And the more politically involved the issue, the more essential it is that these uncertainties are articulated clearly, freely and in a language that everyone can understand» (1998, p. 1458). From this, the need arises to provide citizens with not only scientific knowledge but also with sufficient analytical and critical tools so as to allow them to enter a dialogue and exercise an active judgement on the results of science. Therefore, as a minimal condition, we need to make sure that

> non-scientists (and non-philosophers and non-sociologists) […] should be able to distinguish obviously bogus from valid arguments and to judge between claims based on careful assessment of evidence and manifestations of a sham reasoning, which uses evidence selectively and unscrupulously to bolster prejudice and goes through the motions of inquiry only to demonstrate some foregone conclusion. (Taverne 2005, p. 10).

This means establishing a fertile, essential albeit fragile equilibrium between an empathetic approach to science and awareness of its limits; between its acceptance as a model of reason (the Enlightenment tradition set out in § 2.1), and its partial nature (it does not know everything in "extension", does not penetrate everything in "depth", does not have absolute "precision" and is not deterministically limited to a single evolution path, like a railroad track leading it – in Koyré's words – "from the world of approximation to the universe of precision" – see Koyré 1961); between the recognition of its cognitive and progressive nature (what we know today is more than what we knew yesterday) and the acceptance of the fact that it is impossible to exhaust the whole of the real only by its means: in the words of the pagan Simmaco (384, § 10), but regarding nature (and not God), «*Uno itinere non potest perveniri ad tam grande secretum*» (it is not possible to reach such a great mystery by only one path).

2.3.3 – *The "construction" of the object*

The actions made to transmit among citizens critical tools and empathetic sentiments towards science make use of the wide network of areas and ways highlighted in this report. Besides, regarding the actions already proposed and those that will be illustrated later on, we believe that attention should be paid to the construction of *objects of culture and entertainment* aimed at transmitting scientific topics, to stir the interest of the wider public in science and rational thought, to stimulate the creativity of the user in order to make him active in the cultural and social life of his territory. These objects take different forms: books, videos, theatre, exhibitions, CD ROMs, Internet sites etc. However, if they are to be efficient, they must avoid slipping towards both scientific divulgation that is not very discerning and therefore imprecise and banal, and the didactic tool in the classical sense that – as stated above – risks not being stimulating for the public, and even risks arousing feelings of aversion towards the subjects transmitted.

What should these objects of culture and entertainment be like? After the wonderful experience of Marcus du Sautoy – professor of mathematics at the University of Oxford – in a Senior media fellowship for the programme "Maths for the Masses", two points have come out that could provide the reasons for the negative correlation registered by the House of Lords between scientific literacy and support for research: the topic must seem "sexy" and people want a story.

These two points appear more intelligible if we reflect on what contemporary science is like. In the past, part of the scientist's work consisted in writing great essays which were also appreciated by the public at large; this was done in a much more substantial and consistent way than today. Instead, today, science, exasperated by the increasingly stringent and rapid ways of our times, has reduced its communications to the brief space of articles for specialised periodicals. Though this way increases the speed and diffusion of data, it risks removing a great deal from scientific enterprise: its philosophical guise, its human content and humanist dimension. Science loses the function of global reference, its role of great guide in human reasoning, to be reduced merely to a sectionalised, practical tool. In this way, if we want to know which neuron cells cause pain, we ask the scientist; but if we want to know how to face the pain of life, here the scientist is presented as one who is unsuitable, who lives in a Iperuranio of mathematical formulae and cannot find his bearings in feelings and the needs of the human soul. In this case, it is better to go to a priest, or to find his secular substitute in the form of a psychoanalyst or in philosophical practices.

But that is not all – if we take up again what was said before about science as a tale and the importance of biography, we feel that in order to involve the public *science must make itself into a story and promote the emotional interest of the interlocutor.* Actually, science has never been able to get out of this task. In order to draw the attention of colleagues, to get funds (as much in the times of the great kings and queens as in today's European framework programmes), to reach the *status quo* that precedes the revolutions (both great and small) theorised by Kuhn, every intellectual enterprise – and therefore, also those that invest in strong sciences – has to talk about itself to a public of experts and otherwise. They have to make themselves understood; they have to make the interlocutor interested, like Volta did for the invention of the battery (see Pancaldi 2003).

The emotive data becomes even more decisive when addressed to a non specialist public. The assessments that emerged from the BBC scientific committee concerning a successful programme dedicated to climate change, called "Britain under Threat", presented by Sir David Attenborough, agree that one aspect should not be neglected: the great popularity of the programme and the strong mobilisation on environmental subjects it activated in the viewers is proof that "although people like programmes that encourage reflection, they do not want to be educated". Therefore, it is necessary that the object is constructed paying attention to aesthetics and a "strong narrative" (Wild *et al.* 2007, pp. 48-49).

Much can be said about the role of narrative in scientific enterprise. We could add some more on the reciprocal influences between science and literature (see Holmes 1991; O'Hara 1992; Rouse 1990; Roger 1975). Here, for the sake of brevity, we will just remember that texts like Galilei's *Saggiatore* , Benoit de Maillet's *Telliamed* or Darwin's *The Origin of Species* were cases of great publishing success that had a lot in common with literature. In brief: in order to make itself known, science must tell a tale and in doing so, paradoxically, become "sexy".

Who should promote these *objects*? Where should the laboratory be prepared to make them? We are of the idea that the ideal place to set up a laboratory like this is the university. Given the many different people who use it (teachers, researchers and students) and the possibility to link realities, public and private subjects, the university offers the best conditions in which to realise *cultural objects* with the characteristics we have outlined: precision of contents, research dedicated to the most opportune ways to proceed; investigation and experimentation on language; tests on a diversified public; and possible financial promotion.

This last aspect must not be neglected. Not only since we have to stop considering cultural initiatives *a priori* as financial drains, destined to survive only thanks to support on the part of public bodies (increasingly forced to go into hiding), but also because, just in a time when the funds for research are more uncertain (especially in the field of human sciences), the construction of *cultural objects* that are able to answer to the market requirements may become an economic contribution for more serious humanistic research (with a limited budget).

Matt Ridley, English author of famous texts on evolutionism encountered great success in different areas: both in the academic field and with the general public. The profits from ten years in publishing enabled him to participate with a significant quota in a company that deals with the planning and management of a science park whose balance sheets – cultural, educational and economic – are very positive. If a university team or a committee of interdisciplinary work had promoted such an initiative, now the resources matured would be active in the academic context.

2.4 – The interaction between the public and science

Several instruments have been proposed with a view to the model of dialogue and participation of the public, and forms have been suggested in which they have tried to implement this interaction. In this case, this means going towards a model that has been defined as "public co-production of knowledge" or also "co-production of science and social order" (Jasanoff 2004): citizens and interest groups are actively involved in the production of knowledge that is directly useful for them (some interactions between scientists and non-experts can become permanent, contributing to the construction of a relationship of trust and reciprocal learning, through the joint work in hybrid collectivity). The knowledge created in the laboratories remains central but it is generated within diverse schemes, fuelled by the actions of citizens and by reciprocal enrichment. In brief, it concerns approaches to the *creation of meaning,* that are more rooted, systematic and shared, that enable society to create public knowledge, a knowledge that is more and more solid because it is based on trust. But what are the places and the forms of this involvement? In which areas can this "co-production" take place?

2.4.1 – *"Hybrid forums"*

To this regard, Michel Callon proposed the creation of "hybrid forums" (Callon *et al.* 2009) in which to discuss scientific controversies. *Forum* because it concerns open spaces and groups who can mobilise themselves to debate technical choices that concern society as a whole. *Hybrid*, because these groups are heterogeneous: you can find experts and at the same time politicians, technicians and lay citizens who believe they are able to discuss the subject; and also because the questions tackled and the problems raised are written in different registers, from ethics to economics, to physiology, atomic physics and electromagnetism (Callon *et al.* 2009, p. 18). In them, «the direction given to research and the modes of application of its results are discussed, uncertainties predominate, and everyone contributes information and knowledge that enrich the discussion» (*ib.*, p. 9).

But where does the need to share knowledge come from? Not so much from a deficit of communication and information, but especially from the circumstance, pointed out before, that every scientific "modeling" is always "partial" and presents intrinsic limits. If no-one has the monopoly on knowledge, but everyone brings competences that must always be precisely defined in their area and in their limits of approximation, then the public debate may constitute an essential enrichment since also normal citizens can participate in it, or those who possess a tacit knowledge of the issues concerned often not available to experts and specialists. Every attempt to ignore the fertility of the disputes or to reduce debates to mere formality, fuels the presumption of those who claim to know the plot of the film already, underestimating the possibility of a twist in the tale.

Controversies allow people to explore the elements that are "outside the script", triggered by the continuous development of science and technology, since the issue is not so much knowing if a solution is in essence good or bad, but rather integrating the diverse dimensions of the debate and the diverse competences available in order to reach a significant solution, that is complex and not limited to just the more immediate and economically advantageous aspects. The sterile juxtaposition between experts and lay people, science and politics is replaced with the fabric of socio-technical argumentation in scenarios that articulate considerations of a different nature (economic, political, and ethical). Seen in this way, controversy allows people to conceive of and try projects and solutions that incorporate many points of view, questions and answers. Smoothing the unnatural asymmetry between experts and lay people, hybrid forums propose to demonstrate that both categories hold specific knowledge – capacity for diagnosis, interpretation of facts, an array of solutions – that become enriched and develop continuously and mutually. Rather than meeting with swords drawn and debating in a direct way, the protagonists of the opposing parties do not hesitate to get new representatives that are closer to their way of thinking:

> A socio-technical controversy makes it tangible that planners are not just developers, that opponents of nuclear power are not just nostalgic for candlelight, that the councillors of small communes are not just simple spokespersons for their electors, and that scientific experts are not just monsters of abstraction indifferent to any social cause. Controversy makes it possible to go beyond a simple opposition setting defenders of the general interest against defenders of selfish interests, or representatives of progress against the standard bearers of a backward-looking mode of life. For a time, the relative equalization of "rights to speak," the opportunity for everyone to argue on his or her own account and to question the justifications of others, transforms for a time the usual hierarchies and their underlying conceptions. This mutual discovery obviously affects each actor, whose identity is modified in turn. Becoming aware that one's sworn enemy is not the person one thought he was facilitates the revision of one's own positions. (Callon *et al.* 2009, p. 34)

The organisation of hybrid forums is even more necessary when one reflects that risk is now ingrained in our society (Beck 1992) and in science that increasingly influences its dynamics; our institutions (both on a National and international level) are no longer able to respond to global changes produced by "radicalised modernity", that is hypermodernity, regarding which, fast action is needed, to make rapid decisions. The society of risk is setting the basis for a new modernity, a "second modernity" in which we need to redefine a new way to understand responsibility: «we need a frame of reference to talk about responsibility and global justice» (Beck 2009, p. 101). And faced with these challenges and these decisions –

that cannot be entrusted to a selected technical-scientific group of people – it is essential for all citizens to participate and being responsible:

> […] only by making a large number of people responsible can we protect outselves from the evils generated by hypermodernity. Without real responsibilisation, the virtuous declarations of intentions, lacking concrete effects, are not enough. We need to privilege the intellegence of men and women, mobilise institutions and prepare outselves for the problems of the present and the future. Making people responsible should be collective and exercised in all fields of power and knowledge, but it must also be indidivudual since each of us must assume this autonomy that modernity has bequeathed us and understand that the future has never before been so determined by current decisions that we choose to take or not take. Basically, what hangs over us in the short term is less a new era of barbarians but rather a great exertion, the very effort of existing in a world where every person has to incessantly choose, redefine and justify his way of existing, completely assuming his responsibilities, always more complex, of social and political actor in a world which is increasingly difficult to read and understand. (Charles 2009, p. 39).

For Beck, the aim of organising hybrid forums is to enable scientists and experts to communicate with a public which is different from their limited circle. So, if science and technology are to be politically controllable, researchers and engineers must be obliged to provide information in the most complete and honest way regarding all the possible situations that could arise from any of their productions. The fundamental social responsibility of the scientist consists in informing the public and his own government, on the basis of his scientific knowledge, of the possible consequences of scientific developments on society. Moreover, the moment of dialogue should define the procedure through which the points of view of different actors are taken into consideration, each according to his own sphere of competences, enabling the different actors to verify that their positions are considered in the elaboration of measures to be put into operation to tackle the problem concerned, and most importantly, allowing the instauration of a climate of trust. Only in this way can we hope for a renewed and profitable dialogue between public opinion and institutionalised science. Science can no longer be servile to politics but must take charge of its own possible effects on society. In order to take the society of knowledge seriously we have to overcome the level of a science-based policy in favour of a plan in which there is a policy-related science that is democratically oriented.

2.4.2 – *"Civic epistemologies"*

As much as one might hope for an involvement of the citizens in the policies of science and technology, there is, however, a certain reluctance to admit that citizens can have an active role in the choices of the use of scientific knowledge. It raises the spectre that scientific issues can be solved by a show of hands (Corbellini 2009, p. 26). But the problem should not be couched in such simplistic terms, since the democratisation of science cannot affect the cognitive values of theories, but applies only to the "boundary conditions", making science a reference point within a multipolar field of energies responding to diverse interests and values. As we shall see better in Chapter 4, the very simplifying and modeling nature of the theories make them open to corrections or alternatives that build different conceptual organizations of the real, that respond to criteria of applicability and have thresholds of risk that are different and perhaps correspond better to a multi-polar field of interests. This, in our opinion, is the meaning of "civic epistemologies" proposed by Sheila Jasanoff:

> faced with the same technological alternatives, societies that are similar in levels of economic and social development often choose to proceed in different directions, founded on diverging arrangements of what is at stake and, correspondingly, on different assessments of risks, costs and benefits of the various possible alternatives. Science and technology produce, in individual political cultures, diverse impacts on the public imagination, impacts that are the reflection of the specific ways in which knowledge comes and what I call "civic epistemologies. […] the term "civic epistemology" refers to the institutionalised practices with which members of a given society try out and put into operation cognitive assertions, used as a basis to make collective choices. (Jasanoff 2008, pp. 304-305)

In brief, civic epistemology has its roots in the idea that in every society there are styles of thought and ways to accept statements, the way in which they should be presented, articulated and justified in order to be comprehensible and therefore acceptable. Obviously, this goes beyond levels of culture and technology or the degree of scientific development of a society, and places and times: even "primitive" societies display such ways of communication, of "narration" of facts. And those who want their statements to be accepted must be in tune with these consolidated ways of knowledge (not necessarily scientific) which are at the basis of the way in which people perceive the world, of this "tacit" dimension of knowledge which we will return to later (see § 5.2). Also in hypermodern societies, characterised by the pervasiveness of techno-science, scientists and politicians have to be in tune with this "civic epistemology" seen as the «ways of knowledge on the part of society, culturally specific and historically and politically rooted» (*ib.*, p. 297). Since,

> by analogy to how each culture possesses its own customs to confer significance to social interaction, so I maintain that the modern techno-scientific cultures have developed tacit cognitive ways to evaluate rationality and soundness of assertions aimed at creating order in their lives; the demonstrations and arguments that do not mange to satisfy the test can be rejected as illegitimate or irrational. These forms of collective knowledge form the civic epistemology of a culture; they are characteristic, systematic, often institutionalised and articulated through praxis rather than translated into formal rules (*ib.*, p. 305)

Unlike the model proposed by the PUS, civic epistemology does not have a normative character, that is, it does not presume to explain the differences of opinion on science in the public through the difference between the level of knowledge of individuals and the optimal one. Therefore, it does not draw the conclusion that if people had an adequate knowledge of science, then they would accept it without any qualms. Civic epistemology has, on the contrary, a descriptive character and tries to bring to light the circumstances and the real procedures of thought that lead to acceptance or refusal of certain results and scientific proposals. Therefore, it places itself – to use a familiar distinction – on the level of the context of the discovery rather than on that of the justification; it is interested in the "quid facti" rather than the "quid juris" and is – for this aspect – the "analogon" of cognitive science rather than of the normative philosophy of science. The acceptance or refusal of science is a fact that must be explained and cannot be taken for granted; an explanation that cannot be attributed to mere disturbing factors, to deviations from a "normal state" in which the absence of prejudice and ignorance should naturally and inexorably lead to convergence of opinion of scientists and the acceptance of science. Besides, civic epistemology gives us a better grasp of trans-cultural diversity in the response of the population to science and technology.

Civic epistemology therefore, is a very complex concept that gathers within it the different ways in which knowledge is spun round in the public arena. Moreover, it will have meaning especially when the public arena can be considered as probative for statements of knowledge in competition with each other to establish credibility of State actions. Citizens will stop being passive spectators and become more attentive to how public knowledge is produced and dispensed: then we shall witness the transition from "citizen" or "member of the public" to "stakeholder".

However, the modalities and typologies of public involvement are still – at least in the field of EC directives and initiatives – open to numerous questions: how can participation be realised? What are the basic motivations? Does it represent a solution? And if so, for whom? These and numerous other problems have to be solved, for example, the way of constructing diverse typologies of the public or the epistemological statute of terms such as "meeting" and "participation".

2.5 – The value of democracy in science

We have seen that trust in science, which is at the basis of a society of knowledge and for support for funding policy of R&S strongly backed by the EC, cannot be excluded from two joint and converging EC strategies, the former necessary but not enough, the latter able to bridge the distances between the public and scientists and policy makers. The first strategy involves providing more information and divulgation of science, while the second involves the creation of places of interfacing and debate in which scientific options and the choice between them are publically and collectively assumed.

It is easy to see the danger of neglecting the first point which has been underlined very often by scientists and intellectuals like John Ziman:

> Science is under attack: people are losing faith in its powers, pseudo-scientific beliefs abound, anti-scientific orators take the chair in public debates, industry abuses technology, legislators put the de-

> faulter to test, governments cut funds for research. Even scholars are becoming sceptical about its announcements… And yet, opinion polls regularly report that the vast majority are in favour, science education is widespread on all levels, writers and TV and radio presenters enrich public understanding of science. Exciting discoveries and useful inventions come from research laboratories, imposing research tools are constructed with public funds and science has never been so popular and influential. (Ziman 2000, p. 13)

It would be a serious matter if they did not carry out a project of scientific education of citizens if they want to create the premise for a democratic society based on justice and equality.

> Only citizens equipped with conceptual tools to critically assess the new frontiers of scientific knowledge can guarantee a democratic system because they are able to influence the social body effectively and directly with their own independent opinions. (Redi 2005)

Many examples show that knowledge, in particular science, technology and innovation are needed to face this challenge:

> well-informed citizens are the guarantee of strong support for investment in resources for scientific research and the formation of independent opinions that are reflected in democratic decisions of what is held to be permitted and what should not be applied. (Redi 2005)

When this does not happen, there is a delay in the affirmation of a political-cultural reflection that is critically adequate and able to re-elaborate the relationship between democracy and rights, and between welfare and democracy.

Regarding the second aspect, in our opinion, the institutional and concrete ways should be explored in which the process of democratisation can take place. There is no doubt, however, that in this case, we must be ready to face the greatest difficulty that this strategy poses: the gap between the need to make rapid and efficient decisions to keep up with the speed of scientific advances and the necessarily slow times required for every participated deliberation, in which consensus must be formed in a molecular way and through shared procedure: «Science, if it can deliver truth, cannot deliver it at the speed of politics» (Collins & Evans 2007, p. 1). In this lies an implicit tension of the Lisbon Strategy: on the one hand, there is the drive for translation of results into commercial products able to compete on the global market, which implies the need for a re-organisation of science and research so it can better respond to these aims; on the other hand, there is the request and the need for policies aimed at involving the public in choices of research policy, so as to respond to the scepticism and mistrust of citizens towards some of its developments (see Wynne *et al.* 2007, p. 14; Di Tommasi 2009, p. 56).

Rapidity and democracy do not make good bed partners; an exemplary case in which we have to deal with two axiological directives that clash apparently without remedy. Speed is functional to productivity and economic growth, democracy is necessary for participation and solidarity. What should we choose – to have more technology products and increase our GDP or to live more happily, in harmony with the natural and social world?

However, it may be possible to find a third way to escape this paralysing dilemma and see democracy not as an impediment to economic growth, but as one of the factors whose presence helps to raise our general level of well-being. Of course it also raises the GDP, but not as rapidly as it would do if general well-being were neglected.

This is the view of Amartya Sen (1985, 1999), who presents the "capability-based approach" to development seen as an expansion of the substantial freedom of peoples, so as to enable them to live a life worthy to be called so; not only free from poverty and need, but also rich in culture, freedom, participation in public life and entrepreneurial ability:

> This way of looking at development refers to the capabilities people have to act and to choose a life they value rather than to their level of income and possession of wealth. Poverty, for example, is in this perspective mo re a deprivation of basic capabilities than just low income. Human capabilities rather than resource endowments are the fundamental factors of development. Another aspect of Sen's approach is that from the instrumental point of view the different freedoms – political freedoms, economic facilities, social opportunities, learning opportunities and so on – are linked and feed upon each other. Political participation depends on education and trust; education and training depends on income and social security; economic facilities depend on health care, education and participation, etc. This has to do with the systemic character of the institutional set-up, which is an important aspect of Sen's way of thinking about development. (Johnson et al. 2003, p. 9)

But in order to make this possible, it is necessary to re-think the model of development developed so far and understood by the Lisbon Strategy, freeing it from economy-oriented and positivist difficulties. In what sense it is possible we will see in the next chapters.

Section two

3. Historical Philosophical and Sociological Models of the Interaction between Science and Society

3.0 – Overview

The twentieth century has seen a change in the perception of the role and function of science in society. In the Modern Age, science has always played a pivotal, instrumental and beneficial role. The eighteenth century is characterized by its "scientific" revolution that also implied a change in the way mankind would perceive the world and organize social life. In the eighteenth century, for Enlightenment thinkers, science – in itself and as a paradigm of impartial reasoning and intersubjective agreement – became the instrument to achieve individual emancipation from religious dogmatism and political despotism. The same applies to the nineteenth century with "positivism" investing all areas of cultural thought as well as institutional arrangements. There again science would serve the purpose of emancipating man from superstition and ignorance. Furthermore, industrial modernization was perceived as a beneficial, material instantiation of the emancipatory powers of science.

Up to the first decades of the twentieth century, science enjoyed unconditional support from the general public and political institutions until the two World Wars showed the bad side effects of its powers. After that, in the midst of the Cold War, pollution, overpopulation, economic disparity, and suchlike prompted many to call for a critical discussion over the main tenets of positivistic modernism. This was the conclusion everybody could agree on: in the postmodern age, science cannot be left uncontrolled. Its display of power during the two world conflicts had led governments to take up the role of controllers. Here, in the aftermath of World War II, the prestige of nations (or factions) during the Cold War depended on their economic and military edge, which, due to the paralysis (to some degree) of material conflicts within Western civilization ultimately depended on the techno-scientific edge – while ethnic and political aggressiveness was played on the outside in the form of economic coercion, cultural advertising, espionage, and suchlike. It was especially with the official end of Cold War in 1989 that a radical change in the way the perception of science of both professionals and the general public occurred. All the techno-scientific resources accumulated during those thirty years could be directed towards public, social and civic purposes. It is at this point in history that public opinion entered an area of social organization that was previously held only in government quarters and discussed within university walls: science policy. Once the thirty-year threat of a nuclear and final conflict between the (then) two poles of the planet had stopped exercising a sort of coercive assent towards public expenses for techno-scientific development for defence purposes, the general public's risk perception was turned entirely towards other potential and real effects of government control over science. The environmental and social effects of industrial modernization became the object of public debate and it is still so in contemporary times.

This is the historical sequence along which the history, philosophy and sociology of science (HPSS) have developed in the twentieth century. Here we have tried to show how the thesis has been consolidated among HPSS practitioners - (the evaluation of this will be discussed critically later, from a methodological prospective - see Chapter 6) – that it is only by looking at extra-methodological, ideological motivations beyond methodology implementations that we may justify the efficaciousness of a given descriptive model as a means for a cross-methodological objective: to employ the analytical and descriptive tools of HPSS for science policy.

In § 3.1 we have presented the twentieth-century historical background in which the relationship between science and society was instantiated. As we have seen above, or perhaps just because it is so close to us, the history of the twentieth-century is rich and complex. As a consequence, we have tried to look as far back as the eighteenth-century Enlightenment in order to point out those basic tenets of modernity concerning the relationship between science, democracy and society, that were instantiated and opposed in equal measure in the context of the twentieth-century. This has enabled us to explain the motivation beyond the methodological variation among orientations of

HSPP by singling out historical-cultural diversification factors that would otherwise escape simple meta-methodological analysis. For instance, we have discussed in § 3.2 and § 3.4 how the philosophy of science underwent a transformation in the 1960s which can be characterized as a debunking of the modernity tenets discussed in the previous section. Specifically, such a turning point in the philosophy of science is characterized by the return of a historical perspective which pays due attention to extra-logical and extra-empirical factors determining scientific consensus over rival theories.

The reintroduction of an historical perspective had opened the possibility of integrating historical, psychological and sociological themes into the framework of the philosophy of science. We have discussed in § 3.3 how before the 1960s, the history, philosophy and sociology of science were quite separate from one another. They both had the same subject - science practice - but each of them considered only one dimension of science. Specifically, the history of science was considered to be an activity primarily concerned with the "external," contingent development of science that had nothing to do with its "internal" development i.e. relative to the rational, intrinsic development of science contents. The philosophy of science was concerned with a logical reconstruction of the decision episodes of science, and therefore it simply represented the choice of one theory over a rival one as a matter of logical coherence and empirical correspondence. The sociology of science as put forward by Robert K. Merton, on the other hand, was only concerned with the institutional dimension of science.

This unproblematic division of labour broke down at the same time as the historicist turn of the philosophy of science. In fact, the protagonists of the historicist turn, who we shall refer to as the "post-positivist," by showing the underdetermination of theory by logic and evidence (i.e. the fact that the choice of one theory over another could not be decided by simply considering their logical and empirical virtues), implied that theories get selected because of "irrational" merits (such as group affiliation, prestige, financial gain and so on) and therefore the truth of a given theory was determined by those socio-historical factors that were before considered as extraneous to rational decision assessments. This gave rise to a more invasive sociology of science programme that would reject the division of labour established by Merton and henceforth will be referred to as "post-Mertonian." This is the Sociology of Scientific Knowledge (SSK) that is first introduced in § 3.4 in connection with another important but somewhat different sociological approach, the Sociology of Knowledge (SK), and is subsequently critically discussed in § 3.5.

A history of HPSS would not be complete without linking it to the more recent history of Science and Technology Studies (STS) that we have tried to describe in § 3.6. After all, HPSS is the methodological hardcore of STS which in fact tolerate a great variety of approaches within their boundaries. The history of STS offers us the possibility to single out some of the historical contradictions within their often invoked methodological tolerance. For instance, STS scholars often embrace an anti-modernist, anti-scientistic perspective that they mistakenly refer to as "post-modernism." We have tried to show in § 3.7 that theirs is just an anti-scientistic perspective that does not assimilate the main methodological postmodernism as represented by the works of Lyotard. This has helped us to clarify the ideological reasons beyond the methodological divergences of HPSS that are the basis for a better understanding of the methodological questions that will be tackled in the next chapters.

3.1 – The twentieth-century philosophical Received-View of science

Ernan McMullin (2002) divides the history of 20th century philosophy of science into three periods punctuated by three developmental phases. The first one begun in the second quarter of the century and is characterized by the origin and consolidation of logical empiricism as a philosophy of science developed in the Austro-Germanic philosophical context by scholars belonging to the Vienna Circle and the Berlin Society and that later became the dominant perspective in North America (see also § 3.2).

A second phase, temporally framed in the third quarter of the century, is characterized by the rapid decline of logical empiricism and its progressive substitution with more historical and pragmatic approaches, and punctuated by two important methodological turns: Willard van Orman Quine's *naturalistic turn* and Thomas Kuhn's *historicism* (see § 3.3) – respectively the idea that philosophy of science must employ (and not just "mimic") the methods and results of empirical sciences, such as psychology and sociology, and that phenomena of *scientific change* (theory-acceptance and theory-choice) cannot be understood without reference to the socio-historical context.

The third phase (see § 3.4) concerns the last quarter of the century, a period characterized by the consolidation of the alternative approaches put forward in the preceding phase. During this phase, *via* Quine, Kuhn and the influence of post-Mertonian sociology of science, philosophers of science progressively abandoned their traditional normative heuristics in favour of a naturalistic and thoroughly descriptive one (see Kitcher 1992; see also Coniglione 2002, pp. 283-332). The new philosophical narratives that consequently emerged resulted in a more complete description of science practice encompassing the historical, economical, sociological and psychological/ cognitive dimensions of science that traditional philosophy of science had seemed to put aside by recurring primarily to logical-argumentative and evidential factors for reconstructing cases of scientific change.

During the first phase and particularly after the second world war an approach to the philosophy of science has been progressively consolidated, that represents the choicest and ripest fruit of the program initiated by the Vienna Circle between the two Wars and subsequently developed in America after the emigration of its main exponents. It is usually referred to as the *Received View* (Putnam 1962). Such an approach is addressed to complete that received tradition described above concerning the seventeenth-century Scientific Revolution and the image of human nature formulated by eighteenth-century Enlightenment thinkers. Both these historical roots have a common conceptual origin in the Ancient Greeks' conception of *logos* (Coniglione 2008; see also § 2.1) formulated in the midst of the great "enlightenment" season of Classical thought which started with Sophism and Socrates and perished with the return to superstition and religious cultural dogmatism (Dodds 1962, pp. 179-195). These are the conceptual ancestors of the rational reconstruction of science practice (i.e. a modeling representation of science decision episodes through formal, abstract, logical means) put forward by the scholars supporting the *Received View.*

The way of approaching science and cultivating the philosophy of science of the Received View was indeed characterised by a formalist approach, in which the central focus of attention was the abstract and the meta-temporal. European philosophers who had emigrated to the States, like Hempel, Feigl, Carnap, Reichenbach, von Neumann and Frank, had installed a style of thought that saw in formal rigour a yardstick to measure the adequacy of intellectual activity also in every other sector (Toulmin 1977, p. 143); so the formalization of theories was conceived as a procedure not only useful, but also indispensable for achieving as much conceptual rigour as possible. On this reading, the aim of the philosophy of science (and of philosophy in general) «is to clarify conceptual problems and to make explicit the foundational assumptions of each scientific discipline» (Suppes 1968, p. 653; 2002). Furthermore, it is through formalization, systematically, that those embracing the Received View thought they would resolve the controversies that afflicted science practice:

> There is no other general means of resolving conceptual conflict in science. Moreover, in a wide variety of experimental situations, there is no way to resolve disputes about the interpretation of data objectively except by careful and explicit use of the set-theoretical methods of contemporary mathematical statistics. But what is necessary is necessarily desirable, and so it is with formalization in science. (*Ib.*, p. 664).

Each problem domain of the philosophy of science had to focus on the logical structure of science and its argumentations, with a rigid separation between the context of discovery – consigned to the irrationality of psychology – and that of justification, on which the philosophers of science had to concentrate their efforts. One may claim that this distinction – that had already be put in place by Kant in general terms, and then conceptualized concerning scientific theories first by Cassirer (1920, p. 485) and later by Popper (1934), Carnap (1928, p. 80; 1938), and Reichenbach (1938, pp. 6-7, 382; 1949, pp. 178-9) – constituted the common supposition of all philosophers until the end of 1960s, including the dissenter Popper who thought it a priority to establish a neat demarcation «between the process of conceiving a new idea, and the methods and results of examining it logically» (Popper 1934, p. 8).

According to this formalist approach,

> The central convictions were: (1) that careful scrutiny and analysis of the arguments which emerge within the scientific "context of justification" will reveal that properly conducted natural science does indeed have a canon, "method," or *organon*; (2) that the essential procedures of that method can be captured and expressed in formal algorithms, relating the empirical observations of science to the theoretical propositions in terms of which they are to be explained; and (3) that the "rationality" of the natural sciences lies in conforming to that set of formally valid procedures. (Toulmin 1977, p. 147)

At least for our purposes here (but see Hoyningen-Huene 1987; Nickles 1980; and more recent essays in Schickore & Steinle 2006), the distinction may be characterized as allotting specific professional tasks to philosophy of science, on the one hand, and history, psychology and sociology, on the other. Specifically, history, psychology, and sociology are concerned with the process of discovery of scientific theories, while philosophy of science is concerned with the justification of such discoveries. The process of justification is to be "logical" in the sense that it is based on a formal reconstruction and analysis of the relationship between the relevant scientific theory and the evidence that supports it. Therefore, it is a matter for historians, psychologists and sociologists to tell whether there are external circumstances, besides logic and evidence, constraining theory-choice, such as subjective or psychological motivations and socio-historical constraints. These extra-evidential factors may be present in the discovery process, but by placing it outside the scope of philosophy of science, which is only concerned with the logic of justification, there is no room for such factors.

Hence the trust placed in the idea that it may be possible to "discover" an algorithm able to define once and for all the status of both "scientificity" and the degree of scientific validation that could be ascribed to a given set of propositions. This was an idea shared by neopositivists as well as by their "internal" (i.e. working within the framework of institutionalized neopositivism) opponents. Laudan noted, there is a shared conviction

> that the only kind of rational rule worth considering as a rule is some sort of algorithm-mechanical in application, unambiguous in sense, and capable of invariably producing a unique outcome. Some of the positivists believed that it would be possible to articulate such rules; indeed, there are still inductive logicians who believe in some such utopian nonsense. (Laudan 1996, p. 18)

This attitude led to a lack of consideration for the historical dimension of philosophical and scientific problems, that had to be tackled and resolved only in their conceptual and logical configuration. As Reichenbach (1935, p. 59) claimed, the solutions to problems are never found by historical considerations: we need to make things and objects of reflection speak in order to find the logical order so ardently sought by all of us. And Hempel (1979, p. 365) reminds us that the logical empiricist school was not very interested in the analysis of theory-change (i.e. the analysis of how and why one theory comes to be considered better than an alternative one), since its primary interest was induction, confirmation, probability, scientific explanation, concept formation and the structure and function of scientific theories. In this heuristics environment the history of science was often undertaken by "retired" scientists or at least it was a subject on the margins of the primary profession of the philosopher of science, historian or scientist (Kuhn 1977, pp. 105-6). This situation was not different even in the case of thinkers who may be considered to be pioneers in this respect, such as Ernst Mach, Paul Tannery, George Sarton, Lynn Thorndike, Pierre Duhem and Charles Singer. Their contribution, however, enabled the history of science to be consolidated as an autonomous subject in the 1950s. For instance, in that period in the States we go from the five historians of science in the immediate aftermath of War World II to 25 in the 1960s, then to more than 125 in the mid 1980s (Baldini 1986, pp. 16-7).

This was still a history of science influenced by the heuristics of logical empiricism. It was devoted to the study of the internal development of a discipline and it would not allow for abrupt change (or "revolutionary" change, as we shall see later). It would therefore view scientific development as continuous, that is as a progressive accumulation of scientific truth and the systematic rejection of superseded theories and concepts. This was an history of science holding a balance between a strictly "inductive" position – according to which the problems worth pursuing are those concerning chronology, priority and genealogy, with scant attention to the existence of alternative schools of thought within the same discipline, ideological and sociological tendencies of the historical actors, and philosophical controversies of the general type – and a "conventionalist" one – according to which scientific theories are neither true nor false; rather, they are just useful to systematize empirical information – together with the search for continuity, simplicity of theories, and gradual change; a history, indeed, in which each scientist has had a predecessor who had "anticipated" his/her ideas (Agassi 1963, pp. 17-20, 49-64 ff.)[5].

On this reading, the phenomenon of consent within science was favoured. It was considered a fact that even if there were profound controversies within the scientific community, sooner or later scientists would end up agreeing upon fundamental truths (Laudan 1984, pp. 3-13). To this was added the conviction that there was an undisputed corpus of knowledge accepted by all scientists, and that divergences took place only at the margins of scientific research, at the periphery of theoretical constructions, where research was still going on. However, it was thought that once the ground was settled, an acceptable corpus of knowledge and sufficiently stable theories would be obtained in these new areas too. Also in Popper's view, apart from the emphasis on the constant revolution in science, the existing relationship among theories in succession fell within this way of thinking.

Of course, the great masters of neopositivism were not so blind as to ignore the simple fact that science has a *history*, that scientific theories change and are replaced by new concepts that are both more precise and more general. And somehow they had to take this into account. To this end, the concept of the progress of theories by reduction was elaborated. This represents the standard way in which the issue of the historical dynamics of science is tackled and the point of convergence with the ideal of unified science which, it was claimed, could be obtained by means of inter-theoretical reductions (from biology to chemistry and then to physics, etc.), to be carried out on a linguistic level independent of ontological assumptions (Hempel 1966, pp. 151-64). Thanks to this concept, the evolution of science was conceptualised by analogy to the deductive-nomological model of explanation, thereby freeing scientific progress from the idea that it consisted in the mere accumulation of new observed data, while preserving cumulative progress at the theoretical level.

It is not necessary to go into the details of this concept (Coniglione 2008, pp. 50-9); it is enough to note that this is the vision of the development of science, often described as *cumulative* and *continuist*. As far as science is concerned, nothing is lost in the passage from a less general theory to another more general one; the predictions of the old theory do not suddenly become invalid but only limited to a more precise range, out of which they would lose their value: Newtonian mechanics has not been dethroned by relativistic ones but only held to be valid within a universe in which bodies do not travel at the speed of light (Toulmin 1953, pp. 82-83); it is just a restriction of the relativistic mechanics by which, with appropriate assumptions, it can be deduced. Conforming to the model of nomological-deductive explanation, the link that holds together successive theories in time is analogous (or rather, identical) to the one that makes *explanandum* derive from *explanans*. Scientific development is no more than a chapter of the logic of scientific explanation, as has been canonised by the masters of neopositivism, Hempel first of all.

[5] This is not to say that traditional philosophy of science denied the causal influence of extra-logical factors for framing science decision problems. As seen in § 3.7, due to historical circumstances (especially high modernity de-ideologization), second phase philosophy of science had somehow exasperated the logical and abstract character of the discipline as practiced in the inter-wars years, as explained in Reisch (2005). This has partially caused the contemporary image of philosophy of science to be detached from flesh and blood science practice. However, recent history of philosophy has shown that inter-wars philosophers of science did not conceive of philosophical practice as "different" from social and political engagement (Uebel 1998, 2004) helping also the recovery of a "sociology of knowledge" more or less explicit in the genetic phase of the discipline (Richardson 2000; Uebel 2000).

This is the picture supplied by the Standard Conception, within which we can also place the way of conceiving the evolution of science, of reading its history, and understanding its link to society. This is the approach that, since the beginning of the last century, had taken on the task of providing a picture of the cognitive evolution of mankind characterized by rationality, intersubjectivity, axiological neutrality and by a progressive and optimistic vision of the future, relying on a progressively capillary diffusion of scientific rationality and its technological derivatives. This position has progressively crumbled since the end of the 1960s and it is one among the main factors that determined the beginning of McMullin's second phase.

In fact, since the beginning of the 1960s the philosophy of science has undergone a period of radical change during which the certainties of the previous years have been gradually eroded, and a new way of seeing science has been established, regarding its evolution and constituent parts.

The erosion of the positions inherited by logical positivism came about thanks to a small group of scholars who, over time, criticized some key aspects, though without managing to shake the foundations until the work of Thomas Kuhn brought about the explosion. Some of these critics have a long, honored tradition of opposing (Popper above all, considered for a long time to be the official contradictor of the Vienna Circle); others have developed their criticisms in more recent times, beginning at the end of the 1950s: philosophers like Norwood R. Hanson (1958), Michel Polanyi (1958), Paul K. Feyerabend (1962), Wilfrid Sellars (1963) and – further back in time – Willard v. O. Quine (1953) and Ludwig Wittgenstein (1953). Many of the critical points placed under attack entered the canonical literature (the verification principle of meaning; the problem of confirmation; the difficulties linked to the concept of explanation; and an adequate characterization of the correspondence rules, etc.), like also the criticisms Popper brought to neopositivist conceptions. But here we want to focus our attention on other problems that concern primarily the way the scientist conceived of change in science and its relationships with society, topics which are closer to us.

We do not intend to go into detail on more technical questions that regard the already mentioned approach to the progress of science by reduction, which concerns issues like the change in meaning of theoretical terms belonging to subsequent theories, strongly emphasized by Feyerabend. Likewise, we will not mention those issues linked to the complexity of providing empirical significance to the theoretical vocabulary of a theory through particular "bridge principles" with an empirical basis. In fact, apart from these difficulties, one of the basic assumptions of science, as conceived up to now, that has been at the core of its method and even its logic (including the distinction between inductive and deductive) was challenged: the possibility of establishing a clear demarcation between theory and observation, with the consequent stress on the role of theory in pre-establishing or even predetermining the empirical material that it must explain.

A consequence of the conception of theoretical dominance, according to which observations are theory laden, and to the fact that terms have a precise meaning only within the given conceptual framework, is the claim that in subsequent theories, the homonymous terms have a completely different meaning. So, for example, the concept of a planet changes with the passage from Ptolemaic to Copernican astronomy, in such a way that old and new astronomers end up talking about completely different things. Feyerabend has assumed the role of interpreter in this, claiming that meaning invariance is continually disproved and violated in concrete scientific practice and that it would be pernicious for the advance of knowledge to assume rigid methodological canons (see Feyerabend 1962, pp. 81-2).

It is clear how a criticism comes from this that goes right to the heart of the model of scientific change elaborated by the masters of neopositivism. It even negates that very theory of explanation that we have seen to be the presupposition of the theory of reduction: for the reduction of one theory to another to be possible, there have to be some correspondence rules able to connect the theoretical postulates with the observation statements. But, first of all, as Feyerabend (1965, p. 16) points out, the rules of correspondence turn out to be false or meaningless. Secondly, the descriptive terms of the two theories do not coincide since, like theoretical terms, they too change their meaning: the conceptual systems of different theories are therefore mutually irreducible.

3.3 – Philosophy and sociology of science I: a division of labour

The traditional image of science put forward by philosophers of science – as exemplified by the Received View – was complemented by the sociology of science. Under the heading "sociology of science", however, we find different approaches that we shall try to sort out here because of the importance their differences make for the kind of research activity we have conducted. There are in fact at least three acceptations: "Sociology of Science" (SS), "Sociology of Knowledge" (SKn) and the "Sociology of Scientific Knowledge" (SSK).

SS studies the relationship or existing interactions between science and society and it considers the former in much the same way as the Received View conceives of it. According to Ben-David & Sullivan (1975, p. 203), SS is concerned «with the social conditions and effects of science, and with the social structures and processes of scientific activity». In this respect, science is considered as a specific cultural tradition that is transmitted across generations; unlike art or literature, it is characterized by the employment of rigorous criteria and procedures that enable it to establish whether a given innovation constitutes a genuine improvement on the existing tradition. Although such criteria are not univocal and stable, they are nonetheless superior to those employed in the context of other cultural enterprises. The main representative of SS is Robert K. Merton (1910-2003). His work had been at the basis of the subject for a considerably long time in the Anglo-American sociological environment and it follows a positivistic approach.

Merton is especially remembered for his role in establishing SS, immediately after War World II, as an autonomous subject with a specific structuralist-functionalist heuristics that takes, by analogy, natural sciences as a model. However, he envisaged science in a way that was still too close to the transformations that the concept underwent in the second half of the 1970s. This can be explained by the fact that Merton started his sociological investigation already during the 1930s, specifically by studying the institutionalization of modern science in seventeenth century England that was considered an event closely linked to the establishment of Puritan ethics. Already in the 1930s, Merton concerned himself with those values and norms that constrain or favour the institutional consolidation of science. Only later was he concerned with the normative structure of science as separate from the rest of society, that is as a community of researchers with their own particular values and organizational and functional modalities (Merton 1949; 1957).

Merton pointed out four norms peculiar to science: universalism, communism, disinterestedness, and organized scepticism. "Universalism" refers to the irrelevance of the personal values and convictions of an individual science for the relevant scientific work. In this respect, science must be "universal" in the sense that it must be valid for each rational human being. The truth of scientific claims, according to Merton, must be established through impersonal and univocally shared criteria based on observation and the established corpus of knowledge (Merton 1957, p. 352). "Communism" refers to the public character of science and its results. The only owner of science is mankind, therefore everybody can employ its results whose circulation and public access cannot obstructed. By "disinterestedness" Merton intended to address the need for scientists not to work for profit but only for the benefit of the scientific community and general society. Finally, "organized scepticism" refers to the open attitude of the scientific community to always and systematically put under critical scrutiny, without prejudices, their own scientific results for the sake of genuine and ever progressive scientific growth. The only advantage for a scientist is to be acknowledged for the work he has done and therefore to be celebrated publically as the first to have had a given idea or to have made a discovery to which he can give his name. We shall see how with the advent of the knowledge society, none of Merton's four values would fit the contemporary state of affairs.

As we can see from what has briefly been discussed so far, Merton's analysis (and others of h is studies on the social dimension of science, such as those concerning the mania for publication, deception and fraud, slander among competing scientists, and so on) are in line with the Received View concept of science; they are, as we have already said in the opening of this section, a "complement" of the Received View. In fact, they do not doubt the neutral and objective character of science, which is therefore understood as the best cognitive practice at our disposal. The norms making up the "ethos" of science say nothing about either the truth value of scientific claims or the criteria necessary for accepting and rejecting scientific theories. Merton's norms simply point out the moral premises for their optimal achievement and therefore they simply are a "social" complement to the evaluative standards elaborated by positivists in order to establish the scientificity and validity of knowledge claims. Furthermore, social norms play in this respect a subordinate role regarding the "logic of science" or "scientific method", that is with respect to the discriminant that has been traditionally employed by the sociology of science. Merton's sociological evaluations rule out any consideration regarding scientific content. The validity of the latter is evaluated and regulated by methodological criteria and procedures that are thought to guarantee objective and cognitive validity. To this regard, Merton arrived at a division of labour between philosophy and sociology of science: the criteria employed by scientists to evaluate the validity of scientific claims and depicted by philosophers of science in terms of logical coherence and empirical correspondence are not the concern of the sociology of science which is rather engaged with the descriptive study of the institutional and ethical dimension of science practice. Other sociologists followed Merton, such as Barber (1952), Storer (1966), Cole (1992), Crane (1972), Hagstrom (1965) e Ben-David (1971). In this respect, Merton's paradigm enjoyed widespread success. However, it is the separation between the content and the social structure of science that will be argued against by the new wave of philosophy of science in the 1960s and the new, "post-Mertonian" sociology of science that will be discussed in the next section.

SKn is different from Merton's SS in many ways. It is the study of the existing relationship between human thought and the social context from which it emerges. Here "human thought" refers to all those activities that are not usually referred to as "cognitive" traits. These should include human forms of expression such as art, music, literature, poetry, and so on. In this respect, SKn's genealogy may be ascribed to authors such as Scheler (1980) and Karl Mannheim (1929, 1974), while we may trace its rebirth in more recent time in Berger & Luckmann (1966). According to another one of its representatives, Werner Stark, SK(?) argues for the thesis according to which cultural phenomena are connected to social ones and they can be fully understood only if this link is made explicit (Stark 1935, p. 10). Here it is important to point out that "cultural phenomena" do not refer to scientific knowledge alone; in fact, Stark uses examples drawn from music, or from the relationship between typologies of philosophy and socio-economic development (i.e. English empiricist philosophy vs. German speculative philosophy), since his aim is to give us the opportunity to discover the social, existential roots of our mental structures or artistic achievements by unveiling their deep meaning, essence, and existence (*ib.*, p. 15).

Such a wide way to understand knowledge can be justified by the fact that for the SKn practitioners, social conditioning is significant not only in order to arrive at knowledge of the physical world and of factual events, but also to arrive at a *knowledge that is specifically social*. In fact, while when facts are ascertained everybody can agree and social context plays a minor role, when we try to perceive things that go beyond physical and formal facts, the social dimension of man become essential (*ib.*, p. 18).

We may argue that SKn holds a relationship with epistemology that is very similar to the relationship between SS and philosophy of science. SKn, however, is not only concerned with knowledge, but also with activities that do not have a proper cognitive character (unless we would like to imply that art and literature are a way to know reality).

Contrary to SKn, SSK is closely correlated to SS. It is concerned with the role played by social factors in scientific development compared to the role played by other factors, such as empirical and rational ones. As a matter of fact, SSK is a developmental stage of SS that occurred in the 1970s. It radicalizes Mertonian sociology, giving rise to a so-called "strong programme" of the sociology of science. According to Sheila Jasanoff, SSK is «a particular approach to the study of scientific knowledge that traces its genealogy to the work of David Bloor and Barry Barnes in Edinburgh, and to earlier authors such as Ludwik Fleck» (Jasanoff 1996, p. 414). SSK is an approach that has had incredible fortune in recent years and thus deserves special attention, for it plays a fundamental role for the methodological results of our research activity. Specifically, SSK represents for the sociology of science the same turning point that Kuhn and the other post-positivists represents for the philosophy of science.

3.3 – Philosophy and sociology of science II: the historicist turn

The most devastating criticism to the Received View comes from an unexpected source – history. In fact, starting from the middle of the 1960s up until now, history, pushed to the margins of reflection on science, gate-crashed the tranquil community of scholars thanks to the problems it posed regarding the concept of evolution or progress of scientific theories. According to the new wave, the history of science, the science that philosophy had mummified, was now freeing itself of its bandages; and so, little by little, scholars realised that the science had gone through a historical process of change and discovery (Hacking 1983, pp. 1-3). Philosophers had transformed science into a mummy because they had neglected the history of scientific thought, given their tendency to study science only in its formal and synchronic aspects. Previously, the history of science had been a discipline rarely cultivated by specialists and until the 1950s it had lacked an adequate disciplinary status and a stable academic position.

In fact, while Hanson, Achinstein, Feyerabend (at least at first) and many others carried out their criticisms of the Received View from the point of view of the philosopher of science, taking note of its internal deficiencies and pushing it to extreme consequences, the author who precipitated the crisis at the beginning of the 1960s was a historian of science, Thomas Kuhn. His epoch-making work (Kuhn 1962) can be said to be the most influential on the destinies of the philosophy of science of the second half of the last century. Published in 1962, *The Structure of Scientific Revolutions* had its effects some years later, especially in the 1970s, when a lively debate was sparked by Kuhn's claims. In this volume Kuhn carries out, in the name of the history of science and the way in which it really developed, a radical criticism both of the model of neopositivist science and also of his greatest internal antagonist, Popper. With Kuhn, the philosopher of science learns from the historian of science, contributing to filling that gap that prevents the former from taking real science into consideration: it is a mistake to prefer the science delivered in textbooks and handbooks, that is, in those works in which a kind of decanting and purification has already taken place, in the light of the accepted standard methods; for this is only a pale substitute for the science actually practised by scientists in their laboratories (see Kuhn 1977, pp. 16-22, 132-4 et *passim*). In this way, this work becomes a symbol of a true revolution, «marking a transition to a post-empiricist era of the philosophy of science» (Rouse 2003, p. 101).

Concepts such as "paradigm", "normal science", "anomaly", "revolutionary science", "incommensurability", and "disciplinary matrix" have now entered the common vocabulary of cultural debate, sometimes in an a-critical and unreflective way, and it would be tedious to dwell on these familiar topics. The fact remains that from the encounter between logical-methodological reflection and the history of science, a new way to express scientific theorizing and the growth of knowledge has arisen, one that has had a strong impact on the way of understanding models of a scientific nature and the relationship with scientific-technological knowledge and society.

Kuhn's thought has also had a decisive impact on another typical aspect of the traditional approach of the neo-positivists and the Popperians, specifically on the afore-mentioned distinction between the context of justification and the context of discovery; and even in the context of justification, broadly considered, between epistemic appraisal and heuristic appraisal, with the subsequent refusal to account for the latter in order to support it through a rational analysis. But in fact – as we shall clarify later – heuristic appraisal plays an important role both in techno-scientific innovation and in the evaluative dimension of policy-making (Nickles 2006, 2009).

It is clear how these distinctions have a strategic role within the traditional image of science: only by retaining them is it possible to claim that the philosophy of science does not deal with the concrete historical reconstruction of the way of operating of the scientist – which is the stuff of psychology or sociology; it deals only with the criteria of assessment of the acceptability of well formulated theories, understood as a finished product. Therefore, also the history of science would be, in this framework, something that regards only logical and methodological procedures that alone are able to account for all the main factors that control its development. The distinction between the two "contexts" serves the purpose of excluding all attempts to basically dismiss science – and so guarantees its objectivity and neutrality – by putting aside its historical-social aspect.

Now, interest in the history of science that arose from Kuhnian reflections focuses attention on the concrete procedures of the scientist, and therefore on what he effectively does or thinks, and not on what he should do or think according to the methodological canons established by the philosopher of science. Besides, what aroused interest in the context of the discovery was the awareness, gradually developed in the field of cognitive psychology (see Kahneman *et al.* 1982; Girotto & Legrenzi 1999; Cherubini 2005), that people do not use, in their inference procedures, a kind of mental logic, applying the rules of deductive or inductive logic. In other words, there is a radical difference between formal logic, as canonised by manuals, and applied logic: people resort to reasoning strategies that, while efficacious in most contexts, nevertheless violate the rules of logic, prescribed as the absolute uncontested canon in the world of science. Therefore, why should one not think that scientific reasoning, carried out by the common scientist in his everyday practice, cannot also apply different strategies to those prescribed by logic?

3.4 – Post-Mertonian sociology of science

The Kuhnian turning point is also at the centre of a revival of the programme of sociology of science, one that constitutes an overturning of Robert K. Merton's old perspective we have previously described – and also an effective convergence with the Marxist positions already elaborated in the past and rejected by philosophers and scientists, since the Marxists made science a variable dependent on society (see Aa.Vv. 1931; Ceruti 1981). It is in this direction that a series of studies has been developed in recent years that has particular relevance to us, since in recent times, this body of work has had a major effect on a reformulation of the image of science. This is also the beginning of what McMullin dubs the "second phase" of the philosophy of science.

The renewed program of SSK that arose in the 1970s radicalized the results of Merton's "soft" approach to the "sociology of science", shaping the so called "strong programme". The programme was almost exclusively British (Collins 1983, pp. 267-71), but later its influence extended to North America, France, Germany, Holland, Scandinavia, Israel, and Australia. The "strong program in sociology of scientific knowledge" was developed by the *Science Studies Unit*, an interdisciplinary group founded in 1964 by David Edge (1932-2003) at the university of Edinburgh in Scotland. Over time, the small group comprised the sociologist Barry Barnes (1974, 1977, 1982; Barnes *et al*. 1996), the philosopher David Bloor (1976; Barnes & Bloor 1982) and the historian Steven Shapin (1986, 1994, 1996). The main sources of inspiration were, besides Kuhn, also Durkheim, Marx, Mannheim, the comparative cultural anthropology of E.E. Evans-Pritchard, Mary Douglas and Robin Horton, the relativistic philosophy of Nelson Goodman, the philosophical work on the categories of sociological explanation of Alasdair MacIntyre, the neo-Bayesian philosophy of science of Mary Hesse (see Shapin 1996, p. 295), and also the thought of Jürgen Habermas and the ethno-methodology of Harold Garfinkel (Giere 1988, pp. 111-32). However, in the thought of Bloor (who soon became the most important representative of the group), we can see in particular the influence of Wittgenstein's philosophical work (and of his follower Peter Winch), with his language games, "forms of life" and the notion of "following a rule", as well as the influence of Lakatos (see M. Friedman 1998, pp. 251-64; Pels 1996, pp. 30-48; Collins 1983, p. 269). Other scholars in England soon joined the movement. Prominent examples are Harry M. Collins (who later formed the "Bath relativist school"), Michael Mulkay, who with G. Nigel Gilbert at the University of York began a programme of research called "analyses of scientific discourse" (Gilbert & Mulkay 1984), Richard D. Whitley (1984) and R.G.A. Dolby (1971, 1974, 1980). These are the six main protagonists of the early sociology of science mentioned by Collins (1983), who carefully analyzed their contributions.

The new movement soon gave rise to its own professional organisations, academic journals (the most important of which is *Social Studies of Sci-*

ence, founded in 1971 with the name Science Studies by R. McCleod and David Edge) and became highly visible thanks to anthologies, textbooks and university courses. Naturally, it also attracted the attention of historians and philosophers, since it became a major influence on the so-called "cultural studies" and came to form part of many interdisciplinary research projects (Shapin 1995). This also led to a blurring of the borders of disciplines and a vagueness of objectives, since some people maintained that social studies of science developed in several directions for different reasons, many of which became fertile grounds for research (see for instance the essays in Pickering 1992). In other words, social studies of science became an entire field of inquiry rather than a single research programme.

The new science studies constituted a criticism, sometimes only implicit, of the Mertonian foundation and of the basic idea that governed the sociology of science practised until then: that the sociology of knowledge is the "sociology of error", in other words that sociological comprehension is possible only of the errors and deviations from rationality. Therefore, a true sociology of scientific knowledge would be impossible. Likewise, there was a rejection of the thesis that the answers to the questions posed by scientists are ultimately given directly by Nature and that the scientists' only function is mediation. From this it follows that the contents of scientific answers cannot be open to any sociological investigation (Collins 1983, pp. 266-7).

For the new SSK, it was no longer a case of defining a general relationship between science as a whole and social development, but rather of going into more detail to try to discover the social conditioning inherent in the individual theories, in their acceptance and in why some become established to the detriment of others. With this aim, the new sociology welcomed many of Kuhn's ideas and the post-positivist approach: holism in the control of theories and empirical underdetermination; incommensurability; the theory-laden character of observation; the pervasive function of language; the importance of history and scientific communities, and so on.

According to Shapin, the task SSK took on from the beginning was to create a space for sociology that hadn't existed before, that is, in the interpretation and explanation of scientific knowledge:

> In that sense, SSK set out to construct an "anti-epistemology", to break down the legitimacy of the distinction between "contexts of discovery and justification", and to develop an anti-individualistic and anti-empiricist framework for the sociology of knowledge in which "social factors" counted not as contaminants but as constitutive of the very idea of scientific knowledge. SSK developed in opposition to philosophical rationalism, foundationalism, essentialism, and, to a lesser extent, realism. The resources of sociology (and contextual history) were, it was said, necessary to understand what it was for scientists to behave "logically" or "rationally", how it was that scientists came to recognize something as a "fact", or as "evidence" for or against some theory, how, indeed, the very idea of scientific knowledge was constituted, given the diversity of the practices claiming to speak for nature. (Shapin 1995, p. 297)

At the basis of the "strong programme", there is the so-called "principle of symmetry" according to which the diverse types of beliefs must be tackled using the same forms of explanation, without distinguishing between those that we maintain are true (such as the scientific ones) and those that we maintain are false (because they are not scientific). The value we attribute to an idea should not influence the way in which we explain its history and social role; as Bloor says (1976, p. 5; 1999, pp. 84-8), SSK should be impartial as regards truth and falsity, rationality and irrationality, since both parts of these two polarities require an explanation. It follows from that, that there is no privilege to assign to science and its products: it is not the fruit of disinterested, pure researchers who aim only at the discovery of truth, using empirical data and logic, but it grows and develops in communities governed by social norms that are well-rooted, that regulate people's beliefs, the ways in which theories are maintained and in which consensus or disagreement is expressed, and the criteria with which certain threads of research are brought forward or considered to be outside the work agenda. And these scientific communities are human products, the fruit of social interaction like all the others. It follows that the explanation of why a certain scientific community accepts or rejects a certain theory is of the same type as those that explain the formation of beliefs in any societies, such as tribal ones (see Godfrey-Smith 2003, p. 126). There are no "scientific" beliefs that have to be explained using only rational methods and procedures by contrast with the "non scientific" ones that have to be explained by calling on factors that are merely social, tribal, traditional, or based on superstitions of various kinds. Therefore, sociological explanation does not have a vicarious, subordinate character compared to the logical-rational one.

It is thanks to this anti-normative and anti-prescriptive approach that well-known pronouncements of the new philosophy of science – such as those of the underdetermination of the theories (the so-called Duhem-Quine thesis), of the theory-laden character of observation and of the incommensurability, maintained by Kuhn, between theories belonging to diverse paradigms – were empirically tested by numerous case studies (particularly those dedicated to scientific controversies – see Shapin 1986 pp. 327-386; Pickering 1981, 1981b). All the sociological studies were and are aimed at highlighting the problematic nature and flexibility of interpretation of experimental data, from which it supposedly follows that «neither reality nor logic nor impersonal criteria of "the experimental method" dictate the accounts that the scientists produce or the judgements they make» (Shapin 1986, p. 332). This conclusion has been also drawn by the historical analyses of the way in which scientific controversies are resolved, from which it emerges how not only does science not possess a set of methodological techniques able to prove or contest the diverse hypotheses in a clear and unequivocal way, but also that the ability to produce experimental settings in a laboratory does not establish a firm link between theory and observation (Collins 1983, pp. 274-6, 280-1).

In the early days, the leading approach was of a macrosociological nature, namely the so-called "interest approach", according to which scientific activity is linked to precise social interests. For example, MacKenzie (1978, 1981) tried to demonstrate how the most important ideas of modern statistics have to be understood in relation to the role they played in England in the nineteenth century in the attempt to influence human evolution and its social impact through a eugenics programme that would encourage part of the population to have more children. In this way, he shows how certain "sympathies" were established between a body of biological, statistical and mathematical knowledge and certain segments of the middle classes.

So the strong programme, insofar as it assumes this empirical position and entrusts itself to a model of causal explanation, appears like an empirical analysis of scientific practice aiming to describe and explain natural phenomena by applying the same methods and procedures used by sciences in order to explain natural phenomena. Its aim is «to explain, not why the beliefs are rationally or *correctly* accepted, but simply why the beliefs are *in fact* accepted [...] how local consensus is in fact achieved» (Friedman 1998, pp. 243-4). Remembering the creation of the strong programme, Bloor (2007, pp. 220-1) claims that:

> When it was formulated in the early 1970s it was not offered as a novel approach or a way of telling other scholars what they ought to be doing. Rather than being prescriptive, it was largely descriptive. The aim was to codify the assumptions and practices of the exciting work that was then being done on science, especially by historians. This work was all the more admirable for being done in the face of a barrage of bullying attacks from philosophers who wanted to reify and ring-fence "reason" and who effectively treated the "internal logic" of science as if it were an a-historical, self-propelling and autonomous force. (2007, pp. 220-1)

A distinctive characteristic of SSK is therefore the idea that scientific representations are not determined only by reality in itself, otherwise sociological assessment of scientific knowledge would be impossible: only if experimental data and logic are not able to univocally define the contents of scientific theories, then the road is open to the influence of sociological factors in their construction and certification.

Another theory upheld by all those belonging to SSK is that of its reflexivity: it is the requirement that their sociological claims be subject to the same sociological critical evaluation as any other claims about scientific work, making also the latter a "situated", not over-cultural knowledge (Woolgar 1988; Ashmore 1989). Otherwise, the principle of symmetry would not be valid: there would be a privileged viewpoint, that of SSK, that would enable us to reach general conclusions on scientific practice and its characteristics.

3.5 – The emergence of "Science and Technological Studies"

All these developments and reflections would contribute to form that integrated field of research that has already been mentioned, the so-called *Science and Technological Studies* (STS). This new composite field became established with the foundation in 1975 of the Society for Social Studies of Science (4S) and the handbooks that were subsequently published. The first one was by Spiegel-Rösing & de Solla Price (1977), in which they stressed the need for strong integration and an interdisciplinary approach to the body formed by the intersection between science, society and technology. The next one was published 18 years later by Jasanoff *et al.* (1995), with the official approval of the 4S. A third is the recent volume of Hackett *et al.* (2008), whose contributors had the task of consolidating «the field's accomplishments, of welcoming new scholars to the field, and of indicating promising research pathways into the future» (*ib.*, p. 3). As usual, it was maintained that a history of STS should begin from the work of Kuhn (1962), that «opened up novel possibilities for looking at science as a social activity» (Sismondo 2008, p. 14). By taking as their subject matter concrete instantiations of the science and society relationship, STS presents itself as a kind of intellectual activity that does not consider the criteria for the validity of scientific thought, but rather it investigates the practices through which science makes up its social credibility, that is the modalities through which scientists' assertions become part of society's shared corpus of knowledge.

The foundations of STS can be found in a great variety of disciplines (interdisciplinary is indeed one of its main characteristics) that have often had an independent origin, such as "Science Studies" (which according to Jasanoff 1996, n. 2, is simply the "abbreviation" for STS and include epistemology and philosophy of science as well as history, sociology, and political theory), "History of Technology", "History and Philosophy of Science", and science and technology policy. According to Tallacchini, STS originated in the 1970s from a variety of interests and from the coming together of philosophy, sociology of science and anthropology. They are characterized by

> a shared interest in the socio-cultural roots of scientific thought, in the intricate relationship between science and social science, in the knowledge/power relationship within science, in the general relationship between science and society and especially in the role of science within society, and finally for the role science plays in influencing political-juridical institutions. (Tallacchini 2008, p. 7).

One aspect that came to light from this new approach to science (and is linked to the circumstance that has had considerable importance since the origins of STS), is the so-called "turn to technology", according to the expression of Steve Woolgar (1991), that has been favoured in particular by two works of MacKenzie & Wajcman (1985) and Bijker *et al*. (1987), which gave rise to a parallel programme called *Social Construction of Technology* (SCOT), which Jasanoff (1996, p. 414) linked with SSK. Its supporters – often coming from constructivist and post-modernist perspectives – reject so-called "technological determinism", i.e. the union of two claims:

1) that technological development takes place outside society, that it is independent of economic, political and social forces, and is a consequence of the activities of scientists and engineers who cultivate science based on an internal logic that has nothing to do with social relationships (according to the usual viewpoint of received tradition and Received View);

2) that «technological change causes or determines social change» (Wyatt 2008, p. 168), so that the future of humanity – its cultural values, social structure and its history – is defined by the technological resources that scientific progress gradually puts at its disposal; in brief, that the development of technology is something taken for granted, limiting the scholar to «analysis of the social consequences of technological development» (Bucchi 2002, p. 97). From the determinist view, historical civilisations are identified according to the technology predominant at the time (the Stone age, the Bronze age, the age of steam and the age of the computer) and nations are sometimes characterized by their technologically predominant inclinations: The USA and cars, Japan and micro-electronics, Holland and windmills, etc. (Wyatt 2008, p. 167).

> Determinism thus implies that our technology and its corresponding institutional structures are univer-

> sal, indeed, planetary in scope. There may be many forms of tribal society, many feudalisms, even many forms of early capitalism, but there is only one modernity and it is exemplified in our society for good or ill. (Feenberg 1999, p. 78)

Technological determinism is essentially an optimistic vision that places technological evolution and human progress on an equal footing and that has had supporters both from the Marxists and the conservative right, which sees only in technology the possibility to resolve the crises incumbent on the modern world (such as the energy crisis). But it is also the pessimistic statement of those who contest contemporary society on the basis of its technology drift (e.g., Jacques Ellul and the Frankfurt school), or even all of Western history, marked by Heidegger as the domination of techno-science, "calculating" thought, and the forgetting of Being.

In contrast to technological determinism, often tacitly assumed as a sort of collective sense by the masses and also by politicians, the SCOT programme aims to place the human actions that forge technology at the centre of attention and underline how the reasons for assessing the success of a given item of technology do not lie simply in the fact that it is the best at our disposal; rather, one should seek, in the social context or in the way in which they are defined, the criteria of what "is better" and with which its success is measured, as well as pointing out who are the stakeholders that take part in its definition. We should analyse the stories of competition and failures concerning technological artefacts with the aim of investigating in depth what has really led one product to prevail over another, beyond efficiency-minded determinism. The path of a technological statement is in fact at first multilinear, and leads gradually to simplification; it does not follow a unilateral logic but is the complex fruit of the interaction of numerous socio-political-economical elements (see Bucchi 2002, p. 106). As Feenberg has efficaciously argued: «technical design can only be defined contextually and locally by the particular technology-society relationship. There is a significant degree of contingency, difference, or, "interpretive flexibility" in a society's relationship with particular technologies» (quoted in Veak 2006, p. xiii).

This perspective contributes to re-opening the discussion on the traditional way in which the relationship between basic and applied research has been viewed since the Second World War, when it was theorized in an exemplary way in the report by Vannevar Bush (see § 0.3.1) and still lies at the basis of the politics of science assumed by different National states and by the EU itself. This distinction has been contested more and more often in recent years (not only by SCOT) and is considered to have practically disappeared in many areas of scientific research. John Ziman (2002), for example, claimed that science has now entered a "post-academic" phase, in which the clear distinction between science and technology, and between pure and applied research is no longer useful. And yet, despite these critical reservations, in many countries the financial incentives of governments are paid out on the basis of a three-way division between basic research, applied research and experimental development, and so very detailed definitions are given of these three areas.

It is in the setting of the growing integration between science and technology that we must assess the concrete policies of research that are made by diverse states and by the EC. But this cannot be done without taking into account the vast critical discussion that has taken place in this field, a development that forms the fundamental epistemological premise for a thorough analysis of the politics of research. One of our objectives is to answer one of the fundamental questions: in what way may the epistemological, sociological and technological models of science influence the politics of R&D of the individual countries of the EC?

3.6 – STS and science policy

In order to answer the question closing the previous section, we must now try to assess the role current STS practice plays in science policy.

We have already said that despite the great variety of approaches within STS, their social constructivist perspective and their battle against technological determinism places them, according to many commentators (see especially Gross & Levitt 1998; Koertge 2000; Zammito 2004; Brown 2009), in a postmodernist perspective, the so-called "postmodern interpretation of science"

(PIS). Of course, the postulated dependence of techno-scientific content on socio-historical context ascribe STS to cultural relativism; and this is certainly an anti-modern, counter-enlightenment conceptual trait (Sternhell 2006). But "anti-modernism" is not the same as "postmodernism"; and postmodernism is not "hypermodernism", which we believe better characterizes the condition of the present age, including the function both scientists and general public ascribe to current techno-scientific practice (Charles 2007, 2009; Lypovetsky & Charles 2004). Talks of "metanarratives" in the STS literature is a clear indication of their affiliation to postmodernist positions such as that of Jean-François Lyotard (see § 0.2) and we shall try to show that by subscribing to this perspective, STS unwittingly risk being ineffective in terms of science policy.

In order to be effective in terms of policy, STS should take an ideological stance that they are unwilling to take or simply not equipped for doing so. In fact, once we establish that STS heuristics is mainly concerned – assuming the underdetermination of theory by logic and evidence – with the reconstruction of theory-choice and techno-scientific change episodes through sociological explanatory categories such as macro- and micro-sociological interests, it seems that theory-choice becomes a matter of deliberate choice. In other words, once social interests are thought to condition theory-formation and theory-choice, we should establish criteria for distinguishing "sound science" and "unsound science" in order to be able to deliberate choices concerning science regulation (for example, issues concerning allocation of funds for promising research projects) and so to distinguish between social influences having positive outcomes (in terms of advantage for society in general, in a sense that varies with varying ideological perspective) and those having negative ones accordingly. But given STS's acceptation of the "symmetry postulate" (Bloor 1976, pp. 4-5) – according to which sociology of science is impartial with respect to truth and falsity, rationality and irrationality, «in opposition to an earlier prevailing assumption, still defended in many quarters, which has it that true (or rational) beliefs are to be explained by reference to reality, while false (or irrational) beliefs are explained by reference to the distorting influence of society» (Bloor 1999, p. 84) – they would never surpass this "evaluative" (and thus normative) threshold without betraying their own methodological boundaries. So STS has an ambivalent relationship with science policy: on the one hand, it is the expert area that science policy makers look at for policy advising and this gives them the opportunity to express their social engineering potential; on the other hand, their relativistic position commands them not to discriminate between different scientific opinions.

This is a consequence of their declared stance against modern ways of thinking. Already between the two world wars, neo-positivists such as Otto Neurath had spotted that it is not always possible to choose between rival theories as they very often are logically and/or empirically equivalent; hence the need for deliberative choice based upon a general ideological perspective. He therefore proposed to employ sociological methodology to spot extra-evidential interests biasing theory-choice and to condemn all those interests that would employ science products for implementing egotistical or conservative ideals such as personal profit, prestige, social coercion and suchlike (see Neurath 1935). That is, according to Neurath, in the face of cultural relativism we should employ a cross-cultural ideal, such as the Baconian ideal of a science solely addressed to the betterment of general society. Scientific theories could be therefore evaluated by their effectiveness in fulfilling a predetermined, ideological end. Neurath's view therefore constituted a historicist alternative within neopositivism. Of course, Neurath's view did not attract as much consensus as value-freedom and a-historicism within neopositivism. But we may ask why Neurath's historicist alternative could have coexisted with an a-historicist stance within neopositivism till the end of the 1940s without having the same disruptive effects of Kuhn's historicist turn in the 1960s. The answer lies in the fact that while Neurath and the other neo-positivists were united by their common affiliation to a modern and illuminist scientific ideal, the same cannot be said in the case of Kuhn and his postmodernist heirs. In fact, Kuhn did not propose a cross-cultural ideal in order to overcome the relativistic consequences of his historicism.

And indeed, it should not come as a surprise that Neurath's perspective had not the same impact for philosophy of science that Kuhn's had. When neopositivism entered American soil it was

Neurath's alternative that was welcomed and assimilated, especially by progressive academics (Reisch 2005). It is with the end of War World two and the advent of McCarthyism that the emigrated group of neo-positivism had to dissimulate their leftist commitments by accentuating the abstract and formalist character of their philosophy. This is a situation that regarded many areas of high modernism thought (McCumber 2001), but it came only recently to the attention of historians of the philosophy of science.

Does this have any bearing on the relationship between STS and science policy in contemporary times? The real critical target of STS's postmodernism is not wholly methodological. Rather, it is ideological. As in the case of Neurath's historicism, relativism *per se* does not imply an abandonment of modernity ideals in STS. So STS need more than a historicist perspective to convince HPSS's practitioners to commit themselves to postmodernism.

The real critical target of STS's postmodernism is not the social enlightenment embedded in interwar modernist cultural instantiations such as neo-positivism, it is rather post-World War II high modernity renunciation of civic and social engagement which has left science and technology in the hands of unscrupulous power groups (or benevolent ones; it depends on one's perspective). If this is correct, STS's postmodernism does not aim to go "beyond" modernity as such. It would be rather engaged in a re-ideologization of high modernity that because of the symmetry principle becomes unfeasible to pursue. STS are trying to propose to unveil the power struggle in science without being able to justify the direction they would like science policy to take.

In order to settle this issue we may first try to understand what is meant by "modernity" and "postmodernism". Jürgen Habermas (1983, p. 9) speaks of the "project" of modernity as the efforts of the eighteenth-century enlightenment thinkers to develop science, ethics and law according to impartial, universal and objective standards. In this respect, the project was emancipating, since the employment of universal normative standards by individuals' cooperation would have freed them from intellectual dogmatism and political despotism. The ethics, science and political theory developed in the late seventeenth and early eighteenth centuries are the tools through which the Enlightenment of the eighteenth century sought to achieve the emancipation of society. Neopositivism, an enlightenment emancipation project, as we saw in § 2.1, can be ascribed to the project of modernity as Habermas understands it.

Habermas took inspiration for the eighteenth-century emancipation ideal of the Enlightenment from (among other sources) Cassirer's *Die Philosophie der Aufklärung* (1932). There, Cassirer tells us that eighteenth-century Enlightenment thinkers thought that the key for both individual emancipation and social betterment was to direct a community of individuals working freely and in autonomy towards a common objective. Such a community would accumulate and employ scientific knowledge in order to obtain freedom from poverty and natural disaster.

Unlike Habermas and other pro-enlightenment thinkers, Max Horkheimer and Theodor W. Adorno, in their well-known *Dialektik der Aufklärung* (1947), conceive of the project of modernity as wrongheaded in the light of its twentieth-century outcomes: the two world wars, Hitler's Germany, Auschwitz, the nuclear threat after Hiroshima and Nagasaki, and Stalin's Russia, for instance. These examples show, according to Horkheimer and Adorno, that the real aim beyond the good façade of the project of modernity is domination and oppression. In particular, the scientific ideal of domination over nature was really the ideal of domination over human beings. They saw a view out in the idea of human nature's rebellion against the means of domination of modernity, that is the rebellion of mankind against the oppression of instrumental reason, which is typically instantiated in the ideal of scientific rationality, over culture and personality (Schecter 2010).

But was modernity really wrongheaded? That is, were the horizons of expectations of the eighteenth-century Enlightenment really an illusion in the sense that the means it adopted were destined to give the disastrous outcomes of twentieth century rather than the moral and social betterment the Enlightenment's thinkers envisaged? And did it not in fact lead to social betterment on several fronts? Habermas believes that there really was an impairment of means and ends, but, given the goodness of the ends, something went wrong with the implementation of the means. In other words – and this is Habermas' main thesis – the project of modernity should not be seen as brought to an end by revealing its real domination and oppression aims, as Horkheimer and Adorno claim; rather, it should be regarded as simply incomplete. In this respect, the validity of the project of modernity depends on how we explain the irrational and disastrous outcomes of modernity in the twentieth century. If the cause is the modernity project itself, then it must be rejected, but if the cause is a wrong implementation of the social enlightenment ideal, then the project of modernity must be redirected towards the original end in order to achieve completion.

While the Horkheimer-Adorno thesis can be said to be "anti-modern" in that they reject the project of modernity as Habermas understood it, theirs is not a postmodern perspective. In the wake of human nature's rebellion against the instrumental rationality of the Enlightenment, the two men substitute one emancipatory ideal for another. According to them, the project of modernity must be replaced by another, genuinely emancipatory project, specifically the revised version of Marxism promoted by the Frankfurt School, of which Horkheimer and Adorno are chief exponents. By contrast, Lyotard (1979), calls for the renunciation of both modern and anti-modern emancipation projects by subsuming the latter into the former. The metanarratives, criticized by Lyotard (see § 0.2), serve the purpose of legitimating thought and action or, more simply, knowledge claims and their consequences, in terms of progress and emancipation. This involves placing some specific knowledge claim into a unified theory of history that traces a path toward a pre-established positive end, such as freedom, justice, economic welfare, equality, and so on. Beliefs and general knowledge are therefore justified according to their validity as successful means with respect to progressive and emancipatory ends (and this was, as we have seen, Neurath's main trust in the modernity ideal). Lyotard defines in fact metanarratives as «narrations with a legitimating function» (1979, p. 19). Therefore, he defines the project of modernity as all those metanarratives which serve the purpose of legitimating knowledge (*ib.*, p. xxiii).

Habermas's characterization of the project of modernity in terms of its emancipatory social enlightenment ideal somehow encompasses all the features of metanarratives identified by Lyotard. But why should we be incredulous towards metanarratives? Why should we believe that Lyotard is right when he says that, contrary to Habermas, «the project of modernity has not been forsaken or forgotten, but destroyed» (1986, p. 28), and we now all live the postmodern condition? In this respect, Lyotard offers a socio-economic explanation.

In the first part of *La condition postmoderne* Lyotard analyzes the socio-economic transformation of the "post-industrial" society. The latter is a socio-historical category introduced and discussed by Alain Touraine (1969) and Daniel Bell (1973) (see § 0.1). Drawing from Bell, Lyotard believes that the «the status of knowledge is altered as societies enter what is known as the post-industrial age» (1979, p. 3). By the "status" and "nature" of knowledge, Lyotard seems to refer respectively to the role it plays in post-industrial society and the consequent change in its "performative" function Following Bell, Lyotard rightly interprets the socio-economic history of Western societies by singling out a transition for competition for access to natural resources (consider colonialism, for example) to competition for control of information. There has been in the contemporary age a growing awareness of the techno-scientific potential of nations. Territories such as Europe, which have few natural resources, have strengthened their knowledge potential and put it to the use of a service-based economy. In so doing, they have achieved for themselves a role in the world economic competition despite their lack of natural resources by commercializing their service and techno-scientific potential. It is this latter aspect that Lyotard stressed as early as 1979. Given the transition to a service-based economy in which the knowledge potential of a nation decides its rank in the global economic competition, the performative function of knowledge (its *nature*) has changed in the sense that it becomes "commodified". The rationale is simple. In order to take a role in global capitalism, knowledge has to acquire a commercial value becoming an exchange commodity. In some instances, knowledge is privatized, while in public contexts it is produced by pursuing financial objectives for the public good in terms of economic growth (growth in the production and diffusion of commercial goods and services). Therefore there has been a transition in the performative function of knowledge, from a more general employment for the benefit of general society to a money-making instrumental role in terms of satisfying a complex nexus of private financial interests. It is this transition that defines the main characteristics of "knowledge economy" (see § 0.3), namely the main trust of the concept of "knowledge society" that – according to the hopes and wishes of the EU and many policy makers – is the new phase of world history towards which the most dynamic economies seem to be heading.

So far so good. In fact, the commercialization of science and its negative outcomes are phenomena – as we shall see – that nobody can deny. However, Lyotard wants to show that the commercialization of science elicits incredulity towards the metanarrative of modernity; that is, commercialization of knowledge has a delegitimizing function; in turn, delegitimation should draw us to reject metanarratives. Modern science uses, according to Lyotard, the emancipatory metanarrative of the Enlightenment to legitimise itself. Knowledge and education are pursued in order to free mankind from superstition and despotism. Therefore, it is legitimate to pursue that knowledge which can guarantee the emancipatory result. But, Lyotard argues, with the changed status of knowledge in the post-industrial society, science has lost its original performative function (the emancipatory benefit of general society). Now it serves the financial purposes of private corporations and its performative function is evaluated solely in terms of economic gain. The same apply to public knowledge, especially in the light of the newly shared ideals of nations to invest in science in order to obtain economic growth. As Lyotard puts it: «The question of knowledge is now more than ever a question of government» (1979, p. 9). Yet we cannot see how this should delegitimize the project of modernity in terms of it being rejected and never implemented again.

Lyotard says that knowledge becomes a commodity by acquiring "exchange value" and losing its "use value". But this is unclear, or maybe incorrect. Marx in chapter 1, section 1, of his *Capital*, explains that in order for goods to acquire an exchange value, they must retain their use value for general society. In fact a socio-economic transition towards mass privatization and global economy does not transform the performative function of science in a irreversible way. From a description of a socio-economic context it does not follow that the original performative function of science (i.e. to increase our knowledge of the world and employ it for public benefits that go beyond market-oriented economic growth) cannot be restored. Specifically, the new status of knowledge consists of defining the use-value of science in terms of exchange value, but this is a specific instantiation of the way knowledge can be defined given the relevant socio-economic context. We are indeed able to criticize this special (restricted) reading of the use-value of knowledge because outside its definition as exchange-value it preserves its original general public function. It sounds like we may restore the old Baconian ideal to take science out of the commodification impasse. Nothing can stop us from thinking that the original emancipatory ideal has been betrayed, so to speak.

Perhaps we can trace this sense of irreversibility of the change in the nature of science in Michel Foucault's theory of power/knowledge. According to Foucault, knowledge and power are indiscernible. Knowledge is used for power gain and power constrains epistemic gain. Socio-political factors (i.e. interests relative to the acquisition of power) enter science in the forms of factors influencing decisions concerning what kind of research is to be pursued and which kind of research activity must be funded. There are also micro-sociological factors at play, such as pursuing a specific research activity because it guarantees career benefits, personal or social prestige, money or simple revenge against a colleague. But this concerns the institutional environment of knowledge, not its content. The content may well be used to fulfil interests of every sort. The fact that in the post-industrial society the content of knowledge is employed to fulfil market-oriented interests does not imply that the same content cannot be used to fulfil the Baconian ideal of an increase in the power of mankind over nature by epistemic gain or the Enlightenment emancipatory ideal more generally. Therefore, even if we grant the inseparability of knowledge and power, we do not see how this should impede a rehabilitation of the emancipatory ideal; we do not see how incredulity towards the metanarrative of modernity and the acknowledgment of its failure (in terms of implementing its progressive and emancipatory ideal) should drive us to abandon its conceptual hardcore: the possibility of projecting our future along enlightened lines, that is, according to the ideal of social planning according to rational principles. In other words, we do not think the ideology of modernity has as its necessary consequence the deleterious historical outcomes it seems to have had, as postmodernism wants to imply. Above all, the science and politics of the Enlightenment are not the concrete instantiation of a meta-historical understanding of the ideal of Truth. Nor do they envisage a necessary path for humanity. Rather, they are useful adaptive tools, regulative ideals, for efficacious evolutionary strategies that mankind could adopt, much in the same way as Neurath understood the function of the modernity ideal. Therefore, the project of modernity, its turn of mind on science and social organization, are immune from postmodernism arguments from history and the current socio-economic situation. Secondly, it is untrue that the ideals beyond the project of modernity have been definitively eclipsed, for some of its constitutive metanarratives are still alive and kicking in the context of what has been defined, by opposition to the idea we have ineluctably entered the postmodern age, as the age of "hypermodernism":

> Putting it briefly and schematically, modernity had organized itself around four fundamental elements put in place around the sixteenth and seventeenth centuries. First, "modernity" was the inauguration of a new manner of governance based above all on the notion of a social pact that conferred inalienable rights upon its contract-holders, as well as the view that democracy is the best regime for this kind of legal contractualism; second, it was a new manner of thinking that would make reason and scientific invention central to the functioning of society; third, it was a new manner of production and consumption based on capitalist laws of the market; and fourth, it was a new way of living in which the individual trumped the collective. And far from all four elements having since been invalidated in some newer, postmodern era, these elements still do, in fact, structure our present. Yet they have become radicalized: they have passed over into a logic of excess, to the point where no counter-power seems able to oppose their frenetic development at any point in the foreseeable future. (Charles 2009, p. 391)

On this reading, we may offer another reading of the crisis of modernity that would avoid a redundant talk about incredulity towards metanarratives, delegitimizing and legitimating narratives and suchlike. For instance, when we argue that incredulity may elicit an attempt to restore the project of modernity according to its original lines, we refer to the kind of historicism put forward by Neurath (and John Dewey in the same period) that we have discussed above. Social factors influence knowledge production. Given this, we can regulate social influence towards a desired end, such as moral and social betterment, by deliberation. This kind of deliberate choice requires the adoption of a cross-contexts ideal such as the emancipatory enlightenment ideal. In doing so, Neurath breaks with the pretention of value-freedom in science practice. Instead, he asks scientists and philosophers to assume the socio-political influences on the technical content of science and to take a stance on which social influences should be adopted as ends on the basis of a shared predetermined supra-content ideal.

We shall quote Bell again to clarify this point. Bell (1960) invites us to consider how, from 1950 to 1960, Fascist ideologies became taboo, and communism was condemned and relegated to the East. Once the alternatives were so neutralized, liberal democracy and corporate capitalism no longer required an ideological justification, since they had become the only remaining course of action for the preservation of social order. In this respect, Bell dubbed the decade between 1950 and 1960 as the age of "the end of ideology". Such a thesis can still be applied nowadays – because of the end of communism and the large diffusion of capitalism among the remaining socialist countries – and it has found a more radical ideological metamorphosis in the idea of "the end of history" (Fukuyama 1992). In the age of the end of ideology there formed the illusion that science could be pursued in an impersonal fashion, and that in so doing it would have performed its general social function without ideological guides. This was the case of high modernity neopositivism in North America. With reference to the things discussed so far, the end of ideology may have caused the negative drifting away of the performative nature of science from the Enlightenment ideal. This is a matter apparently decided on empirical grounds: de-ideologization has caused the failure of the enlightenment ideal, as we can see in the history of the second half of the twentieth century in which high modernity culture became the helpmate of corporate capitalism (Guilbaut 1983). Re-ideologization may be the solution. Neurath's stress on deliberation in theory-choice is a re-ideologization attempt in the face of cultural relativism and the context-dependence of scientific knowledge.

In a sense, the end of ideology and value-freedom left science defenceless against private interests of an extra-scientific sort. Science depoliticization has no ideology to set against capitalism and market-oriented interests. Neurath's historicist and Marxist perspective, with his stress on planned deliberation, was designed to avoid that; and the project of modernity was the ideal explicitly employed against corporate capitalism.

But the end of ideology did not affect just science and philosophy. It is a phenomenon that, in the aftermath of World War II, involved architecture, the arts and literature too (Harvey 1990). The end of ideology Bell saw as starting in the 1950s broke with the previous progressive political tradition of modernist movements. In particular, political engagement became a necessity for the modernist intellectuals and artists in the aftermath of the 1848 revolutions and the publication of Marx' and Engels's *Manifesto of the Communist Party*. Before these events, Adam Smith's idea that a benevolent capitalism would have to break with feudalism and would then ineluctably drive mankind toward universal well-being could still be accepted. But the disparity among class within capitalism pointed out by Marx and Engels broke with the enlightenment dream of the benevolence of a self-organizing capitalism (Smith's "invisible hand"). So Marx and Engels inspired the question of political and social engagement: who was to guide the project of modernity? The bourgeoisie or the proletariat? Which side should the artist and the intellectual take?

Although it may sound like a gross oversimplification, we may reasonably say that in the inter-war period, modernist movements in architecture, art, literature and philosophy chose the progressive side (see Toulmin 1990; Galison 1990). For instance, with the end of ideology, like neopositivism, modernist architecture became depoliticized. High modernism in general became institutionalized and well integrated into the framework of capitalism. High modernism, especially in the States, manifested its positivist, technocratic and rationalistic characteristics at their maximum (Harvey 1990). Mass privatization and economic globalization became justified benevolent practices at the international level, as the only possibility for poorer world economies to join the happy life of the richer ones. The ideas of inter-war modernism became essential for the post-war reconstruction in the 1950s and the ideas of Mies van der Rohe and the other modernists influenced architecture and town planning up through the 1960s. Capitalism became almost synonymous with anti-Fascism and a necessary condition for democracy (Guilbaut 1983). Science and philosophy joined the technological war against the East in the service of democracy and capitalism. Specifically in the States, Dewey's pragmatism and Neurath's politicized philosophy of science, with their quest for modernity, disappeared in favour of depoliticized neopositivism. We see nowadays not the end of modernity, rather we bear witness to a radicalization of some aspects of its original progressive aims; it has radicalized the ideals of economic competition, commodification of public assets, specialization and professionalization at the expense of mutual cooperation, altruism and generalism. The modernity of the day is one without a perspective on the future, for there is no perspective on it to be overcome and therefore modified; the end point of mankind's destiny (Fukuyama 1992). We see the dissolution of the original Enlightenment project of modernity: the hope for tolerance towards difference and for the possibility of radical change. In fact, the radicalization of modernity does not allow for any projection that foresees a discontinuity with the original project. This is the reason why current society – which has been rightly dubbed hypermodern – is just the sacralisation of the modern one, its "demonic" sneer (see Charles 2007, p. 36).

Could it be that what Lyotard is really fighting is the depoliticized and de-ideologized cultural instances of high modernity rather than progressive modernism? Given the current socio-economic disaster in the post-industrial age, if the cause is, as we suppose, the de-ideologization of cultural practice that is then subservient to power, does not the postmodernist aversion for cross-cultural universal ideals leave us with no solutions to the takeover of capitalism's egotistical interests?

Lyotard finds himself in an ideological impasse that STS's attempt at science policy making inherits in full. STS are not necessarily anti-capitalistic. Even working within a macroeconomic capitalist framework, however, from the STS literature the idea emerges that macro-economic reform is necessary to deal with egotistical drives within science. Otherwise, the condemnation of market-based techno-scientific and environmental policies would remain just that, a lamentation that is a far cry from normative solutions. At the very least, STS's condemnation of modernity needs further historiographic clarification.

We believe postmodernism and STS have given a voice to this lamentation, but we also believe that the cure they prescribe against modernity risks killing the patient: the re-ideologization we envisage does not imply a renunciation of reason and of the general legacy of Enlightenment thought. Rather it wants to contribute to the cure for that typical "neurosis of science" (Maxwell 2004), that is a cure against the repression of the main ideological and motivational tenets which have been abstracted by the rationalistic image it has assumed in the history of philosophy. We aim to rescue the civic and social dimension of the project of modernity: the metaphysical ideal of the intelligibility of our universe because of its intrinsic order, the values influencing that comprehension, its social, cultural, political and economical dimension supervening upon choice and action. To sum up, we would like to revise that philosophical formalism and abstractness (which we have seen in the case of the Received View and traditional neopositivism) that has given us a disembodied image of science as a ethereal rational enterprise solely aiming at a knowledge of truth for its own sake. By representing itself as more rational that it really is, Science stops itself from achieving a higher level of rationality. As Maxwell argued:

> We suffer not from too much scientific rationality, but from not enough. What is generally taken to constitute scientific rationality is actually nothing of the kind. It is rationalistic neurosis, a characteristic, influential and damaging kind of irrationality masquerading as rationality. Science is damaged by being trapped within a widely upheld but severely defective philosophy of science; free science from this defective philosophy, provide it with a more intellectually rigorous philosophy, and it will flourish in both intellectual and humanitarian terms. And more generally, as we shall see, academic inquiry as a whole is damaged by being trapped within an intellectually defective philosophy of inquiry; free it from this defective philosophy, from its rationalistic neurosis, and it will flourish in intellectual and human terms. It is not reason that is damaging, but defective pretensions to reason — rationalistic neurosis — masquerading as reason. (Maxwell 2004, p. xi)

Only by rethinking science along these lines may we one day fully understand the postmodernist instances of STS, without rejecting the enlightenment legacy of the modern conception of science in the process. Then, it will be possible for us to understand science not just as knowledge (as the most reliable mankind could achieve), but also as wisdom, that is an enterprise able to identify the main problems of humanity and solve them accordingly. In order for this to be possible one day, we need a new image for science, one that is produced by a philosophy of science which is able to grasp science in its social, and not just technical, complexity. It is on the basis of this new framework for science studies that it will be possible to construct a new way of conceiving of the relationship between science and society, as well as of its political governance. This is the task we have set for ourselves that will be tackled in the following chapters.

4. From the descriptive to the normative: a multidisciplinary approach for descriptively-informed science-policy

4.0 – Overview

STS is mainly descriptive. It offers philosophical, historical and sociological descriptions of science practice that should offer science policy makers the best available evidence to better inform the formal construction of the relevant decision problems of science practice.

Nonetheless, there are severe methodological incompatibilities between the descriptive methodologies encompassing STS. Here we aim to solve them by offering a multidisciplinary methodological integration of the special disciplines that are parts of STS against a reductionist interdisciplinary unification (§ 4.1), arguing that if STS wants to contribute to policy advising by constructing narratives of science practice feasible for science policy both in terms of descriptive completeness and intelligibility, then it must avoid the explanatory reductionism tendencies of special disciplines in interdisciplinary contexts (§ 4.2).

Once the conditions for multidisciplinarity have been set and defended, we have proceeded to discuss a special approach to the philosophy of science: the Modeling Approach to Science (MAS) which seems the right candidate among other approaches to the philosophy of science to facilitate the integration of the methodologically different contributions to STS toward policy objectives. In fact, besides offering a more realistic and descriptively complete picture of science practice with respect to its predecessor in the philosophy of science (§ 4.3), namely the syntactic view, MAS is also able to capture some aspects of science practice that elude even sociological approaches to STS, thus inviting different perspective on the same subject matter (§ 4.4). Having shown the kind of contribution MAS can offer as a complement to other approaches to STS, we have articulated further its internal advantages and argue for its important role in the context of the disenchantment of both experts and the general public towards science's quest for certainty (§ 4.5).

Finally, we shall try to see whether STS can establish itself as a normative discipline beyond its primary descriptive nature (§ 4.6). We shall argue that it should not. STS can help policy makers by offering, as we said above, informed descriptive narratives for policy making, specifically for science evaluation and regulation, and that in this respect it may suggest how to use this information without going beyond the threshold of policy "advising."

4.1 – Multidisciplinary versus interdisciplinary integration of STS's methodological variation

While in ch. 3 we summarized the history of post-Mertonian sociology of science, here we shall selectively consider some interesting aspects of SSK approaches. We shall especially focus on the sociology of science developed in the context of the Edinburgh School founded by the sociologist and historian of science David Edge and Bruno Latour's Laboratory Studies (see, respectively, §§ 3.3 and 3.4). Cultural relativism and social constructivism – respectively the idea that the emergence of social and cognitive values in science practice (norms and states of belief) is always relative to specific cultural contexts, so that there are no universal criteria for their evaluation, and the hypothesis that these values are the result of social manipulation – characterizing this approach had a systematic conceptual exposition in the writings of Barry Barnes (1974), David Bloor (1976) and Steven Shapin (1982), among others. Interest theory, the methodology according to which behaviours, norms and practices can be explained in terms of being determined in their construction by group interests, is the sociological approach generally employed by these thinkers. These authors focus especially on the individuation of macro-sociological interactions as factors explaining knowledge production and practice, while their most direct descendants, like Bruno Latour and Steve Woolgar's Laboratory Studies for example (see Latour & Woolgar 1986), focus mainly on micro-sociological interactions that nonetheless are often reduced to macro-sociological ones (this seems to be the case of Latour's *Actor-Network Theory*; see Latour 1987, 1989). The macro and the micro approaches in post-Mertonian sociology, in fact, follow the same heuristics as their Mertonian predecessors, namely interest theory, but differ from Merton's approach in not distinguishing between the influence of scientific content and social norms, making the determination of the first also dependent from social interests.

It is in this naturalistic and interdisciplinary fashion that philosophy of science enters the methodologically variegated arena of STS. But, as confirmed by the large number of sociological contributions compared to those coming from other fields published in the handbooks dedicated to the new subject (the last two are Jasanoff *et al.* 1995 and Hackett *et al*. 2008), it seems clear that the interdisciplinary character of STS looks more like a methodological subsumption of anthropology, literary critics, philosophy, and psychology into the heuristics of sociology of science (see Coniglione 2009; Viola 2009a). This may be a good or a bad thing. It is good because, through STS, as we saw in ch. 3, sociologists of science have created a quasi-tolerant environment for methodological practices that were traditionally distant. It could be bad because interdisciplinarity has feasibility limitations. That is, it is feasible only by establishing a discipline methodology that serves as an umbrella under which others become unified, as we are going to show.

Ronald Giere (1999, p. 63) exploits Thomas Parke Hughes's system approach to techno-scientific development in order to show why we should prefer a *multi-disciplinary integration* of the disciplines comprising STS to their *inter-disciplinary unification* (see Pickering 1995).

This is one of the theoretical results that emerged more strongly from our research activities. As we have seen, the theoretical foundations of contemporary STS originated from the rejection of the basic methodological commitments of post War World II History, Philosophy and Sociology of Science (HPSS). Such a theoretical rejection implied the dismissal of a broader view on science, technology and society that some authors date back to the Modern Enlightenment and whose basic tenets are thought to be embedded in the first phase of the philosophy of science, represented by neo-positivism and its American followers. The basic neo-positivist enlightenment ideas concerned the beliefs that there are universal natural laws governing the material world and that human agents can know whether such laws are "true" on the basis of universal (normative) principles of "rationality". These basic beliefs imply the "autonomy" of science with respect to the rest of society, since science legitimacy, on this view, is based on universal principles detached from social context. Such a separation between science and the society in which it is embedded runs contrary to the very objective of creating a knowledge-based society where science and technology are all but detached from their social endeavour.

The problem is that the alternatives proposed by STS are "sociologically homogeneous", meaning that all analytical explanatory categories are sociological categories: they usually require a mixed assortment of epistemological and ontological reductionisms. Our analysis has not shown that sociology is wrong in its descriptive method, rather that it formulates incomplete descriptions of Science and Technology (S&T) and it needs an extension of its explanatory-causal reach. This means that sociological analysis alone (even if aided by ethnogeography, literature, information technology and so on) cannot picture by means of its models the complexity of techno-scientific practice and development. Our exploration of sociological models, epistemological models and models integrating their respective explanatory matrices strongly suggests that no "mono-theoretical" account of S&T practice and development can be an adequate account. This is due to the complexity of technology as a *system*: although all the components of a system do interact, so as to suggest that we can explain their interaction by means of the same category of factors (social interests, say), a system approach also distinguishes between the different components allowing for internal analysis of individual parts as well as for particular interactions among single components selected from the whole system for the explanatory purpose at hand. Neither standard neo-positivism nor social reductionism would allow for any of these distinctions. The idea is that no techno-scientific development or practice can be treated from a single perspective. Rather, their study requires an integration strategy able to integrate such a variegated field as STS. Specifically, we shall try to show that this is so by picturing the complexity of techno-science as a "perspective" system (in a sense very close to Giere's conception of "scientific perspectivism" – see his 2006), that is, as a complex system representing the varieties of the different angles from which a phenomenon can be understood as interacting component perspective subsystems.

According to current STS practice, we can reasonably distinguish four perspective subsystems in techno-science:

- explaining phenomena of scientific change as dependent on the evidential value of scientific or technological content of science products;
- understanding scientific change by tracing the cognitive and psychological features of the various agents involved in science and technology in terms of biases on scientists' decision and representational capacities;
- explaining scientific change through its causal dependency on micro-sociological interactions;
- explaining scientific change through its causal dependency on macro-sociological interactions.

Each one of the four dimensions represents the methodological core of, respectively, (a) traditional philosophy of science (including the interwar period and the first ten years after the second world war); (b) psychology and philosophically informed cognitive sciences (e.g. see Goldman 1986; Giere 1988; Bechtel 1988 and Goldman 1993 for an overview of these approaches); (c) micro- and (d) macro-sociology of science (e.g. respectively, the Laboratory Studies and the Edinburgh School approach).

Each of these four perspective subsystems points out a particular ontological dimension of techno-science as the pool from which causal factors can be drawn to explain scientific change. More importantly, each perspective explains interactions between components of different subsystems (composing the techno-science complexity) by reducing them to the influence of a single explanatory category of causal factors: this is the reductionist mechanism behind the interdisciplinary "unification" of different perspective methodologies under a dominant one.

If the status of data depends on the ontological status of the causes put forward to explain them, the passage from epistemological to ontological reductionism seems unavoidable when we reduce a complex perspective system to a single methodological perspective within the system. This circumstance emerged in the debate between sociologists and philosophers of science in the last quarter of the twentieth century. Critics of the Edinburgh approach lamented that the ontological ramifications of their sociological reductionism had the undesired consequence of not being able to account for the soundness of certain scientific descriptions of the world with actual phenomena that are accepted and believed true by the scientific community, despite the influence of social interests on scientists' decisions. Latour & Woolgar (1986) defended the position that by specifying that there are no scientific facts but only "artefacts", namely facts are not discovered but rather the result of artificial (cultural) constructions serving the ends of individual and group interests. So, from an epistemological reductionist perspective (science is a function of society) with unexpected relapses into ontological reductionism (effects acquire the ontological status of the causes put forward to explain them), we go to an explicit ontological reductionist stance (scientific facts *are* social facts).

In the case of constructivist sociology of science we may notice that unification within this perspective leaves out other perspective methodologies in STS rather than integrating them. For instance, once scientific facts are viewed as socially mediated, how do we account for the representational components of scientists' decisions in terms of "natural" cognitive constraints and limitations? What about modeling practices such as abstraction and idealization that should account for the "fit" of theories and models to actual phenomena? What about coherence, reliability, logical validity and empirical correspondence for that matter? Contemporary naturalized philosophy of science integrates the cognitive and evidential dimensions by conceiving the former as structural constraints biasing value-attribution on the latter (e.g Ruse 1986, ch. 2). Or, if we model scientific change in terms of decision problems, social factors would be among the other factors (cognitive, psychological and evidential) contributing to the overall value assessment of outcomes (e.g Giere 1988, ch. 6). Maybe the most successful attempts at integration are those formulated by David Hull (1988) and Philip Kitcher (1993) in the context of evolutionary epistemology, where social factors are considered as constraints on selection among rival theories together with other causal influences on decisions such as predictive success and cognitive biases, all modelled in a Bayesian decision framework.

It is the resort to decision theory for modeling scientific change put forward by the approaches mentioned above that makes such integration attempts multi- rather than inter-disciplinary. As we have seen, in the case of interdisciplinarity, looking for causes through and into one of the perspective subsystems and reducing interactions among elements of the different subsystems to the same explanatory category of factors is the integration moment throughout: it is indeed "unification" under a single methodology. Epistemological assumptions making up a specific methodology – such as the quasi-exclusive individuation of social factors to explain scientific change in the sociological instances considered so far – determine univocally the ontological status of the different dimensions of techno-science by reducing other types of influences to the same explanatory category. The ontological dependency of effects on methodological assumptions makes integration at the level of assumptions a matter of ontological reductionist unification.

By contrast, in the case of naturalized philosophies of science employing decision theory, no matter what specific mathematical or qualitative decision framework we employ, outcome values are assigned by modeling directly the typologically different influences without questioning the specific methodology through which they have been individuated. Leaving methodological assumptions untouched by "postponing" the integration moment to the level of implementation of individuated causes in a (ontologically) neutral decision framework makes these approaches multi-disciplinary, that is the result of different perspective methodologies that come together as influences on decision taking only after they have expressed all their explanatory potential.

4.2 – Modelling techno-science complexity for science policy

The reductionist move in interdisciplinary contexts described above is legitimated by simplification practices that each discipline employs to model the complexity of the phenomena its practitioners want to describe. Nonetheless, as in the case of social constructivism in STS, reducing the complexity of techno-science to social influence rules out other influences rather than pointing them out for the sake of descriptive completeness.

A multi-disciplinary perspective comes from debunking both the universal validity of unitary and unchanging principles of rationality supervening upon scientific practice (an Enlightenment legacy fully embraced by the so-called Received View of scientific theories – see § 3.1) and the sociological reduction adopted by the majority of contemporary STS theorists. Both approaches are not able to account for the development of science and technology (techno-science) as a multi-level system and try to unify different perspectives in Science Studies by putting forward a unique methodology that, according to the interdisciplinary principle, would constitute the basis for further articulations of analysis from other perspectives. A multi-disciplinary perspective, on the other hand, would avoid this sort of reduction, aiming to integrate different methodologies horizontally so as to obtain a widening of the explanatory reach of Science Studies.

The interdisciplinary perspective unifies the results of different disciplines on a single methodological perspective. It is the model of bees described by James Clerk Maxwell:

> I suppose that when bees crowd together around flowers, they do so because they are after pollen, although they do not know that it is the pollen they will carry from one flower to another that will allow the flowers to flower as well as more crowding together around flowers in the years to come. Therefore, we can do nothing better than to improve the shining hour by favouring the cross-flourishing of science. (Maxwell 1878, p. 54)

Of course, such a procedure implies the predominance of one methodology over others (i.e., hence "physicalistic" or sociological reductionism) that would constitute the privileged point of view from which to understand reality. On the cultural level, an inter-disciplinary perspective is the analogue of inter-culturalism. Contrary to an inter-disciplinary perspective, a multi-disciplinary perspective acknowledges the impossibility of a cognitive reduction, believing in a model-conception of science for which different perspectives each contribute with their individual methodologies reflecting the complexity of the phenomena to be analysed (this is the meta-methodological transposition of what Giere asserts in his 2006, pp. 14-15, with respect to scientific theorizing). In this way, this complexity is considered in its phenomenic value with the conviction that even a methodological reductionist perspective (which, unlike the ontological one, does not pre-suppose any underlying mechanism understood as the last layer of reality) is inadequate to grasp the polymorphic nature of processes of reality. In this respect, a multi-disciplinary perspective is the analogon of multi-culturalism.

Far from criticizing sociological methodology *per se*, we may legitimately ask whether we can employ models able to capture the complexity of the techno-scientific system without privileging one methodology over another. That is what a multi-disciplinary perspective would be in STS, and that is why we should prefer it for policy purposes. In order to answer these questions, we have attempted to look at science practice itself. Modelling practice requires a simplification, of some sort, of the phenomena to be described. For example, mathematical models in population genetics often assume that the environment is constant so as to capture genetic variation and to account for evolutionary change. But the environment is never constant. So the question is: does this sort of simplification account for evolutionary change as it really happens in nature? The answer is that it does in most cases, but not always and not exactly; which is to say that it is a structural property of theoretical models to be imperfect or not-always efficacious (Levins 1966). Both the strategies of simplification and of model-building (which is fully discussed in Coniglione 1990) have an old history in science and in the philosophy of science which dates back at least to Galileo's writings (see Coniglione 2004). As we shall see later (§ 3.5) this genealogy has not been fully recognized yet and it is also a recent development in the philosophy of science.

By their very nature, models simplify and approximate actual phenomena in a theory domain. Nonetheless scientists want their models to maximize "generality", "realism" and "precision" in understanding nature and predicting phenomena.

Generality is not to be understood in the empirical traditional sense of generalization and abstraction (see Duhem 1906, pp. 85-86; Spencer 1910, § 2; Carnap 1966, pp. 228-231), rather it refers to the ability to enlarge explanatory scope of a theory, including more and more phenomena or natural systems. For example, Newton's gravitational theory is more general than Galileo's because it explains not only terrestrial phenomena but also planetary motion. This is the classical conception according to which progress in science consists of formulating ever more efficacious theories in terms of explanatory scope. *Precision* consists of using exactly defined concepts allowing, through their "operazionalization" (often of a mathematical and logical character), precise predictions (given defined limits of approximation) of empirical phenomena; this should distinguish science from non-scientific enterprises such as philosophy (hence Bertrand Russell's "scientific philosophy"). Finally, *realism* is a concept more difficult to define given its philosophical connotations. Assuming a "low" ontological profile, we could state that realism consists of the ability of science to offer descriptive models that are as close as possible to every-day common experience, so that they can be incorporated into ordinary language. Therefore, one theoretical model (a "theory") is more realistic than another if it can be "concretized", namely if the omitted parameters are explained so that we can know the path that took us to their re-introduction in a calculus and, therefore, to its closeness to every-day experience.

Pragmatic considerations on science practice tell us that, where complex systems are involved, such as in STS, we cannot have all these three attributes of models (Levins 1966, p. 422). Rather, we must adopt a modeling strategy that combines two of the three attributes, therefore giving one up. On this basis, we can draw a matrix representing the fulfilment of only two of the three attributes of modeling practice (obviously, one attribute alone could be used, but it seems to us to be insufficient in terms of realism):

Generality	Precision	Realism
No	Yes	Yes
Yes	Yes	No
Yes	No	Yes

We could sacrifice generality to precision and realism (first row), therefore reducing the descriptive parameters, tackling a few aspects of a phenomenon with great accuracy. We could sacrifice realism to generality and precision (second row), which is typical of highly abstract science implementing equations with unrealistic assumptions that, thanks to these assumptions, yield precise and widely-applicable results. Finally, we could sacrifice precision to realism and generality (third row), which seems to be the right candidate for a multidisciplinary perspective. This approach, indeed, consists of using alternative models (constructed by employing different assumptions reflecting different methodologies) to tackle the same problem, in the hope that the various models will give convergent results. The convergence tells us that our description is on the right track while at the same time freeing us from the details of the different models employed.

This last strategy would resolve the methodological non-homogeneousness of HPSS by integrating "from below", that is at the level of individuated factors, rather than "from above", that is at the level of methodological assumptions that, as we have seen, are not easy to integrate without sacrificing much of the complexity of techno-science interactions. In fact, the retention of precision in the case of the first two modeling strategies – sacrificing realism to generality and precision, and generality to precision and realism – is typical of mono-methodological accounts. Realism and generality are sacrificed through reductionist methodologies of the kind we have described in the case of STS interdisciplinarity through social constructivism. However, if we link the integration moment to the check on convergent empirical results, that is in the case in which we adopt the last strategy of sacrificing precision to realism and generality, we postpone the sacrifice of precision leaving each methodology free to deploy its peculiar technicalities till the moment of presenting empirical results for confrontation and possible integration through implementation in a neutral mathematical framework such as those employed in decision theory.

But why should HPSS practitioners go through all this? Why should we prefer generality and realism to precision? To answer these questions, we should keep in mind the role STS scholars are called to take as "advisors" for the construction of science policy strategies. As documented by several calls in the context of science policy research proposals around the world, it is rightly thought that the disciplines comprising the variegated field of STS, particularly the HPSS disciplinary cluster, in the last 40 years have constructed an expertise on their subject matter, techno-science practices, that makes them the right candidates for science policy advising. From our discussion of the difference between multi- and inter-disciplinary approaches in STS, another possible employment for STS scholars besides expertise on ethical issues and on special technical issues can be inferred. For instance, the descriptive character of sociology, history and naturalized philosophy points at their possible employment in constructing narratives specifically designed for the use of policy-makers. We can ask, then, what kind of narrative would be more informative given specific policy needs. When policy makers ask our advice on, say, making the right decision in prioritizing research funding, they would hardly be interested in a technical narrative that uses terms and concepts proper to a given discipline of the HPSS cluster. Technical reports are scientists' work, while STS could function as a "down to earth" translation of that work without adding more specialization into the picture. At this point STS scholars may use two strategies in order to make their writings feasible for and intelligible to policy makers: either constructing interdisciplinary narratives that avoid or define the specialist language employed, or multidisciplinary ones that sacrifice precision to realism and generality. Both strategies have to sacrifice precision at some point. In the first case, however, technicalities are eliminated but the description is in any case obtained through a single methodology and therefore it is incomplete. In the second case, it is the modeling strategy itself that requires the sacrifice of precision for the sake of a more complete description of the phenomena. If for both cases in order to make narratives intelligible for scientists and policy makers alike we have to sacrifice precision, it is legitimate to prefer the sacrifice yielding the most complete descriptive narrative.

4.3 – Beyond theory and observation: the Modeling Approach to Science (MAS)

The naturalization of the philosophy of science did not only mean the reintroduction of the social and the cognitive/psychological dimensions of science into philosophical descriptions of science practice. What is peculiar to the third phase is that the new philosophy of science – put forward by Kuhn, Hanson, Hesse and others during the second phase – went together, in the third, with a renewed attention to the material and technical culture of science (Lenoir 1988). Experimental procedures and instrumentation began to be the object of philosophically-informed histories of science that before were written as the history of theory alone (Galison 1988). As we are going to show in these two subsections, the the *Modeling Approach to Science* (MAS), that we have introduced as an alternative to the *syntactic view* of traditional philosophy of science, reflects this historical passage in a different way from sociological approaches. This difference does not make the two approaches mutually exclusive; rather, it supports the kind of multidisciplinary integration put forward in the previous sections.

According to the syntactic view – at least according to Rudolf Carnap's version of it (1956, 1963, 1966), the early one of Carl Hempel (1958, 1963, 1965) and some further considerations put forward by many other philosophers of science to the development of this approach that from Putnam (1962) on has been called "Received View of Scientific Theories" (see § 3.1) –, scientific theories can be constructed as axiomatic calculi that are given a partial interpretation by means of "correspondence rules" (or "bridge laws"). The syntactic view identifies the structure of scientific theories with the structure of the language in which they are formulated. Particularly, theories can be formulated by axiomatizing them in a mathematical logic language such as first-order logic with identity. The non-logical terms of the theory are divided into observational and theoretical. The former are given a complete empirical (extensional) semantic interpretation so that observational terms refer to directly observable empirical phenomena (or properties of phenomena). The axioms of the theory are formulations of scientific laws that specify relationships between theoretical terms. The latter are conceived as abbreviations for observational descriptions, that is descriptions formulated solely through observational terms. So the axiomatization of a theory requires a specification of the definitions of its theoretical terms into observational ones, and this is done through the above mentioned correspondence rules that establish the definitional correspondence of theoretical terms with combinations of observational terms. As the definitional correspondence is not a one-to-one relationship, theoretical terms are not given a complete extensional interpretation by means of observable terms (that is, theoretical terms can be given a meaning in terms of reference to observables, but such a semantic specification is not exhaustive in that only part of a theoretical sentence is specified in terms of their relationship with observables); rather, axioms and correspondence rules jointly allow the deductive derivation of empirically confirmable observational statements from theoretical ones and, as a consequence, the strengthening of a theoretical hypothesis by induction from empirically confirmed observation instances (see Suppe 1977, ch. iv; Suppes 2002, pp. 2-3).

On this reading, the choice among rival theories crucially depends on observation reports viewed either as a source of inductive support once positive instances are deduced from theory or, in Karl Popper's (1935) version, as a secure source of falsification when the deduced instances do not conform to experience. This way the syntactic view gave a picture of scientific change in which observations accumulate, unchanged over time, while crucially determining theory change. Kuhn's, Lakatos' and Feyerabend's *historicist turn* (Bird 2008) criticizes this independence of observation over theory by showing that observation is always "theory-laden", that is, that the formulation of data is always dependent on the theoretical framework they are thought to support (see ch. 3). They showed that the same set of data can fit different theories (the so-called thesis of the *underdetermination* of theories by data). This means that empirical support alone cannot determine the choice between rival theories; other factors beside evidential ones must be in place. This allowed for the reintroduction of psychological and sociological factors in theory change so resulting in a picture of science as contingent with respect to historical contexts, hence the expression "historicist turn".

Although the historicist turn, with its opening to naturalized epistemology and sociology of science, did represent an important step towards a philosophy of science more engaged in revealing the "practice" of science against traditional approaches such as the syntactic view more or less centred on its fictional logico-argumentative "structure" (Bailer-Jones 1999), in the 1980s some authors (especially Cartwright 1983, Hacking 1983 and Galison 1987) lamented that both approaches suffer from a common underestimation of experimental practice. By explicating the connection between philosophical visions of science and the history of science, Peter Galison (1988) notes that although experimentation plays a crucial role for logical empiricism, the syntactic view does not properly account for experimental practice since it establishes too tight a connection between theory and direct observation by making the latter the essential engine of theory change. Galison dubs these approaches "observation-dominated". On the other hand, historicist approaches, that Galison dubs "theory-dominated", by establishing the theory-ladenness of observation (see Feyerabend 1965, 1999), render observation together with experimental practice, if taken on their own without theoretical and thus contextual biases, as non-crucial determinants of the growth of knowledge. As we are going to show, MAS overcomes the shortcomings relative to experimentation of both approaches, allowing for a more complete account of science practice. It assumes as a reference point "the semantic view of scientific theories", selecting some of the common elements to be found in the versions proposed by Bas van Fraassen (1980), Frederick Suppe (1989) and Elisabeth Lloyd (1994). But the semantic view is not the only option among MAS's conceptions to analyze the relationship between theory and world as mediated by models. Since the 1980s, a group of scholars in Eastern Europe have developed an alternative conception to the semantic view. It is the conception elaborated by the so-called Poznań School whose represientive scholar is Leszek Nowak (who died in 2009). We owe to the Poznań School the first full articulation of the modeling approach (see Nowak 1980; Nowakowa & Nowak 2000, the most complete work of the Poznań milieu, in which it is possible to find a complete bibliography on the Polish modeling and idealizational conception), although this genesis is often naively ignored. Francesco Coniglione (1990b, 2004) has discussed their contributions both by comparing them to the different approaches to the semantic view developed in the Anglo-American context and by placing their philosophy of science in the more general context of nineteenth-century scientific philosophy. At any rate, the literature on the idealizational and modeling conception of science has increased over time and nowadays this approach is known all over the Western World. Nowadays some scholars have acknowledged the role of Polish epistemology (Cartwright 1983; Hanzel 1999; Kuipers 2001; Dilworth 2006; Niiniluoto 2007; Moulines 2007; Shaffer 2007; for "external" discussion and references to the Poznań school see Jones & Cartwright 2005), while some others have not (see e.g. Suàrez 2009; Wimsatt 2007).

MAS differs from the syntactic view in many ways. One aspect we want to stress here is the basically different conception of how theories and the world can be compared. In order to specify the empirical content of scientific theories, as we have seen, the syntactic view poses a reductionist correspondence between theoretical statements and direct observation of the phenomena to be described and explained. From this viewpoint scientific laws (the axioms of a theory) with the aid of correspondence rules specify the behaviour of the natural phenomena they are supposed to govern directly, by means of deduction. Accordingly, a primitive characterization of the way theory reduced to observation is compared to actual phenomena emerges. Once the reductive deduction takes place, we can tell whether predicted phenomena occur or not by simply observing the world. Furthermore, considering the fact that experimental procedures are specified by correspondence rules which are an essential part of theory, any change in experimental design will necessarily force theory change, which is something that does not seem to occur in real practice (see especially Cartwright 1983; French 2008, p. 271). Both the primitive characterization of the relationship between theory and the world and the characterization of experiments of the syntactic view are replaced by the semantic view with a more realistic picture of science practice, especially as far as the employment of fictional models of reality is concerned.

Practitioners of MAS substitute for the one-stage relationship between theory and observation by means of correspondence rules a two-stage relationship in which theory and observation are mediated by *physical models* (Suppe 1989, pp. 65-72). These are abstracted and/or idealized versions of actual physical systems as (i) theories are designed so to use an "incomplete" set of parameters to describe actual phenomena in their intended scope (*abstraction*), since parameters could never be enough to completely describe non-isolated actual systems, and (ii) the chosen parameters are usually simplified and idealized in their nature for practical (especially calculational) purposes so that the models so constructed employ assumptions that could never obtain in actual systems (*idealization*)

Two specifications are necessary here. First, some writers prefer to name these abstracted/idealized systems "physical systems". This may engender confusion between abstracted/idealized physical systems and actual physical systems.

Hence we prefer to refer to the former through the expression "physical models" and to the latter through the expression "natural (or physical) systems". Secondly, the concepts of abstraction, idealization and simplification are often conflated in the literature, maybe because in actual practice these modeling devices often work together (see for instance Portides 2008, where the concepts of abstraction and idealization are used as synonymous). However both the difference between them and their individual diversification are relevant in many loci of philosophical discourse. Nowak 1980 is the locus classicus of the differentiation and specification of the two concepts of abstraction and idealization both from a methodological and historical point of view (see Coniglione *et al.* 2004 for a contemporary taking on these issues and his further articulation through the concept of "simplification"). In what follows, for simplicity we shall understand these concepts as complementary, that is as part of the same process of model-construction. Thus we shall characterize theoretical models instrumentally as fictional devices that make no realistic of a metaphysical sort. Furthermore, it goes with what we have said above that the distinction we have made between abstraction and idealization is not exact and it is made only to the purpose of facilitating a general understanding of MAS. The same applies to other terms and concepts such as "simplification", "fictional assumptions", and the like, which assume a rather technical and different meaning in more specialized contexts of the logic and philosophy of science. It goes without saying that we suggest the reader should consult the literature cited above if s/he wishes to have a full understanding of MAS in all of its technical facets.

Models so conceived are abstract/idealized replicas of both theoretical claims and observed phenomena in the natural world. On the one hand, by abstracting parameters from a theory domain and modeling them in idealized conditions, theoretical claims refer to (predict and explain) the behaviour of physical models rather than natural systems. So, by contrast with the syntactic view, scientific laws do not apply directly to phenomena and thus are not directly linkable for their confirmation on observation reports. On the other hand, data are defined in terms of the abstracted/idealized parameters common to a theory and its physical models. On this reading, all the data are theory-laden, since they are completely defined in terms of theoretical concepts. So, MAS substitutes a two-stage relationship for the one stage relationship between theory and direct observation. One stage concerns the passage from raw data to physical models. Suppe (1989, p. 69) characterizes this stage as *counterfactual*: physical models are idealizations of actual phenomena in the theory domain since they represent what the phenomena *would have been* if those phenomena were free of the influence of "outside" parameters. The second stage, from theory to physical models, is, in Suppe's view, merely computational (1989, p. 70): descriptions or predictions concerning the behaviour of a physical model are calculated by implementing the theory formal framework (laws, postulates, etc.) through the abstracted/idealized data about physical models.

MAS provides a more realistic (more complete) view of the relationship between theory and the world. According to MAS, once information on the behaviour of physical models is obtained by deduction from the laws and postulates of a theory implemented with abstracted/idealized data, we can obtain information on actual natural systems by reverse engineering the procedure used to make up abstracted/idealized data. On this reading, the acceptance of a theory is not a matter of binary choice, true or false. As we have seen, the models of a theory describe phenomena in the theory domain always partially and fictionally by their very nature. How well physical models "fit" natural systems depends on the degree of simplification we adopt in model-building to describe the behaviour of real phenomena (understanding simplification here broadly enough to include the choice of variables that capture the main features of the phenomenon in question). We can obtain more precise results (in computational terms) by reinforcing abstraction and idealization on data, but our methodological assumptions will decrease in "fit" to natural systems with increasing fictional assumptions. The central point, on our view, is that MAS makes explicating fictional assumptions and procedures the centre of its descriptive activity, thereby revealing much of current science practice. For instance, experimental procedures can be tracked at the counterfactual stage – from raw phenomena to physical models and vice versa – in which data are "constructed" so to "fit" models. Since the computational stage lacks a counterfactual nature, we can isolate the experimental stage (measurement, correction procedures, instrumental design and so on) from it. This implies that if errors (or modifications) in experimental procedures occur we can isolate the problem at the counterfactual stage without rejecting (or replacing) the theory altogether. We have already pointed out how the too tight relationship between theory and observation does not allow this and we can now identify the source of the problem in the fact that in the syntactic view the two stages identified by MAS are not recognized.

As far as the advantages over theory-dominated accounts are concerned, let us consider how, according to MAS, the abstraction/idealization process specifies the theory-ladenness of observation and thus experimentation rather than just assuming it. In the previous subsection we have pointed out how the theory-ladenness of observation takes experimental support as an insufficient determinant of scientific change. But "insufficient" does not imply that evidential factors are explanatorily redundant. If experiments alone cannot help in explaining preferences among rival theories, other factors, extra-evidential factors, must be involved. But evidential support still plays a role, even if it is not as central as that envisaged by observation-dominated accounts.

Contextual factors came to be centre stage in the philosophy of science, putting aside descriptions of theory-laden experimental practice (Hacking 1983). Against this, MAS offers a way in which conceptual biases themselves become the basis of experimental practice. It may be objected that theoretical frameworks are not the only bias on experimentation, that the semantic view cannot account for biases of a sociological character. However, by modeling fictional procedures MAS reveals how abstract theoretical structures fit those natural domains that are accessible to our technical and experimental control in a given historical, cultural and geographical context, thus designing a place for evidential support in contextual analysis. Can the sociology of science do the same?

4.4 – Towards a descriptively-informed science policy

We have responded to the question stated above by briefly focusing on micro-contextualist approaches to the sociology of science, exemplified (at least for notoriety) by Latour's and Woolgar's micro-sociological studies of laboratory life, *alias* "Laboratory Studies".

Both MAS and Laboratory Studies account for the contextual characterization of experimental phenomenon given by Ian Hacking (1983, p. 221) as «a noteworthy, publicly discernable, event or process that occurs regularly under definite circumstances», that is, a fact "constructed" in the laboratory and thus not "discovered". According to MAS, the object of experimentation, as can be seen in the counterfactual stage, is to "fabricate" phenomena in isolated settings according to the constraints imposed by abstraction and idealization on the testability of a theory that allow for the repeatability of the fabrication process. We have described how this is done by setting as constraints on abstraction and idealization the instrumentations and the techniques (both material and computational) available by a specified technical culture at a given place and at a given time. Thus contextualization becomes an essential element of the description as the material and theoretical limitations on the experimental implementation of hypothetical claims relative to the "fit" of theory and world. Laboratory Studies reduces this telling relationship between technical context and abstraction/idealizations procedures on actual phenomena to social interests guiding negotiations for theory-acceptance, thus missing many of the interesting processes revealed by MAS. This can be seen in the different way in which Latour and Woolgar explicate the fabrication process.

The "Frankfurtian" aim of Latour & Woolgar (1986) is to show that scientific papers are constructed so as to exclude any specification of the social context, and thus influences, motivating the fabrication of facts used to support scientific theories (*ib.*, pp. 105, 176). In other words, experimental evidence is reported in scientific journals as if it were not theory and socio-politically laden, as if scientific facts were not artificially constructed in the laboratory so as to fit the theoretical framework they are supposed to support. We have seen that, according to MAS, this is not a surprise: the fictional character of the evidence produced in experimental procedures is an integral part of science practice and it is these fictional procedures that MAS aims to describe. By contrast, Latour and Woolgar explain the *reification* of experimental evidence as the result of social negotiation (*ib.*,

p. 240). The reification process serves the purpose of social interests and the experimental apparatus is the medium used to increment the consensus on a given theory. On this reading, it becomes a "trick" to write reports without specifying the social condition to which the actors involved in the experiments were subjected. The readers of these reports will use the reified facts and the theory so supported as a basis for further work, thus engendering a never-ending deception chain. By putting forward the micro-sociological interactions occurring in the laboratory, Latour and Woolgar think they do justice to the iterated deception of science report-making.

Context enters MAS in terms of material and computational constraints and not in terms of social interests, which is not to deny that they are a real factor conditioning the instantiation of the link between theory and experiment. Micro-sociological interactions *do* explain the motivations behind the fabrication of scientific facts, but they do not explain *how* facts are constructed by abstraction/idealization procedures and constrained by the technical culture context. Social interests do not consider the technical problems relative to experimental design, the difficulties relative to the obtaining of reliable data by instrumentation, and so on. All problems of this kind are reduced to sociological explanatory categories while excluding the specification of idealization and abstraction procedures.

So, MAS specifies one dimension of science practice and Laboratory Studies specifies another. The trouble is, neither of the two approaches completely explains the complex interactions of the different dimensions of techno-science. This should be taken into account when attempting to integrate methodological frameworks in STS, especially in the light of the consideration put forward in the previous section relative to the construction of narratives for policy advice. In fact the integration of the HPSS cluster in the STS field acquires a special significance when we consider the role of that field for science policy-making. This role conditions the integration process demanding complete and non-complicated descriptions of science practice, which in turn allow for each methodology to employ its special method of analysis.

When the same subject matter is analyzed from different methodological perspectives, it is all too natural for a given methodology to reduce all aspects of that subject matter to a given causal category relieving of explanatory significance alternative descriptions of those aspects. It is not disciplinary high-handedness, which should imply a certain degree of awareness engendering critics to point at unsound scientific behaviour. It is rather how the demands of specialization, the education within a given research program, make the biases of others visible while keeping their own invisible. In this respect, the use of STS in science policy and the multi-disciplinary perspective we have envisaged in this chapter should function as a corrective.

4.5 – Further articulating MAS

As we stated at the beginning of ch. 2, the link between science, society and democracy is a constitutive element of Western tradition. But the recent technological developments – linked especially to biotechnology (Borbone 2009) and the global incidence of the anthropogenic factor on the Earth's ecosystem – have contributed to increasing the points of friction between science and society, between "inevitable" technological progress and people's expectations (Hoyningen-Huene 2009), between new perspectives of science and the demands of religious institutions, especially the Catholic Church (Wolters 2009). These include "tensions between science and society" that have made people speak recently about actual "science wars", like the one that set the administration of George W. Bush against most of the American scientific community and on which now there is some well documented literature (Mooney 2005; Shulman 2006; Grant 2007). These tensions pose two sets of problems, both objects of interest to us.

On the one hand we have to deal with the problem of the democratization of choices, in some way connected to knowledge of a technical-scientific nature: to what extent should the politician trust the competences of experts to make his decisions? And to what extent should society be aware of the stakes, so that people can consciously intervene without falling prey to irrational fears or relying in an undiscerning way on the power of technocracy? This is a general problem of high technology societies, i.e. the problem of the so-called governance of science and the role that democratic discussion can still have (see Vasta

2009; see also ch. 2). In a complex society at a high technological level, who should decide what investments to carry out, what lines of research to fund and to what extent these decisions can appear democratic? The role of experts is connected to this: to what extent should it be they who make the choices and what place should be given to politics and public, democratic discussion (see Sapienza 2009)?

As we saw in the previous sections the dispute between philosophy and sociology of science on the descriptive issue leads us to reflect on another, no less important aspect: we have to consider the extent to which it leads us to debate the limits of reliability and correctness of scientific theories and on the possibility of trusting predictive models that, because of their abstractness and necessary simplification, seem to turn out too far from the concrete evolution of complex systems that are their object of study. (This takes place in particular in the sector of the assessment of climatic changes and global warming). This is a delicate issue because it moves along a narrow, slippery ridge from which one could fall into an undiscerning, unreflecting acceptance of the new philosophy of post-positivist science and the new sociology of postmodernist science that we have outlined earlier, with the consequent possibility of justifying any political choice whatsoever through epistemological and sociological backing that focuses on the uncertainties of all the choices that a politician wishes to oppose (a strategy well exemplified by the research policies of the Bush administration). Jasanoff, in the light of the growing success of the constructivist approaches in SSK, especially in the USA, clearly states the problem facing every politician of science:

> How, in one canonical formulation, can a sceptical and reflexive stance in relation to scientific knowledge be reconciled with making authoritative recommendations for social policy? On what possible grounds can social scientists lay claim to a privileged understanding of politics while carrying out the deconstructive, critical project of exposing the social (hence, by definition, subjective and contingent) foundations of scientific knowledge? (Jasanoff 1996, pp. 393-4)

But on the other hand, if the possibility of public discussion and political decision-making is removed, there is the risk of claiming the received views of the autonomy and special authority of techno-scientific elites and of the corresponding doctrine of progress; hence we return to a scientistic belief in technocracy rather than full democracy. We seem to face the dilemma of either corrupting science (according to the traditional conception still favoured by many intellectuals) or corrupting democracy, as claimed by the postmodern critics.

A more balanced vision of science cannot – as we have seen – ignore the importance of modeling and idealization in scientific research, a claim that has been increasingly highlighted in recent times by meta-scientific literature (see § 4.3). For example, the work of Naomi Oreskes (see Oreskes *et al.* 1994; Oreskes 1998, 2004; Oreskes & Belitz 2001) demonstrates the epistemological and cognitive value of focusing on provisional models in the area of environmental sciences. This approach is in line with MAS as we have discussed in the previous sections (see also Viola 2009a). It is by assuming this conception of science that we have argued for a multi-disciplinary approach (as opposed to a inter-disciplinary one), since we want to account for the complexity of science across disciplinary boundaries. A descriptive understanding of such a complexity is in fact essential to decision-taking in science policy and, at the same time, it avoids the problems relative to cognitive and sociological reductionism. This, we think, is the only way to adopt a strategy which combines successfully the virtues of the three modalities of modeling practice (generality, precision, and realism) and to account for those levels of descriptive analysis that represent, according to the system approach we have sketched in § 4.1, the four main dimensions of scientific practice (evidential, cognitive/psychological, macro- and micro-social).

It is important to recall here that a multidisciplinary perspective allows each methodology of HPSS to conduct independent research based on each discipline's methodology. In § 4.1 we exploited Hughes' system approach to represent techno-scientific complexity as a "perspective" system, that is a system representing the varieties of the different angles from which techno-scientific phenomena can be described as interacting component perspective subsystems. Each perspective subsystem singles out a specific ontological dimension of techno-science as the one from which causal/explanatory factors can be selected in order to describe the determination of decisions taken in the context of techno-scientific practice.

Thus we postpone the integration moment to the level of results, that is only after each methodology has explored a given ontological dimension of techno-science from its own perspective. Then we look for convergences and divergences of results and we work on constructing descriptive narratives for policy-making that would be both complete and simple according to the directives given in the previous sections.

In the following two subsections we are going to further articulate the advantages of the modeling conception for STS and science policy. In the first subsection (§ 4.5.1) we are going to show in some detail how the philosophy of science should proceed in analysing the evidential dimension of science according to the idealizational approach. In the second subsection (§ 4.5.2) we shall try to show how the idealizational approach does not simply allow for non-disruptive (non-reductionist) methodological integration, and also how it enables us to formally conceptualize this kind of integration within its own methodological framework – a characteristic of the modeling conception that we may dub "methodological tolerance".

4.5.1 – *Levels of analysis of theory-formation*

In the case of the semantic view in the previous sections, we have seen how a modeling approach enlarges the scope of sociological "contextual" analysis to include theoretical and cognitive factors (constraints from the relevant theoretical knowledge possessed at one time and physiological/mental limitations) as well as material/operational constraints such as the limitations derived by the technical apparatus possessed at a given time.

The MAS has favoured the diffusion of the conviction that it is no longer possible to accept a one-dimensional vision of science, typified by the Standard Conception. On the one hand, it is indeed important to further articulate the relationship between theory and empirical data. In this respect, it becomes a necessity to establish a hierarchy of scientific laws and theories based on their variation in operational and context-relevance in order to avoid any holistic temptation (as we shall see immediately below). There is a complex web of relations within the evidential dimension of science that, as in the case of the four dimensions of techno-science, can be conceptualized as a set of different interacting levels.

Such an articulation of the evidential dimension serves the purpose of avoiding a "naïve falsificationism", that is the idea that a theory can be rejected as soon as a negative experimental outcome falsifies it. It also avoids an uncritical adoption of Duhem's acceptation of "holism" (as in the case of Feyerabend), that is the idea that *no* experiment can decide whether a theory is confirmed or it is not, since a given experiment is designed to control the *whole* of theoretical assumptions of the relevant science and not just a specific theory within it.

Both naïve falsificationism and Duhem's holism seem to exemplify the complexity of science in the wrong way: according to the former the relevant theory is abstracted from the theoretical framework to which it is related; the latter links the relevant theory to its theoretical background, but it establishes such a close relationship that it becomes impossible to distinguish the theory to be controlled from its theoretical assumptions. In both cases, therefore, we would be unable to distinguish clearly a hierarchy of theories that may enable us to better establish intra- and extra-systemic roles.

In order both to solve the epistemological issues addressed above and to furnish an adequate framework of descriptive analysis for the philosophy of science, in this subsection we have focused on the evidential dimension only. We have distinguished among six levels of descriptive analysis of the evidential dimension that are especially concerned with the search for the factors that determine theory-formation and that partially determine, as a consequence, theory-choice.

A first "level", or *level 0*, is the level of *metaphysical assumptions.* Modern science, from Galileo onward, has shared a metaphysical background which greatly differs from that employed in the Classical and Medieval Ages. Such metaphysical assumptions have constituted an "ideal of knowledge" (Amsterdamski 1983, pp. 21-41) accepted by the relevant scientific community with few exceptions; a sort of *Weltanschauung* (Barone 1984, pp. 21-4) that has guided modern science practice across controversies on the acceptance of single, local theories. These metaphysical assumptions make science a *rational* and *progressive* endeavor, for they constitute a common background from which disputes can be settled through shared procedures and standards of validation. Without them, we would have a proliferation of mutually incompatible metaphysical systems made by individuals in splendid isolation, and this is what differentiates modern science from system-philosophies in Hegel's all-encompassing style.

As an example of the several types of metaphysical assumptions at work in science practice (see Maxwell 2004 for a full articulation of this argument; see also Bunge 1998, pp. 329-341) we can single out the following dimensions within *Level 0*: (a) the idea that there exists some fundamental order of reality, whatever it may be in practice, that can be grasped through (and in contrast with) the mediation of analytical tools (intellectual or otherwise) that would enable us to ask the relevant questions about nature; (b) the confidence that nature is cognizable and that, as a consequence, scientists can eventually and progressively reach certain truth about it through physical laws formulated in mathematical terms. These two assumptions were at the basis of Galileo's work and through them he had often formulated laws and theories even when empirical evidence pointed in favor of his Aristotelian competitors. For example, the belief that there is a prefixed order of the world derives from Galileo's conviction that the orderly nature of the world was the result of God's intentions. He also believed that the natural world was cognizable as our knowledge is no less perfect than God's, although it is different in other respects. We find the same basic metaphysical assumptions everywhere in the history of science; this is the case of Einstein, for instance (Sachs 1990, p. 154).

Along these two assumptions – which even tacitly are always at the basis of modern science practice (at least regarding physics and chemistry) – there is a third one that is more pragmatic in nature. It was clearly identified by Francis Bacon: (c) the task of science is not just theoretical contemplation, but also the search for efficacious practice. In Bacon's view, theory must show its efficaciousness through its being able to produce material effects in two respects: it must show itself to be efficacious in practice, in the sense that it must yield positive experimental outcomes; it must be efficacious in terms of offering technical solutions to everyday problems. In this latter respect Bacon braked with the classical medieval conception of the separation between *epistéme* e *techne* towards a more active and operative ideal of science. Without this perspectival change, it would be impossible to understand the scientific revolution of the Modern Age and its effects that are still felt in contemporary scientific practice such as the incorporation of the latter into general economic process of production.

By combining (a) and (b) together, we can reach an interesting conclusion on current science practice and its basic guiding ideals. We assume there are laws of nature which are both absolute and objective. We may not have discovered them yet, but if nature is uniform (i.e. worldly phenomena are all connected so that to each effect there is always a corresponding cause) we may eventually find them sometime in the future. However, the absoluteness of natural laws contrasts with the relativity of both the formal and natural language we employ to formulate them. Therefore, it becomes an epistemological imperative to seek for the essence of reality beyond the variation of the linguistic tools employed for its description (Sachs 1990, p. 157). This implies that science cannot limit itself to simple generalization from empirical data, for it would not otherwise go beyond superficial phenomenal appearance. The exactness and certainty of natural laws, given the uniformity of nature, can only be obtained when the subject matter of science is the *essence* of reality beyond common experience. In this respect Galileo and all of modern science tried to get rid of Aristotelian physics with its reliance on direct observation.

Aristotelians would judge Galileo's reliance on idealization procedures of theory-formation and the consequent postulation of ideal entities as "a violence against nature." But the exemplification of reality through simplification, abstraction and idealization, its quantification in mathematical terms and the consequent elusion of qualitative properties (remember Galileo's difference between *primary* and *secondary* qualities) were necessary in order to achieve the universality and exactness expected by laws of nature. And so theory-formation started to be understood as the creation of idealized models of phenomena, unrealistic replicas of the rules regulating their behavior – a characteristic of science practice that is well captured by both the semantic view and the idealizational conception of scientific theories. Exemplification of real phenomena through abstraction and idealization, which had already been envisaged by Archimedes and then conceptualized by Galileo, was further articulated by Newton and it is now the procedural way adopted by the great majority of contemporary descriptive practices.

Another level of analysis of theory-formation is *Level 1*, that is the set of scientists' *logical-mathematical assumptions.* Many scientific theories are formulated on the basis of what Bunge (1973, pp. 170-172) has defined «formal assumptions of a physical theory» and that concern theory-formation in many other fields besides physics. In fact, each scientist's background must include at least a first-order predicate calculus (which involves basic principles such as identity, contradiction, and tautology) plus a number of mathematical theories and principles, such as set-theory, which are essential for those formal procedures that s/he uses in order to conceptualize the behavior of phenomena in quantitative terms.

However, even at this level there is an applied metaphysics at work, that is philosophical assumptions concerning the application and theoretical foundation of formal principles. Although scientists in the field often apply these assumptions without concerning themselves with metatheory, which is rather the subject matter of the philosophy of science. In fact, very rarely do working scientists change or critically discuss these assumptions, although it has happened as in the case of the debate concerning the possibility of creating and adopting a "quantum logic" to back up some of the inconsistencies of quantum theory with respect to modern logic.

A further level, *level 2*, concerns scientists' employment of *instrumental theories*. Instrumental theories are those theories scientists draw from fields of inquiry outside their specialization or theories within their field that are adopted uncritically because they are widely accepted. Those theories are usually the ones employed when experiments are set, especially as far as data-building is concerned. Therefore, instrumental theories are tacitly assumed so that they do not need to be tested together with the relevant theory they back up. For example, a physicist of particle physics (tacitly) assumes the validity of electromagnetism or classical mechanics which are employed to set up the relevant experiment; a chemist assume the validity of thermodynamics by employing it instrumentally without inquiring into its foundation, and so on. So instrumental theories are employed to test the validity of "substantive theories" (see Bunge 1973, pp. 64-66, for the terminology here employed) so that the latter are subordinate to the former; that is, *ceteris paribus,* once a theory is shown to be false we first see if the problem lies in the substantive theory and only later would a scientist critically inquiry into the validity of the relevant instrumental theories. This is how Duhem's holism is rejected and especially the Duhem-Quine's thesis (see § 3.4), that is the thesis according to which it is not just the relevant theory to be experimentally tested, but the whole of science, as we have seen above. It is not true that the choice between two rival theories is impossible because we should also test all the other auxiliary assumptions that are often implicitly at work when theories are instantiated and controlled: in order to decide between the roundness and the flatness of the Earth, in the context of a thought-experiment in which an individual observer from the dry land believes there is a ship in the open sea but s/he can only see its sails, the observer must not necessarily take a stance between the theory according to which light travels on a straight line and that according to which it progressively bends down. For optics is a consolidated scientific field, that is, it is part of those assumed instrumental theories and therefore it is accepted tacitly. If we rather take a stance on the alternative optical theories (light travels on a straight line or it bends down), then the two substantive theories (either the Earth is round or it is flat) are not equally underdetermined by experience. In this case, the following methodological rule is in place: if we have to choose between two rival (substantive) theories, choose the one that most agrees with the relevant corpus of instrumental theories and that, at the same time, does not yield to a loss of informative and/or predictive power.

The formulation of *substantive theories* is the fourth level, *level 3*, of analysis of theory-formation. This level is better articulated into two sublevels: *level 3.1* and *level 3.2*. The first level corresponds to the counterfactual and computational stages of theory-formation according to Suppe's view; the second level refers to the stage in which, once information on the behaviour of physical models is obtained by deduction from the laws and postulates of a theory implemented with abstracted/idealized data, we obtain information on actual natural systems and we proceed by controlling the theory against them. For the most part, scientific practice (what Kuhn dubs "normal science") starts from this level, that is from the level of substantive theories (with instrumental theories and "background knowledge" implicitly assumed), which includes control procedure, comparison among rival theories, explanation, and estimation of the future behaviour of phenomena.

The process of *concretization*, *level 4*, is different from approximation. It captures a dynamic aspect of theory-formation that has been somewhat underestimated by the practitioners of the semantic view. Concretization occurs when we relax abstraction/idealization procedures on natural systems. It is a reverse-engineering procedure that increases the fit of theoretical models to the relevant natural system by decreasing fictional assumptions and by rendering the scientific models nearest to the empirical surface of data setting. However, concretization is always partial and it is this partiality that explains how physical models in some instances of theory-change are only modified and not discharged, so that we retain the relevant theory against claims to their definitive falsification. What is retained is the majority of the abstraction/idealization procedures, thereby increasing fit without discharging the whole theory. This is the case, for example of theory-change episodes such as the transition from the ideal gas law to van der Waals' law, from Newton's conception of the speed of light as a physical constant to Einstein's conception of it, and so on; that is, for all those cases in which we eliminate just one, but relevant, idealized assumption while retaining the others.

There is another level of theory-formation that the idealizational approach accounts for in a different way from the semantic view. It is *level 5*, which is the level of *experimental setting and data processing*. Specifically, on the idealizational approach it is called *approximation* and it refers to the moment in which we compare idealized laws that present a high degree of concretization with the relevant natural system and then establish limits on approximation procedures that decide whether the law is confirmed or falsified (Nowakowa & Nowak 2000, pp. 127, 451). In fact, since the models of a theory describe phenomena in the theory domain always partially, how well physical models "fit" natural systems depends on the degree of approximation we adopt in model-building to describe the behaviour of real phenomena, with the "fit" decreasing with increasing fictional assumptions of a theory or scientific law.

However, we can also try to obtain more precise results (in computational terms) by introducing abstraction and idealization of data, i.e. building "models of data" or "models of experiment" in order to take in account «those aspects of the experiment which have a parametric analogue in the theory» (Suppes 1962, p. 258). In this case, i.e. in the field often named "theory of experimental design", a modeling strategy that is the reverse of idealization is applied: in this case the models are built up by starting from the bottom, from data and from experimental setting, according to the conception first proposed by Suppes (1962) (see also Giere 2006, pp. 68-69). We have verified that this procedure presents some advantages. For instance, when errors (or modifications) in experimental procedures occur, the problem can be isolated at the counterfactual stage without rejecting the theory altogether. There is, however, a hidden assumption at work in Suppes's argument that some of MAS's practioners make explicit and reject (especially the practitioners of the idealizational approach): it is not at all clear whether we can formally account for experimental procedures in the way described above without losing both some idealizational aspects of experimentation and some concrete features of experimental setting and data processing procedures. The hidden assumption in Suppes' argument is that the counterfactual stage at the theoretical level can be fully compared to what really happens when experiments are set up in practice. Instead, in the idealizational approach, experiments are not replicas of physical models. They are rather an approximation (according to the technical definition of the term given above) of the idealizational concretization operated at the theoretical level. Suppes, simply put, eludes *level 5* and this is one of his shortcomings with respect to descriptive completeness. For instance, by employing Suppes' approach without further articulations we cannot account for the "instrumental" role played by the set of background theories employed in experimentation, such as probability theory, measurement theory, theory of errors, and so on. That is, we need to account for the hidden theoretical assumption at work when experiments are approximated from physical models. As in the case of instrumental theories, theoretical tools employed in setting experiments are rarely discharged when experiments fail. For instance, probability theories are rarely blamed for an experimental failure. This also means that the instrumental theories at work in experimental practice have a stronger degree of resistance with respect to the kind of instrumental theories of *Level 2*, which are more local and transient. We therefore need a further level of analysis besides the counterfactual stage to see what factors inform experimentation and how they affect evidence-based theory-choice.

This stratification of theory-formation has far reaching consequences for the descriptive work of STS. Articulating the evidential dimension of theory-formation makes us understand the real nature of theory-ladenness. As we said in § 4.3, specifying the abstraction/idealization process of theory formation means specifying the theory-ladenness of observation and thus experimentation. The main thrust of this conception is that it would be a mistake to put forward theory-ladenness as a sufficient argument for showing that experimental support cannot determine scientific change, as Paul Feyerabend did for example (see § 3.3). It is true that evidential factors (such as successful experimental outcomes) by themselves do not explain preference over rival theories. However, it is quite another thing to deduce from theory-ladenness that evidential factors play no rule in theory-choice. For extra-evidential factors as conceived by, say, SSK, do not account for all those other evidential factors involved in theory-formation that we have pointed out above, such as the instrumental theories of *level 2*, the metaphysical assumptions of *level 0*, and so on.

In real practice, when an experiment fails to confirm a substantive theory, a scientist will start by controlling those assumption that are at the "periphery" of her/his theoretical assumptions. That is, s/he will start to blame all those assumptions whose revision is less disruptive with respect to the possibility of completely rejecting a well-consolidated background of theoretical assumptions. S/he would then start by assuming there is something wrong with the procedures employed at *level 5* and *4*, then s/he would probably control the cogency of the instrumental theories employed at *level 2* and only as a last resort s/he would start to doubt more substantial assumptions (in terms of widely-shared acceptance within the scientific community) such as those employed at *level 0, 1*. On our view, this is the way to confer an operational meaning to Quine's idea of science as "field of forces" (1953, pp. 42-43), but without implying some form of holism for which "every caw is black": a kind of empiricism that, although "without dogma", is not completely deprived of orientational criteria for choosing and evaluating theories, even if it can be formulated naturalistically on the basis of concrete scientific practice rather than simply inferred from the dreams and myths of a preconceived rationalism (and from this perspective Kuhn's and Feyerabend's teachings have been precious). The history of science shows how this is the way many have proceeded, with the rejection of *level 0* as both the last resort and the start of a completely new way of understanding science itself – a circumstance that may have only happened once in the history of Western culture with the Copernican revolution.

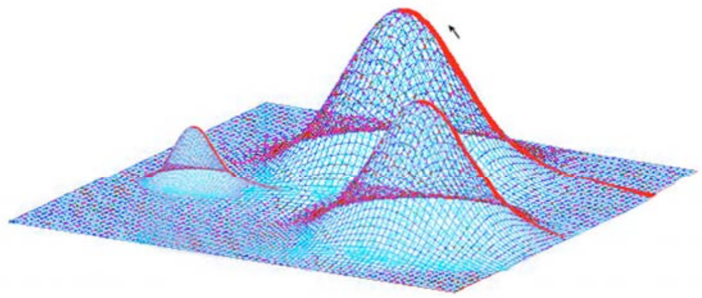
4.5.2 – *MAS and "methodological tolerance"*

One further virtue of MAS we wish to highlight here is that it allows for the acceptance of alternative models, since «adopting a model is an arbitrary partition the observer does on the system/environment relation» (Licata 2009, § 6). This means that

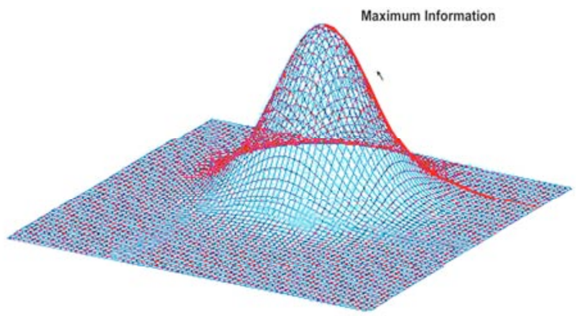
> […] the most interesting things in research happen […] when we *change the code* and choose to observe the system from different viewpoints. It means that the builder of models changes his "perspective" and the key variables, and he uses a different observational-experimental context. In practice, the same system can be described by an entire family of models, finite or countably infinite, each one "specialized" in seeing different features. (Licata 2009, § 4)

This facet of MAS – that in this respect agrees with Giere's "scientific perspectivism" (2006) – derives from the fact that one model is very rarely better than another model in all respects; in most cases M_1 is better than M_2 for aspects $a_1, a_2, \ldots, a_m$, it is worse for aspects $b_1, b_2, \ldots, b_n$, and it is equivalent for aspects $c_1, c_2, \ldots, c_q$ (with $m, n, q \in \mathrm{N}$ and m, n and q non-necessarily equipotent). So, two *correct* models are "correct" depending on different points of view, and this generates the need to add to the cognitive value of "fitting" other different kinds of value, if we want to consider all the aspects of the techno-scientific system listed as (1)-(4) in § 4.1.

The explanatory power of a theory (made up



Fitness landscape for different modelling perspectives



Fitness Hill for a Single Model

of several models with a different number of idealizing assumptions) can be depicted as a surface with multiple peaks, representing theoretical models of a theory, that differ from one another in terms of "fit" to a given "natural system" (as in the case of "fitness landscapes" in evolutionary biology). So, contrary to the preference for a unilinear model in classical epistemologies, in which a theory can be depicted as a figure with a single peak, so that theory change can be represented as the new theory reducing the old theory into its axiomatic framework as the new peak encompasses the old one, we propose a pluralistic conception of science according to which different perspectives inhabit the same landscape, so as to allow different perspectives to confront one another (as in the figures from Licata 2009), hence *methodological tolerance.*

From this perspective, we can consider a natural system as characterized by a strong logical openness (Licata 2008) that addresses the measure by which information is exchanged and put forward by the actors participating in its development and between the levels of the techno-scientific system it inhabits. The complexity of a system indicates that a single model accounting for all its aspects at once is impossible to obtain. A certain degree of approximation is always needed. Nonetheless, given the limits implicit in MAS that we have addressed, one model can still be more efficacious than another on the intuitive basis that it can yield better predictions and allow the construction of reliable technology compared to other models. But it is essential to specify – especially in order to inform science policy – the choices behind the selection of parameters to favour generality and increase realism.

Another important aspect is the degree of convergence between alternative models, which can tell us about the efficacy of selecting certain parameters over others and which allows for the possibility of attempting their integration while avoiding the reductionist temptation of constructing an "all-comprising" theory, a sort of super model that would be the analogue of Laplace's God.

We are convinced, in fact, that what three hundred years of modern science guarantees us is not the complete and definitive knowledge of the world, but the certainty that this inevitably tortuous path is not a Sisyphean task (Licata 2008, p. 55). Therefore, we must give up the *hybris* of attaining an impossible objectivity, able to embrace all the aspects of a complex situation, and instead accept a concept of science based on the need for simplification, built on idealized models using different perspectives, that inevitably impoverish the real world, but nevertheless enable us to make choices that are informed, within the accepted limits of approximation, by conclusions that are truly scientific, rather than prophecies and other products of mysticism.

The society and the politicians that have to make crucial choices must always be aware of these limitations, without making them an excuse for not choosing, knowing the consequences that every decision brings, and living with inevitable levels of uncertainty that only Laplace's God could avoid in a Newtonian universe. The time frames in which politicians must make decisions are far shorter than the time frames in which scientists may (or may not) be able to achieve universal consensus (see also § 2.5). Politicians cannot hide their own fears or interests behind the need for a mythical "sound science", lacking uncertainties, as they did in the USA, where «the corporations […] are quite eager to exploit the insights of SSK in their efforts to deconstruct the basis for restrictive health and safety regulations» (Jasanoff 1996, p. 399). To be sure, in the words of Oreskes (1998, p. 1458): «we have an obligation to invite open discussion of uncertainties. And the more politically charged the issue at hand, the more essential it is that these uncertainties be articulated clearly, freely and in a language that anyone can understand». Nonetheless, it is up to us, as intellectuals and scientists, to make it clear that predominance of good evidence remains an important basis for policy decisions, even in the face of uncertainty and contingency.

And of course, despite science's fallibility, its evidential claims are still at the basis of almost everything we do, including policy-making. In fact, we would expect decisions to be taken based on the best available evidence. Evidence-based policy is therefore designed to avoid arbitrary decisions by basing our choices on objective facts, namely facts that can be ascertained through reproducible and universally accessible justificatory procedures (such as empirical validation by experimentation) that can therefore be, at least in principle, ascertained by anyone and equally invalidated by anyone. We know however that "objective evidence" is a myth. We have already encountered an instance of this problem when we discussed the theses of theory-ladenness and underdetermination. Especially in ch. 3 we have shown that in the face of underdetermination, we have to assume the role of extra-scientific values in theory-choice. Awareness of the "mythological" status of objective evidence, however, should not lead us astray. A set of ideological assumptions may be made explicit in order to guide our choices without renouncing science's attempt at objective choice altogether. Although science can never achieve objectivity, the attempt to justify scientific claims through universally accessible, empirical and reproducible procedures should keep functioning as a regulative ideal beyond their instrumental employment. In this respect Gereon Wolters (2009) invites us to distinguish between "factual" and "orientational" knowledge. "Factual knowledge" is descriptive, it «gives us an account of what there *is*». "Orientational knowledge" is normative both in the regulative sense – it «tells us how to *act*» – and in the evaluative sense – it tells us «how to *value* objects, institutions, events, and the like» (p. 484). Knowledge has traditionally been defined as "justified true belief". Although epistemologists have proposed counter examples to the effect of showing that such a definition is not sufficient to determine unequivocally when knowledge claims constitute genuine knowledge (that is knowledge that is certain in a universal way), we may reasonably work under the assumption that factual knowledge is that knowledge we consider true because of some justificatory procedure. Empirical confirmation by experimentation, as we noted above, is one such procedure. For the Christian Church, factual matters are decided on the basis of what The Scriptures say, and this counts as a justificatory procedure as well. As Wolters emphasizes, however, much of Europe's identity is defined along the lines of modern science rebellion against the Church's authority on factual matters and the consequent relegation of that authority on matters of value. At least on factual matters, such as fossil dating (one among Wolters' examples), the great majority of European citizens trust empirical procedures and avoid explanations recurring to supernatural powers and what the Bible commands (literary or by our interpretation of the original text) people should believe. This trust is based on the idea that

> Science gives us the most reliable information about the world that is available, and that science's reliability rests on the norm that the justification of scientific propositions has to be independent of place, time and personality of the researcher and to be repeatable by everybody. This *intersubjectivity* of true scientific research is the basis of the *objectivity* of its result. (Wolters 2009, p. 483)

Universality and value-free objectivity (with intersubjectivity as the concomitant effect) are not completely realisable in practice. Nonetheless they are good heuristics, as the success of science shows. Science, despite its fallibility, is therefore an instrument subjected to orientations much as a hammer is: you can use the latter for a good purpose (to build a doll's house for your daughter) or for a bad one (to hurt somebody). The descriptive methodology of STS should single out those orientations at work in science for policy makers to evaluate them and proceed with their normative work accordingly.

There remains the problems to see how objective evidence in general can help science policy. Montuschi (2009) accounts for contemporary conceptions of objective, scientific evidence and concludes that evidential support is not sufficient to qualify a policy choice as non-arbitrary. Then, what should policy makers do when not even evidential support can make their choices objective? Again, we must assume the complexity of the decision problem and try to combine all evidence at our disposal, including the extra-scientific one. This, of course, can be achieved in a number of ways. The multidisciplinary approach envisaged in the previous section offers an instance of the «combinatorial framework» Montuschi suggests (2009, pp. 436-7). Specifically, the complexity of science practice requires it to be viewed from different descriptive perspectives (methodological tolerance indeed) in order to combine all the causal, explanatory factors at play; and, in this perspective, a multidisciplinary approach is better suited to the task, since the varieties of descriptive methodologies of HPSS are addressed to the specification of one or two of the four dimensions of techno-scientific practice we have singled out in § 4.1 and we require each one of them in order to achieve descriptive completeness. Descriptive completeness is in turn a requirement for adequate normative action; therefore a evidence-based strategy such as science policy requires more than objective evidence as traditionally understood and multidisciplinary methodological tolerance may offer just that.

The philosophy and sociology of science must each revise their role in the face of their policy feasibility. MAS enlarges the scope of the contextual analysis of SSK by adding new constraints on scientific change. These constraints (instrumentation available at a given time, local experimental setting, formalization techniques, heuristic and metaphysical assumptions, background knowledge, and such) all relate to evidential support but this acquires a new significance as it is not the only constraint of theory-choice. The philosophy of science has been neglecting the non-sufficient status of evidential support for theory-choice for a very long time. MAS, in fact, have been traditionally put forward as new tools to understand the role of evidential factors irrespective of social context. Treating their findings as contextual constraints has given us the opportunity to rehabilitate some of the traditional tools of philosophy of science and see more clearly how they should interact with SSK. On the other hand, as in the case of levels of analysis of theory-formation, the evidential dimension of science is shown to be of pivotal importance despite SSK's claims to the contrary.

4.6 – From descriptive to normative STS: heuristic appraisal

MAS simply takes descriptive completeness to be a better ground for evaluation and regulation procedures that are normally ascribed to policy-making, with the proviso that even the demands of descriptive completeness must be relaxed in order to achieve policy feasibility. In this final section we ask whether it is possible to push forward the role of STS for science policy beyond the construction of descriptive narratives.

Thomas Nickles (2009) has argued that, within STS, philosophy of science has neglected one important policy issue, "innovation". We have seen in ch. 3 that this was especially so until the 1960s. Even well after Kuhn's historicist turn took place, Imre Lakatos (1978) would distinguish between "internal" and "external" (historical) accounts of science practice. "Internal" historical accounts describe the development of a discipline as a linear succession of changes in theoretical developments (i.e. developments relative to changes in the scientific content of disciplines). In Lakatos' own preferred version of internal history, such histories serve also as rational reconstruction. They single out the normative rules that regulate theoretical production. In so doing, linear accounts represent the development of a discipline as if it could be portrayed in a graphical plot of linear progress of theoretical work according to specific lines of action such as the retention of empirically successful theories and the exclusion of unsuccessful ones. But, as Lakatos reminds us, «the history of science is always richer than its rational reconstruction» (*ib.*, p. 118). The production and systematization of scientific content occurs in fact in the context of specific socio-historical and cognitive backgrounds. There are therefore historical, psychological and sociological factors influencing theoretical activity. The individuation of such factors is the concern, according to Lakatos, of "external" accounts of the history of science.

Lakatos' distinction is certainly too rigid. Already in the 1960s, following the lead of Thomas Kuhn, many philosophers of science offered criticisms of this approach and attempted to offer a more comprehensive account of the heuristics of history of science (see Laudan 1984; Nickles 1992, 1998). Specifically, Lakatos' distinction marked too strong a separation between philosophical and sociological approaches to the history of science, and this created an impasse towards their reconciliation. Historians proper tended to privilege external approaches by employing the theoretical framework of newly born post-Mertonian sociology of science. The latter, especially those committed to a strong social constructivist approach, postulated an overly strong context dependence of scientific content as deriving from social interests. Such historians often invoked relativism as their methodological hypothesis and instrumentalism as their metaphysical view. This separation was often exacerbated by the refusal of historians and sociologists of science to consider their relativism and instrumentalism as a problem worth discussing. As Steven Shapin puts it: «One can either debate the possibility of the sociology of scientific knowledge, or one can do it» (1982, pp. 157-158). This separation within the history of science runs parallel to that between the context of discovery and the context of justification (see § 3.1). Hence we refer to current sociological and philosophical approaches to science practice as "naturalistic", since they blur the discovery/justification distinction by declaring evidential and logical factors as insufficient in order to fully determine the factors involved in theory-choice, calling upon the descriptive genealogical methodologies of history, psychology and sociology to fill the gap left open by purely normative philosophy of science.

Elsewhere (see MIRRORS's *Report 1*, especially § 3: http://www.mirrors-project.it /images/stories/report_wp2.pdf) we have offered a full account of "naturalistic" enterprises in STS. It has been beneficial for philosophy of science to break with the discovery/justification distinction and to join sociology of science in making STS a descriptive endeavour. MAS, for instance, may be taken to be a further articulation of traditional philosophy of science's search for normative rules of evaluation; but once the modeling conception is viewed as a tool for contextual analysis, it finds a place in descriptive STS that is advantageous, as we hope to have shown, for both the philosophy and sociology of science, especially as far as their integration is concerned. Furthermore, and more importantly, naturalized philosophy of science can now face issues concerning techno-scientific innovation which were traditionally relegated to the context of discovery. For instance, given the close link between techno-scientific innovation and economic growth (see § 5.1), policy makers are interested in studying the conditions leading to new discoveries in order to regulate science practice towards their implementation. In this respect science policy asks more than simple description of actual science practice. They ask for methods that would enable them to evaluate «the potential fertility or promise of the available options» (Nickles 2009, p. 442), for they are called on to evaluate risky scientific enterprises such as techno-scientific innovation which, by definition, breaks with traditional and established knowledge. There are social and economical outcomes to be evaluated, such as environmental impact, financial return and costs, social sustainability, and so on. These issues were traditionally ascribed to the context of discovery and, according to Nickles, break with the slippery separation within STS between its descriptive heuristics and its normative vocation. Nickles dubs *Heuristic Appraisal* (HA) this kind of evaluative framework and, while viewing it as the right subject matter for STS, notes that the descriptive heuristics conflicts with the normative vocation in many respects.

For instance, the policy maker faces a difficult issue. S/he should recommend policies that foster techno-scientific innovation for social benefit purposes while at the same time s/he is required to set economic growth and competitive advantage as goals. These two objectives are often in conflict and a right balance is difficult to achieve (this tension can be seen throughout ch. 5). STS's practitioners, as Nickles notes, have the tendency to favour the social benefit side of innovation outcomes and this often translates into a critique of free-trade ideology regarding central planning, that seems instead the right ideology to follow in order to democratise decision processes in science (see for example Wynne *et al.* 2007). Economic reform and social engineering are therefore the normative realm in which a balance between science and society is sought. We have seen this at work when we have discussed underdetermination in § 3.6. There we said that in the face of underdetermination of theories by logic and evidence, what remains to be done is to take an ideological stance which would guide our choices concerning the implementation of techno-scientific innovation strategies. This amounts to fixing a finality and adjusting means accordingly. This is not however a no-win situation, that is a situation in which either our finality is social benefit, and then economic reform towards statalism would be the right means, or it is economic growth, which would fit with *laissez-faire* economic ideology.

As Nickles suggests we may look at alternative capitalistic models (such as Hawken *et al*. 1999) that offer a framework for science policy in which sustainable development strategies are shown to be convenient for economic growth. There is a number of proposals within the EU and worldwide which try to find an equilibrium between the above mentioned two economic ideologies, and these will be variously discussed in the next chapter. These should not be ignored as well as the tension that caused them. STS may (descriptively) highlight the expected outcomes of science policy decisions in the face of economic and social finalities, (normatively) propose reforms accordingly, and aid the work of governments by offering them the best available evidence for successful and forward looking choices. This we shall try to do in the next chapter.

5. Implementing New Strategies: Towards the Recommendations

5.0 – Overview

What has been said in the chapters so far forms the historical and epistemological background of the premises that justify the steps made towards making the recommendations laid out in chapter 5.

In the first place, we have discussed the genealogy (§ 5.1.1), the development (§ 5.1.2) and employment in the field of European policy-making of the models of techno-scientific innovation. Of the three models discussed – the "linear model", the "Chain-Link Model of Innovation" and the models based on the concept of "National Innovation Systems" (NIS) – we have especially underlined the inefficiency relating to the double aim of responding to the needs of the private sector and those of civil society through techno-scientific innovation. In fact, the three models assume "economic growth" as the equivalent to the growth of civil society. The efficiency of the strategies fixed to stimulate innovative processes is therefore measured on the basis of the achievement of purely economic-financial objectives to the exclusion of more general objectives such as the improvement of quality of life in terms of a better management of natural and human resources. (see § 5.1).

Therefore, we have analysed the connection between tacit knowledge and expertise, a fundamental link to clarify the correct definition of the Knowledge-based Society. In fact, we believe that in addition to the current definitions in the literature on the subject, the best way to stimulate a greater opening and more shared social understanding of science is to modify the point of view both of experts and the general public. We think that this process is possible also through the recuperation of the concept of expertise, as suggested by the scientific epistemology of the twentieth century. This means being able to encourage the meeting of implicit and explicit areas that are present within professional competences with that unexpressed knowledge incorporated in knowledge of a biological-structural nature to which the theoretical concept of tacit knowledge refers. In fact, expertise, as part of the widest perimeter represented by tacit knowledge, is always an "incorporated" part of knowledge. It can never be separated from those processes of metaphorical representation of knowledge that everyone elaborates, expert or otherwise (see § 5.2).

In the following paragraph we have analysed the role of creativity in the formation of the knowledge society, stressing how it is an essential tool for humanistic and scientific innovation; and the EU is well aware of this (they declared 2009 year of creativity). Creativity, present in all individuals and not only the prerogative of a chosen few, should be nurtured from a young age, especially at school. We have also analysed the creativity present in companies with regard to innovation; in this case, it is essential to create an environment that is rich in stimuli, and arrange for creative areas in the workplace and in society. If companies take into consideration the well-being of their employees, giving them the possibility to express their creativity and imagination, they would benefit not only on an economic level, but especially in terms of personal, human well-being. A final aspect we have analysed concerns widespread creativity. These days our society is going through a great creative explosion thanks to information technology tools that have changed our ways of thinking. Knowledge on the net is increasingly an open system in which we can all create knowledge; Wikipedia is an example. However, we have described the creativity of users of ready-made products, the so-called "prosumers" who are able to modify the products to adapt them to their needs. Companies are well aware of this and they are creating forms of interaction with the users, whose creativity is in fact essential for the re-programming of the products. Creativity is indispensable, also for a new way of managing the company, no longer seen as a vertical system, but a horizontal one, in which employees and users collaborate to create new products and especially new knowledge (see § 5.3).

Considering these premises, the role of universities and knowledge in general appears to be crucial, as they are engines of development for a society of knowledge that can evolve in the direction we want it to go: human, serious and critical. Naturally, it is not enough to expand or invest; we need to establish in a critical way, after thorough analysis, what to expand and what to invest in. In this sense, the human capital formed within the universities and the new knowledge that depends on it form the fulcrum of these reflections, our final objective in analysing the most serious problems of contemporary universities and the challenges they have to face, in questioning the role and the most appropriate mission of universities today, in making comparisons with other university systems, and in suggesting possible moves or proposals for reforms. At the same time, the aim of the analysis of the most valid concept of knowledge today is to justify the objective to invest in the development of culture, knowledge, innovation and creativity as a means to understand the real, and as tools for the cultural and civic education of citizens; subsequently, the development of culture, knowledge, innovation and creativity could also be a real engine for economic, human and sustainable growth. (see §§ 5.4-5]

Finally, we have outlined the general perspective in which we have fixed our proposals and which we have defined as a "humanistic scenario" focussing on greater investment in human capital rather than in technology and infrastructures; privileging education as an essential factor for the growth of human capital and to stimulate greater creativity in schools and universities; overcoming fragmentation and hyper-specialist knowledge; increasing shared and interdisciplinary knowledge; privileging the increase in employment, opposing the tendency towards loss of jobs and outsourcing; attempting to replace the GNP with an index of well-being that is not merely economic; and finally, privileging the Scandinavian and Finnish model of innovation over the one embodied by Silicon Valley (see § 5.6)

5.1 – Frontier research: beyond economic growth

Much policy worldwide works under the assumption that "techno-scientific innovation" yields to economic growth. This is a correct assumption, but it needs, in our view, further qualification. According to a general pragmatic criterion, the efficaciousness of science policy strategies varies with different finalities, and we shall try to see this variation in the case of policies addressed to the regulation of techno-scientific innovation assuming economic growth either as a sufficient condition or as a necessary one for public benefit. We shall argue that although techno-scientific innovation is certainly an essential factor for economic growth, the latter is not enough to achieve general society welfare and that therefore it is wrong to work under that assumption. More pointedly, it is possible to envisage economic growth as an undesirable goal, for general ethical reasons and with regard to the limits of sustainable growth, given the fact that much evidence indicates that it is impossible for our ecosystem to tolerate the current rate of industrial development. We may assume that sustainable development with a strategy that respects the natural environment is the desired aim, as has been pointed out by recent EC deliberation on this matter that we discussed in § 1.3.2 and that we shall further discuss in § 5.6. Nonetheless, we do not think there is a linear relationship between knowledge growth, technological implementation, GDP rate of increase, and the current crisis of environmental sustainability. That is, we firmly believe that even if we might embrace an "apocalyptic" vision of mankind's future, it cannot be avoided through a deliberate reduction of the growth of scientific knowledge and technological application. On the contrary, we believe we can escape the pessimistic forecast of our future by postulating a new direction for scientific progress as the one we have outlined in the previous chapter concerning the modeling conception, regarding the idea of deliberate choice in the face of underdetermination, that is an idea of science as an imperfect, indeterministic, and manmade (for better or for worse) endeavour that does not follow an ineluctable, predetermined, and value/society-free destiny.

By keeping this general orientation in mind as our working hypothesis, we are going to discuss the feasibility of a specific science policy issue: government funding of both private and public research. Funding policy is a means to achieve public well-being, the efficaciousness of which varies according to the way we understand what well-being for general society is. However, we suggest that fixing economic growth as the one and only finality of research activities addressed to the production of innovation (frontier research) rules out much of the positive effects of those activities for general society as well as research means that do not pursue, indeed, the goal of short and mid-term economic gain.

5.1.1 – *The linear model of techno-scientific innovation and economic growth*

We will proceed by first analyzing the connection among scientific research, techno-scientific innovation and economic growth. More specifically, we shall first try to understand the connection between innovation and economic growth by discussing some of the current models that have been employed to depict techno-scientific innovation. The linear model has been both the most employed and the most criticized worldwide since the end of World War II. The essential characteristic of the model is that it articulates and explains the connection between R&D and economic growth.

R&D can be defined as the set of all theoretical and experimental activities put forward and practiced by scientists (researchers) and technicians, in the context of both public and private research institutions, universities, industries, and companies, aiming to increase our knowledge of natural phenomena and technology in order to exploit it for new applications (we discussed this issue in §§ 0.3-0.4). *Scientific research* refers to all those activities addressed to the theoretical and empirical inquiry of natural and cultural (manmade) phenomena in order to increase our knowledge of them and our ability to manipulate them. According to a well established – although contested from a theoretical point of view – practice (as we saw § 3.5), such activities may or may not be addressed to a specific application or employment. We generally refer to the first kind of activity as *basic research*, while we refer to the second as *applied research*. *Experimental development* exploits the knowledge obtained through basic and applied research in order to "produce" new materials, systems, processes, products and services or to significantly improve those already produced.

So conceived, the main aim of R&D activities is to create "new" knowledge to solve, at least in principle, the problems of mankind. The activities are designed for the production of *techno-scientific innovation* which is based on the exploitation of our scientific and technological heritage. In this respect, techno-scientific innovation cuts across the traditional boundaries of basic and applied research. The more general expression "frontier research" has been proposed (see HLEGR 2005, p. 18) to characterize research activities that yield techno-scientific innovation. Although "frontier research" accounts for the fact that especially as far as new technology practice is concerned, basic and applied research activities are somewhat indiscernible, we believe it is important to distinguish between those research activities that have a specific finality, and those that at first do not seem to show an immediate practical employment. For we believe that, as we shall see later in this section, some models of techno-scientific innovation tend to privilege the first kind of activity at the expense of others. The main aim of this section is to unveil the assumptions that produce this, in our view, undesirable effect.

Techno-scientific innovation can be defined as that set of activities "developed" by companies and institutions in order to produce new products and services, as well as new techniques for producing them, and to make them available to users (both beneficiaries of public services and consumers). The latter process is called *diffusion*. Here the connection to economic growth becomes explicit. In fact, economists define *economic growth* as the process of growth of goods and services made available to a given population. The economic success of techno-scientific innovations can be (and usually it is) measured by users' reception of them in terms of both the successful commercialization of techno-scientific innovations and the general benefit the introduction of a new technology brings to the economy of a nation in terms of economic growth. In this respect, innovation is sometimes equated with a Darwinian process of selection in which users are the selective force of new ideas determining their "survival", in terms of successful commercialization and social "demand", and their consequent "reproduction", in terms of becoming one of the building blocks of future innovation. There is another economic advantage often associated with the diffusion of techno-scientific innovation, i.e. the effect of the quantitative and qualitative increase in employment caused by the very process of R&D and the mastering and production of new technologies.

We have now defined the terms of the linear model of S&T innovation. This allows us to picture the model, at its simplest, as a linear relationship going from "basic research" to "applied research", then to the "experimental development", that is the development and production of the discoveries and inventions obtained during the

Fig. 1 – The linear model of techno-scientific innovation

process of scientific research, which yields "S&T innovation" and its "diffusion" among the members of a population (see fig. 1).

The model is widely used by science policy makers and advisors of economic policy to show that government public funding of the activities related to R&D, as well as governmental incentives for private sectors to invest in R&D, have a social benefit return in terms of economic growth and jobs increase. As we have already discussed (see § 0.3.1), the model originated as a consequence of the incredible reception of Vannevar Bush's *Science: the Endless Frontier*, published in 1945. That was an important moment for the history of science policy that occurred at a special conjuncture of the history of science and technology (see § 0.3.2).

In fact, it was during the Cold War that the validity of the equation "international edge = techno-scientific edge" was institutionalized and policy makers were called to the task of designing regulations addressed to a nation's increase of its techno-scientific potential. The favorite mechanism to obtain innovation and, consequently, economic growth, became the linear conception of innovation, expressed by the above mentioned Bush's report, and it was disseminated through writings such as the NSF's report *Basic Research: A National Resource* (1957). In the same period, the model found justification in economic quarters, so that the linear conception of innovation became a credo for policy makers that would justify the need for its implementation in terms of economic return (see, e.g., Nelson 1959). In the aftermath of World War II, the impressive growth of many countries was connected to massive R&D funding: the USA increased expenditure in R&D from 0.6% of GDP to 3.1% in 1967 and then to 2.7% in 1983; likewise, for the same years, Japan started with an expenditure of 0.1% to 1.2% and then to 2.7%; the EU from 0.2% to 1.2% and then 2.1%; the USSR from 0.3% to 3.2% and then to 3.6% (although in this last case only 1.0% of total GDP expenses for R&D were devolved for civil purposes). Based on this data Chris Freeman (1995, p. 9) argues that «[i]t was hardly surprising either that a simplistic linear model of science and technology "push" was often dominant in the new science councils that advised governments».

Hence the policy strategy designed in the face of the equation "international edge = techno-scientific edge" consisted (and still consists) of putting forward the validity of a new equation: "R&D = S&T innovation = economic growth". Given the essential role of economists as policy advisors, the model found both a theoretical and a practical justification, the validity of which lasted for several decades (Mowery 1983).

Nowadays the model has been discredited as a consequence of fifty years of negative critiques from several quarters. In the literature of R&D policy Nathan Rosenberg's claim is often cited, according to which: «[e]veryone knows that the linear model of innovation is dead» (1994, p. 139). More recently, this model has been criticized by the authors of *Taking European Knowledge Society seriously* (Wynne *et al.* 2007) with respect to the assumption at the basis of the linear model: «science invents, industry applies and society conforms» (p. 21). In the report this critique runs parallel to that of the idea – typified by the Lisbon Strategy (see § 7.4 of Wynne *et al.* 2007) – according to which, in order to create a knowledge society it would be sufficient to increase R&D funding by increasing the quota of GDP normally devolved for this purpose. This mode of reasoning may have the negative consequence of ascribing the eventual failure of the direct funding strategy not just to some fault in its basic assumption, but rather to society's reticence to make its correct implementation. In this case we may sometimes hear that «[s]cience is the solution, society the problem» (*ib.*, p. 22).

Nonetheless, the model is still widely employed. Why this is so? And, is there a valid alternative to the model?

5.1.2 – *Alternative models of techno-scientific innovation and how they fail to meet general society needs*

One of the main problems regarding the linear model debated in the literature is that although there is a clear relationship between a nation's potential of R&D and innovation on the one hand, and economic growth on the other, increasing the R&D potential of a nation (in terms of labs, researchers, and projects) is not "sufficient" to produce economic growth. It is by further understanding the relationship between R&D and economics, the very same relationship the model is supposed to explain, that we can understand these shortcomings.

The linear model depicts a situation in which the role of scientists and technicians is to produce a scientific discovery or invention, which is selected by entrepreneurs that foresee the economic return of a given innovation and investment in its production and dissemination according to a market perspective. On this reading, R&D (basic research, applied research, and experimental development) is an integral part of the process leading to economic growth. However, this reading of the model, from left to right, is not the only possible one, for *R&D is an integral part of the economic system since it both conditions the market and is conditioned by it*. The conditioning effect of the market on innovation can be seen when we read the model in fig. 1 as a process going from right to left. We can in fact depict innovation as a process starting from R&D, which makes its discoveries and inventions available to society (*science-push*) that are then developed and exploited by the market; alternatively, innovation may derive by user demand for products and services (*demand-pull*). The demand is received by the market, which, as a consequence, conditions the activities of R&D towards a production of innovation directed by user demand.

Although the reading from right to left of the linear model does justice to the role of the demands of the market for the innovation process, the linear character of the model still keeps R&D in centre stage.

Stephen J. Kline and Nathan Rosenberg's (1986) proposed an alternative model of S&T innovation that identifies the company as the main agent of innovation. Their model is called the "Chain-Link Model of Innovation". They start from the considerations that companies seem to have a more complex role than simply developing and producing innovation created by basic research. According to their model, companies develop innovation in autonomy, exploiting the knowledge of their technicians. When they are not able to solve a problem, they draw or invent the relevant technical solution from the knowledge available from scientific literature, patents, experts, technical advisors and so on. Only when they cannot solve the problem at hand through the afore-mentioned resources will they rely on R&D institutions (either internal or external to the company). Practitioners of the Chain-Link model, then, show that subsidizing R&D is not sufficient for economic growth. In so doing they put an emphasis on the production/diffusion process that responds to the demand of users, incentivizes and then motivates innovation. At any rate, according to their perspective, innovations originate within the firms, while R&D institutions would play a secondary role. The model is therefore a typical example of "demand pull" innovation, since the innovative solutions developed are driven exclusively from market demands.

However, we should not take this to imply that either to subsidize private R&D through public funds or to allow the private sector to better interact with the public one through financial and structural incentives is bad policy. Nonetheless the pull of demand innovation risks subverting the innovation process to mere economic advantage, with the consequences of favoring applied research and marginalizing basic research. This is not a desirable policy outcome. In fact, basic research is addressed to increase our knowledge of the basic principles of natural processes, creating a formal corpus of knowledge transmitted by teaching bodies such as universities across generations; it is a resource on which applied research and experimental development draws heavily. Considering the Chain-Link model, it may be true that innovation is a process determined by user demand. However, as the same model shows, the resources employed by technicians working in the private sector derive from the free corpus of knowledge produced by non-market-oriented means.

Fully submitting R&D to the demands of the market would progressively erode the common pool of knowledge produced in the context of basic research. Hence the need to preserve market-free research activities, that are those research activities that do not promise short or mid-term benefits in terms of economic growth. We may assume that as far as applied research is instrumental to economic growth, and thus market-oriented, private interests will define the ends of R&D and they will constrain it to the effect of excluding those activities that pursue knowledge for its own sake, that is those activities that do not yield immediate economic return. Of course, in the light of what we have said so far, if our policy strategy is addressed to foster economic growth, funding basic research without foreseeing immediate economic return would be unsound.

It seems that the EU is pursuing this "unsound" (given the economic growth finality) strategy. We can infer this by recalling the "strategic goal" set for the EU by the Lisbon Agenda by 2010 (see ch. 1 for a more general discussion of the Lisbon objectives): the connection between R&D and economic growth is given for granted and according to the linear model this can be obtained by subsidizing R&D through public funding and incentives for the interaction between the private and public sectors. We have already argued how far away from the implementation of these objectives we are (see § 1.1). Furthermore, in the light "European Paradox" (the fact that these countries, especially England, have developed an incredible R&D potential which did not translate into the expected high level of economic growth – see § 5.4.2 below), public funding of R&D has not produced the desired effect. Given this, shall we reject the linear model and implement the Chain-Link model? We believe that even the Chain-Link model would fail, irrespective of its deleterious effect on basic research. In fact, both the linear and the Chain-Link models fail to consider other factors necessary for economic growth and increase in employment. This is why other models complicate the interaction among the actors of S&T innovation further in order to obtain a more realistic picture of the process of techno-scientific innovation.

Steven Casper (2007) has recently brought to the fore the relevance of socioeconomic contexts, particularly of national macroeconomic, organizational, political, institutional, and financial factors to determine the outcomes of innovation. He employs the "varieties of capitalism approach" to explain the causes of the failure of EU nations to develop "new technologies" (biotechnology and information technology) with respect to the USA, especially Silicon Valley. The varieties of the capitalism approach is a version of comparative institutional theory, originally developed by Peter Hall and David Soskice (2001); it argues that the successful implementation of policy at the institutional level depends upon specific macroeconomic contexts that act as constraints. Casper shows how the success of innovation strategies in the Silicon Valley area, based on the linear model, depends on the specific macroeconomic constraints on innovation of the American economic system which is a paradigmatic example of share-holder dominated economies, or Liberal Market Economies (LMEs). As the linear model suggests, the translation of innovation into economic growth depends on the successful commercialization of the knowledge produced by R&D. LME greatly favors this process. Each of its components seems especially designed for this purpose: with respect to the management of financial capital, venture capital is particularly encouraged; regarding human capital, a deregulated labor market favors the flexibility needed for the ever-changing industry of new technologies and the exchange of new knowledge from company to company; as far as corporate regulation is concerned, laws favor high-powered performance incentives leading to increasing competition. These are essential elements for allowing innovation to lead to successful commercialization. In order to create the same conditions, European countries have tried to promote venture capital to new technology companies. They have also thought of helping the commercialization of science by giving financial support to universities and creating science parks. However, they did not succeed (see § 5.4.2).

It seems that the success of the main institutional policy directives suggested by the linear model depends on the macroeconomic setting of the areas in which the policy is applied. Now, the failure of the linear model has been especially felt in Europe. While the linear model shows some success in the field of the so-called "new technologies" (biotechnology and ICT) in the USA, as we have seen, it has failed to produce the expected results in the same sector, compared to the economic return from R&S public funding in important EU nations such as France and Germany. Other EU nations, such as Ireland and England, obtained a modest success. This pattern of "success", "failure", and "partial success" follows the same pattern of variation of macroeconomic contexts among the areas analyzed by Casper. The USA, in fact, is the paradigm of a LME which is the perfect environment for the commercialization of knowledge produced by R&D institutions. Germany and France are so-called "Coordinated Market Economies" (CMEs). These economies are characterized by non-flexible labour markets and a strong degree of State regulation that slows down the innovation process. England and Ireland have elements of both LMEs and CMEs. Hence, Casper concludes, the success of innovation policies, such as subsidizing R&D as suggested by the linear model, depends on macroeconomic settings, since the linear model functions only in the context of LMEs.

These considerations are especially useful once we study modalities of technology transfer, when, for example, we see the success of the Silicon Valley model and decide to apply it in another context. Varieties of capitalism show that a given innovation strategy may function in one given economic context and not in another. If our objective is to "create a Silicon Valley in Europe", according to Casper, we should work on changing the EU economic system, since the latter supervenes upon the institutional one.

Casper puts special emphasis on the implementation of the linear model in Germany and England in the 1990s. He identifies the causes of the *European Paradox* in the excessively state-regulated economies of central Europe. Whatever laissez faire practitioners may say, it seems unrealistic to transform a current CME into a LME. Then, given the fact that linear innovation strategies fail in the European context, shall we stop R&D funding for we can outcompete the USA's style of economic growth, given the current EU macroeconomic context? Of course we should not. What then?

A model of innovation that seems to be more suited to the current EU social, economical and political environment is that based on the concept of National Innovation Systems (NIS), which explains innovation as the complex interaction of traditional innovation agents, such as companies and R&D public and private institutions, as constrained by macro socioeconomic contexts. This model has its origin in the nineteenth century in the work of the economist Freidrich List, while the expression NIS was first used by Christopher Freeman in 1982 and then by Bengt-Åke Lundvall (1992). According to a four-year study in which six OECD (Austria, Finland, Japan, the Netherlands, Sweden and the United Kingdom) countries were examined, NIS

> rests on the premise that understanding the linkages among the actors involved in innovation is key to improving technology performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use. These actors are primarily private enterprises, universities and public research institutes and the people within them. The linkages can take the form of joint research, personnel exchanges, cross- patenting, purchase of equipment and a variety of other channels. (OECD 1997, p. 9)

This well developed approach (see Nelson 1993; Schmoch *et al.* 2006; OECD 2000, 2001, 2001b, 2001c, 2001d, 2002) is characterized by a systemic vocation that argues in favor of the hypothesis that

> the innovative performance of an economy depends not only on how the individual institutions (e.g. companies, research institutes, universities) perform in isolation, but on "how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as values, norms, legal frameworks)". (OECD 1999, p. 24; the quote in the passage above is by Smith 1996).

Considering the importance of phenomena such as globalization and internationalization, the NIS approach is motivated by increased attention towards techno-scientific institutions, such as education and industrial systems, as well as more general governmental policies and cultural national variation (Freeman 1995). Hence for this approach, as List had already noted and as industrialization in Germany has shown, the most important challenge is «to build national infrastructure and institutions in order to promote the accumulation of "mental capital" and use it to spur economic development rather than just to sit back and trust "the invisible hand" to solve all problems» (Johnson, Edquist & Lundvall 2003, p. 2). The stress upon the role of institutions that through laws, regulations and norms influence the innovation process runs contrary to the rather diffused idea that national institutions were relevant for economic development only as far as underdeveloped countries were concerned. This expresses the non-linearity of innovation that is based on the systemic interdependence of its components.

Furthermore, the NIS approach clashes with the linear model of innovation because it does not assume the existence of a LME as a sufficient condition for innovation and development. The NIS approach better fits environments in which CMEs are in place, like in Europe. This is so even in those part of Europe whose macro-economies are a combination of LMEs and CMEs, such as Norway, Sweden and Finland (and indeed the NIS model has been first applied in Finland with good results on the growth of the technological sector of this country starting from the 1990s; symbols of this positive outcomes are, for example, Nokia and Linux – see Bound *et al.* 2006). The latter, among the other EU countries, has seen a very rapid transformation towards becoming a knowledge society. Hence the so-called "Scandinavian model" that is posing itself as an alternative to the American model as typified by Silicon Valley (see Schienstock 2004; Veugelers, Toivanen & Tanayama 2009; Veugelers *et al.* 2009).

NIS is especially characterized by the attention it places on enhancing the creativity of both individuals and communities. For instance, consumers are valued for their contribution in the production of goods and services. Following in the footsteps of the linear model of innovation, the approach privileges basic research, and also the importance of climate, labour conditions, and suchlike. It also puts a premium on a multidisciplinary and holistic approach:

> Successful innovation is the result of an innovator's ability to bridge parallel domains which may […] or may not […] overlap with one another. […] Innovation – bringing ideas to the market – is a multidisciplinary activity often conducted not by specialists but either by generalists or by a diverse team of specialists; expertise that crosses disciplinary boundaries is paramount. (Breznitz *et al.* 2009, p. 73)

According to the NIS approach this is the task allocated especially to universities, which should give students professional qualities of a generalist sort (Veugelers, Toivanen & Tanayama 2009, p. 277). This should also be the task of public authorities in general, as the authors of the Finland report suggest: «funding new initiatives such as emerging (potentially multidisciplinary) scientific fields» (*ib.*, p. 292). Funding should amount to 10% of total funds devolved to education and research.

The case of Finland and, more generally, the Scandinavian model, has been praised by many scholars (see, for example, Florida & Tinagli 2004; Castells & Himanen 2002, 2004), who have especially argued that we should stop pursuing economic growth by traditional means. Maybe it is the case that Europe cannot compete with other nations or supranational institutions on an equal footing. As we have seen, Europe has already reinvented its role in the global economic competition by taking the lead of "post-industrial society" in the face of its lack of natural resources. We should take the intention to make Europe a knowledge-based society seriously. Europe has the knowledge to offer as a special product in the global market; the problem is to transform our knowledge heritage into frontier research, despite its failure to directly translate into terms of "grand" economic growth. But, if we change finality, a seemingly unsound policy strategy suddenly makes sense. On this reading, the case of Finland should not be transplanted elsewhere as has been attempted without success with other models such as the German, the Japanese, the American, the Chinese, and the Indian[6] one. Rather the Finland model should make us aware of the fact that

> innovation can no longer be associated with economic growth only; instead it needs to be recognized also as a means with which to solve social and ecological problems. This implies that more emphasis has to be given to non-technical innovations, including social, organizational, service and regulatory innovations. The broadening of the innovation concept implies a great challenge for innovation policy and governance. The traditional idea of a sequential policy process, which first concentrates on supporting innovation processes and afterwards

[6] «India's success in science and technology represents the antithesis of a national innovation system, it is truly dependent on the global flow of people, finance and knowledge. India is highly dependent on international networks of non-resident Indians, working for multinational companies or as academics» (Bound *et al.* 2006, p. 15). This show how technology transfer is a very sensitive issue that requires a complete picture of macro-economic, social, cultural, political heterogeneous environments.

> deals with the negative consequences, can no longer be applied. Policy-makers, being confronted with large-scale changes, have to deal with the various problems simultaneously, which demands cross-departmental co-operation and a highly flexible political system. (Schienstock 2004, p. xiii)

Besides, from the development of Finland – a country that until three generations ago was mainly agricultural and poor – we can learn some indications that seem to adapt much better to the European case than other models – such as the American one of Silicon Valley (entirely centred on the market) or the one in Singapore (whose modernization has an authoritarian character). Above all, we can see how the *Welfare State* is not at all incompatible with a society of information and advanced knowledge, but can represent a decisive contributing factor to the growth of this new economy on a stable basis: «In Finland, the heart of the model is the welfare state and the legitimacy of government acting on behalf of the nation, a nation affirming its cultural identity in a rapidly globalizing world» (Castells & Himanen 2004, p. 81), contributing also to avoiding those phenomena of social inequality, social integration, ecological disruption, growing stress and anxiety and political polarization that Florida (2005, pp. 171-176) diagnosed as the main limit of "creative economy" (see § 5.3.1) and that – not by chance – he maintained could be tackled better by «a series of smaller, more nimble countries that have well established mechanisms for social cohesion and are able both to mobilize their own creative energy from all segments of society, and to compete effectively for global talent» (*ib.*, p. 176). And he includes Finland among these countries (together with Canada, Sweden, New Zealand and Australia. In fact, these countries «may have inherited the broad systems for generating social cohesion, the openminded and tolerant values, and the capability not just to spur innovation and creativity, but to respond to and to internalize the tensions and externalities the creative economy implies» (*ibidem*). Besides, the existence of the Welfare State and the cooperation between companies, the government and trade unions has permitted a development of work flexibility that does not translate into the precarious nature of work like in other countries, that does not leave anyone behind, and therefore does not discharge the social cost for the transition to a knowledge economy only on the workers. The active function of the state in promoting the knowledge economy, acting as promoter of technological innovation and investing heavily in R&D, has not been translated into the bureaucratisation of the economy (the nightmare of the neoliberists), but into incentives and strategic planning able to complete the mechanisms of the market without substituting them. This has allowed them to carry out a policy of inclusion of the whole of the population in the society of information and knowledge, avoiding the digital divide within the same nation (the Bangalore effect). Finally, we should also mention the positive aspect of hackerism: «The Finnish experience, thus, confirms the importance of transboundary hackerism in cultural and tecnological innovation. Societies repressing hackers may be cutting off one of their major sources of intellectual capital and material wealth» (Castells & Himanen 2002, p. 168).

However, as we have suggested, all this requires us to broaden our *Erwartungshorizonten* (German expression for "horizons of expectations") when science policy is involved. We have worked under the assumption that economic growth in contemporary society is a function of techno-scientific innovation. But as we shall suggest below (see § 5.6) it is incorrect to measure the well-being of general society solely in terms of economic growth. Besides current economics "externalities", such as pollution and socioeconomic disparity, the strong drive toward privatization that seem to be a hidden effect of economic growth is by definition a subtraction of public *good* (i.e. "scarcity"). Policies addressed to the distribution of funds for research to both market-oriented and non-market-oriented research would qualify as a partial restitution of that subtraction; and the latter, in turn, would be the right new end towards a re-adjustment of frontier research as a means to meet the general needs of society as well as for the EU to gain the lead of "cooperative advantage" as opposed to "competitive advantage": this is the main message beyond what we shall refer to as a humanistic scenario as opposed to a mere industrialist and economic one (see § 5.6). These are the general objectives that guide the formulation of the other policy recommendations below, with the general working hypothesis that although economic growth is not sufficient to meet the general needs of society, we should keep on pursuing policies that promote science and technological growth. In other words, we have to add new terms to the equation "S&T innovation=economic growth=society's well-being": more specifically, we need to envisage new societal finalities for S&T that, by breaking with traditional linearity, should bring a new meaning to our understanding of the general needs of the EU society.

5.2 – Tacit knowledge and expertise

In the last decade, together with issues concerning possible models of an alternative measurement of growth of national economies (see § 1.3.1), great importance has been given to studies concerning the maximization of all cognitive resources available in various social components (training, economic, research etc.). The aim of this is to keep the processes of production and development competitive and innovative in the society of knowledge, in which the cognitive factor is of structural importance, besides being strategic.

One of the factors that is often quoted – also in the official documents of International bodies – as an essential component of knowledge that enters in a more or less direct way in productive mechanisms, is that of the so-called "tacit knowledge". In a report of 1996 concerning the knowledge-based economy, it is stressed the importance of tacit knowledge, for it possesses «the skills to use and adapt codified knowledge, which underlines the importance of continuous learning by individuals and firms. In the knowledge-based economy, innovation is driven by the interaction of producers and users in the exchange of both codified and tacit knowledge» (OECD 1996, p. 7). In particular – as we have seen (§ 0.4) – a classification of the different kinds of knowledge was carried out (*know-what*, *know-why*, *know-how*, and the *know-who*). These concepts have also been taken up in the OECD documents: the report on the NIS maintains that for a fluid innovative process between companies, universities and research institutions to take place, «both *tacit knowledge*, or *know-how* exchanged through informal channels, and *codified knowledge*, or information codified in publications, patents and other sources, are important» (OECD 1997, p. 3). Tacit knowledge can be identified as that set of cognitive practices that everyone has, that goes everywhere with us since it cannot be completely codified in scientific manuals and articles: it is our general approach to innovation, competence in resolving problems, the ability to localize and identify relevant information and access research networks; in brief, a set of "skills" and "adaptive ability" that are «largely determined by the qualifications, overall tacit knowledge and mobility of the labour force» (*ib.*, p. 18). These concepts are taken up again in subsequent documents (OECD 2004, pp. 18-20; OECD 2005, p. 9) and are also linked to the concept of expertise, regarding which it is stated that the «the tacit knowledge embodied in people can be multiplied through interaction and transfer of expertise» (OECD 1999, p. 65).

Also the EC documents show awareness of this problem and make continual reference to tacit knowledge, but often these are only indications, almost taking the concept for granted and in essence identifying it with *know-how* (EC 2000c, p. 10) and as something «embodied in personal experience and social networks» (EC 2003b, p. 29) which one must take into consideration in the processes of knowledge transfer (EC 2007g, p. 2).

5.2.1 – *The representation of tacit knowledge*

However, the impression we get of this use of the concept of tacit knowledge is that it has been practically despoiled of the epistemological complexity from which it originated and led to a specific autonomous category within which many of the unresolved problems of an exemplificatory or representational character of knowledge are collocated. The first and most important of these concerns the diverse modalities of representing the skills and experiences in the cognitive field on the one hand and the analysis of the concept of knowledge on the other. While the latter touches a substantially theoretical sphere, the former concerns the field of practical applications. And it can be easily understood how, according to the theoretical perspective acquired as a personal reference point, the nature of cognitive practices can be interpreted in a different way

For these reasons, from an analytical point of view it is important to distinguish between concepts of a theoretical nature and concepts of a practical nature. Therefore, for the aims of our approach, we will assume tacit knowledge in its most complete form, that is as a concept of a theoretical nature based on specific assumptions of an ontological and epistemological character, involved in various theoretical perspectives, and also as a practical concept, that is, as a tool or category able to construct meanings. The notion of tacit knowledge may be considered to be descriptive of some practical problems while not necessarily based on well explained theoretical assumptions. In brief, tacit knowledge refers to all those intellectual or corporeal abilities that the individual does not manage to fully manifest, represent or codify. Therefore, tacit knowledge should be seen as a series of imperceptible but existing points in a fabric of well known explicit knowledge.

From the theoretical point of view, before becoming part of the reflective dimension of science, reflection on the category of knowledge, was fertile ground for philosophy. Plato himself considered it to be a pre-existent human faculty, and described it as the memory of eternal ideas to which the individual could access through exercise involving the faculty of thought on a higher level. In fact, that Greek idea linguistically distinguishes diverse ways of understanding knowledge, depending on whether it concerns sections of scientific thought in which doubt has been removed (*episteme*); common opinion lacking certainty (*doxa*); artisan or artistic ability *(techne*); or capacities and abilities based on practical reason (*phronesis*); these distinction are kept also in more distant areas from epistemological regions in which a specific contact has been foreseen or a contamination between problems of scientific methodology and questions of a metaphysical nature has occurred. From this point of view, an example could be the distinction made by Foucault (1972) between *connaissance* (specialist knowledge) and *savoir* (scientific knowledge). However, regarding the levels and places involved in the concept of knowledge we feel it is essential to also keep in mind the fact that it should be considered to be «provisional as an aggregate – whether in a human mind, in a technical handbook, as an organizational knowledge base, or in a science» (Zwass 2008, p. viii).

The notion of tacit knowledge was introduced for the first time in an explicit way by Polanyi (1958), although the concept had already appeared in the reflections of Ryle, in the terms of "Knowing that"/"Knowing how" (Ryle 1949, pp. 16-20), and subsequently taken up by the philosophers of the mind and language (Dretske 1991; Chomsky 1972, 1986; Searle 1983, 1992, 1995; Reber 1995), until it reached an almost stable collocation in studies concerning the processes of formal and informal learning (Sun *et al.* 2007). Following this, as we have seen, it was made functional to the problems of technological innovation and the transmission of knowledge useful for economic growth and the economy of knowledge (Howells 1996), with the consequent distinction between knowledge and information (Lundvall 1998).

Distinguishing between explicit and tacit knowledge, Polanyi identifies tacit knowledge as being part of that knowledge that escapes every representation in an objective measure, but always keeps an active role in carrying out specific operations or activities. In fact, he claims that «the aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them […] the principle by which the cyclist keeps his balance is not generally known» (Polanyi 1958, p. 49).

According to Polanyi, the organism in the physical sense is the basis of our knowledge, both intellectual and practical: «All knowing is personal knowing» (Polanyi 1969). By this he means that all knowledge is acquired by he who knows and is incorporated through processes of a physical and mental nature. Naturally, this does not mean that knowledge is subjective in itself but that all knowledge, both intellectual and practical, is indissolubly linked to the person who acquires and transmits it; thus the gap between what is relative to the professional sphere and what concerns the personal sphere is removed. According to Polanyi, this is because, in order to be professionally competent and able to know, we must act in first person through our physical being. Regardless of the kind of activity we are involved in, our personal knowledge is called into operation to actively collaborate, even if, now firmly structured within us, it transfers itself along with the large portions of knowledge that are most visible in the professions, or more in general, in any kinds of behavior, in information that is easily objectified. Usually only the latter is immediately recognizable by others, professionals or otherwise. Learning to use a tool or acquire a skill means accommodating and incorporating them. For this reason, there is always something non-explicit that cannot be completely objectified in the relationship between formulated practices that have been carried out, and definite roles.

Therefore, Polanyi's theories appear to be an implicit criticism of representational theories, which, on the contrary, maintain that reality coincides exactly only with what can be said and represented by them, attributing a marginal and non objective value to everything that remains outside this process. Since its conception in the modern age, this representational style of science has been influenced by a conceptual frame according to which any form of objectification, be it a concept, a figure, a formula, or a graph, always constitutes an instrumental pre-requisite to explain reality and make it available in a symbolic and intersubjective way (Knorr-Cetina 1999; Latour 1999). Therefore, according to such a concept, science would remain deeply linked to the field of one representation, however well defined.

5.2.2 – *The possible explications of tacit knowledge*

A paradigmatic example of how the notion of tacit knowledge is explicated in the field of science is provided by the considerations of Werner Heisenberg. In the attempt to illustrate how science and representation are interconnected, he underlines how already in the period of the prehistoric formation of human language, there was the problem of the definition of the meaning of terms, since a definition always involves using other concepts. Avoiding a *regressus in infinitum* essentially means using key concepts ("data") in a non analyzed and definite way (Heisenberg 1958, pp. 168-169).

This is just a problem of representation that directly concerns the issue of tacit knowledge on a more general level: on a par with those "data", many of our skills and capacities cannot be easily expressed through an "average" of representations available to us. Thus we cannot communicate all the knowledge in our possession, including in it every clarification both of all the cognitive contents and all means at our disposal to communicate with others. Apart from a specific theorization of it, the original context of reference of the relationship between what one knows and what one is capable of transmitting to others regarding one's knowledge seems to be situated almost exclusively on the level of communication; once this obstacle has been overcome, the cognitive "data" would not encounter any obstacle in reaching their destination and in being decoded by another person. In reality, a theoretical reflection on the question leads to a division in the field of literature according to the fact that some or all tacit knowledge can be considered to be convertible to explicit knowledge.

For example, Max Boisot maintains that three distinct variations of tacit knowledge can be identified: 1) things that are not said because everyone understands them and takes them for granted; 2) things that are not said because no-one can fully understand them and therefore they remain elusive and not articulated; 3) things that are not said because if even some people are able to understand them, they cannot articulate them or if they do, they cannot do it well (Boisot 1998, p. 57). According to Boisot, Polanyi referred mainly to the second variety of tacit knowledge, while the theorists of the so-called "knowledge management" referred to the third definition. Philippe Baumard, on the other hand, claims that two characterizing aspects of tacit knowledge should be highlighted: 1) a cognitive dimension constituted by paradigms of mental models of representation and 2) a theoretical dimension, that is, the *know-how*, that is the expertise applied to a specific context. (Baumard 1999, p. 59). This type of approach means that tacit knowledge does not only lie in the mind of the individual but is distributed in organizational resources that include a multitude of technologies, processes, subjects and means of representation For Spender (1998, p. 243) it is the introduction of the very notion of "tacit" that represents a difficulty: in fact, many other notions flow into that of tacit knowledge; however, the concept of "tacit", as a container of meanings must not be seen as a kind of single substratum containing some homogeneity. The notion of "portmanteau term", introduced by Spender, describes this difficulty to define tacit knowledge very well; in essence, it interprets it as a residuum that escapes objective representation when the usual means of communication that are available on a semantic level are used.

This strengthens the view, already wholly shared, that tacit knowledge completely involves the cognitive sphere, since it cannot be reduced to «a purely physical skill or know-how». Because of this specific quality, it «cannot be considered a belief, a competence or an acquaintance but can play a relevant role in scientific work» (Pozzali 2008, p. 236). Anyway, all this suggests the hypothesis that human sciences, and epistemology in particular, deal with a representational and semantic problem that concerns entities, events and processes that form one's personal knowledge and also the knowledge relative to organizations.

The attempt to resolve this division between representational/non-representational made by Bergson who held it to be a "false" problem (Bergson 1988, p. 125), since no language is able to exhaust every ontological aspect semantically, goes in this very direction. In this way, it is also possible to understand how the construction of concepts made by science and the decision regarding which objects to include in a potentially representative perspective and which to exclude, since the latter do not lend themselves to being elaborated on and communicated according to a shared inter-subjective scientific language, directly concerns what it is possible to explicate from reality and what cannot be enunciated from it.

From this viewpoint, the division between explicit and tacit knowledge may suffer from the question of demarcation posed by Popper (1935): science is only concerned with problems that it manages to communicate through its own language. And this is the typical limit of a realistic approach based on the concept of truth as correspondence – criticized, together with foundationalism, by Richard Rorty (1998); according to him, concepts and theories would be limited to projecting on a mirror an underlying reality characterized by nomic regularities. But in this way, we are not exactly able to say where explicit knowledge begins and where the tacit starts, because the latter cannot be completely objectified in an intersubjective language since it concerns, above all, the ability of the individual to recognize it, and therefore it does not have a meta-theoretical language at its disposal (a higher level than the conventional one) or a pragmatic device able to explicate it to others. Therefore, a single dimensional view of science, characterized by rigid links of correspondence between facts and theories, constitutes a serious obstacle to the reappraisal of tacit knowledge in the context of scientific discovery, while what should be held essential is the regime of the categorical contamination in a heuristic perspective of knowledge (see heuristic appraisal in § 4.6) and the more fluid assumption of an idea of science as the one we presented with the MAS (see § 4.3).

Besides, in a foundationalist vision, consideration is not taken of the link between the factors relating to the social contexts and the cognitive process in general, that is conceived of *per se* and is totally estranged from the matrices knowledge/power, knowledge/interest, knowledge/context, which are equally important and considered, for example, in the reflections of Michel Foucault and Bruno Latour (see Foucault 1980; Hacking 1999; Latour 1999; McKinlay & Starkey 1998; Sismondo 1996; Townley 1993). Wittgenstein even claimed that the refusal of the foundationalist perspective passed also through a clear reappraisal of the specific context of reference, as in the case of error (Wittgenstein 1969, § 156).

Following this clearly descriptive direction, different epistemological approaches, though constructed according to views of science that are quite distant from each other, agree on rejecting ready-made concepts; they are limited in paving the way for discovery and the structuring of new ways of thinking (Bergson 1999), though remain vital in the training and apprenticeship of novices to provide them with embodied ability, with an automatic character, to link exemplary cases of "normal" science to relative solutions (Kuhn 1969).

In the case of science, the relationship between tacit and explicit knowledge, does not draw questions of a semantic or procedural nature, but directly concerns the passage from an "interpreted" view of reality, to which science makes reference, to one made personally, through the use of the *Gestalt* typical of the scientific community of reference (Kuhn 1962). The transition, the "sliding", that is not voluntary but aware, from a dimension in which the knowledge made explicit through the objective knowledge of manuals and instructions is directly incorporated within a new vision of the world, without being translated or interpreted, means for Kuhn that we do not simply find ourselves before problems, but within them; that is, one tackles them using a mental *Gestalt* that foresees the simultaneous knowledge of facts and relationships: the former can without doubt be assimilated in objective knowledge, and therefore expressed, while the latter can be assimilated to a connection, a structured link, incorporated and therefore implicit, very close to the idea of tacit knowledge.

5.2.3 – *Society, tacit knowledge and knowledge-based view*

Bearing in mind the most recent epistemological acquisitions, many studies regarding the analysis of the "immaterial" character of the goods that come to be part of the "knowledge-based society" have highlighted its problematic character. They have particularly insisted on the fact that an organization of any kind, and not only that represented by the scientific community, may be capable, if guided correctly, of exploiting the great potential of tacit knowledge, in order to increase its competitive capacity; this particularly applies to small companies which are better able to enjoy the benefits of this tacit knowledge than big companies, especially in the field of technological innovation (Koskinen & Vanharanta 2002). Unlike traditional organizations, that are only able to integrate resources of a physical, financial and human type and make them react, the particular systemic structure of knowledge-based companies places at the fore their character of organizations functional to development and other forms of resources and intellectual goods, driven by a highly competitive context.

The concept of tacit knowledge, long neglected by traditional epistemologists, has been given new life thanks to the applications that the Japanese management "guru" Ikujiro Nonaka made of it (1991; Nonaka & Takeushi 1995; Nonaka & Nishigichi 2001) in the study of the use of knowledge in organizations according to the perspective of strategic management and given the label "knowledge-based view" (KBV), that deals with investigating the organizational theories concerning the use of knowledge.

One of the main keys of "knowledge management" is to capture and explicate both tacit and individual knowledge present within the organizations, subscribing to the point of view according to which knowledge contains a component that we can never completely represent and codify. This means that there is always something undetermined, fluid and ambiguous that can be represented as a hidden or latent component of knowledge, precisely defined "tacit", that conserves strong theoretical marks of the original connotation given by Polanyi. However, subsequent theoretical contaminations of the concept expressed by Polanyi have increasingly pushed tacit knowledge towards a possible inter-subjective, less solipsistic interpretation (see Ray 2009, pp. 76-77); this is what happened with the category of "reflexive knowledge" elaborated by Pierre Bourdieu (2004), according to whom, it «is both a practical tool (of research, analysis, critique), and at the same time something which can be taught and learned» (Schirato & Webb 2002, p. 267).

The birth of KBV and other theories of cognitive management have also contributed to a growth of the complexity of analysis on the notions relative to knowledge, such as ability (Knights & McCabe 1999), competence (Gherardi 2000; McEvily, Das & McCabe, 2000), tacit knowledge (Athanassiou & Nigh, 1999; Baumard 1999), expert knowledge (Blackler, Crump & McDonald 1999), cognitive heritage (Boisot 1998; Teece 1998), narrative knowledge (Polkinghorne 1988); and creativity (McFadzean 2000; Oldham & Cummings 1996). Together with these directions, a specific area of discussion concerns researchers regarding the theories of the working process seen through the lens of the connection between knowledge and power (see e.g. Hardy & Clegg 1996; McKinlay & Starkey 1998).

However, going beyond the various specific directions, one of the main interests of KBV and the literature that deals with cognitive management is to study how to get the maximum use of the cognitive resources available in an organization, focusing, as has been said, particularly on the sphere of tacit knowledge. In this specific field of investigation – despite the fact that empirical evidence shows how it is quite difficult to codify, distribute and exploit all the cognitive resources (e.g. Pfeffer & Sutton, 1999) – there has been an astonishing growth of studies. However, even in the framework of KBV, knowledge is not presented as a simple resource: in general, it cannot be examined, manipulated or used as if one were dealing with a simple sum of individual entities. Rather, the approach that KBV takes is that knowledge, including tacit knowledge, should treated as an organizational resource, that can always be strategically transformed, for those who know how to investigate it correctly, into a competitive advantage.

This emphasis on the studies on management regarding the presence of a silent knowledge in the nerve centers of productive factors has provided the opportunity to rethink the profound idea of organizational structure. So the field of knowledge management has produced a large number of studies concerning the modalities by which knowledge is created (Nonaka & Takeushi 1995), disseminated (Davenport & Prusak 1998; Dixon 2000) and used (Boisot 1998; Choo 1998; Pfeffer & Sutton 1999; Seely-Brown & Duguid 2000).

But unlike the direction of the KBV itself and its excessive objectification of the concept of tacit knowledge, it has been revealed that knowledge cannot be treated like another form of resource (Grant 1996; Teece 1998). In fact, treating knowledge as a simple resource as if it were a static entity, the same as any other productive factor of an instrumental type, would bring about the loss of the opportunity to transfer the theorization also on a fundamental level (see Spender 1998, pp. 234–235). According to this instance, the concept of tacit knowledge can be further explored in its characterizing aspects, to be opportunely modulated, when it is not just considered for itself, but kept inserted in the background of a social or contextual scenario and examined, therefore, in relation to specific cases of reference. And this particularly applies when dealing with contexts of Information Technology where, according to some of the literature, if «tacit knowledge is recognized as playing a key role in determining the extent to which companies are able to create sustainable competitive advantages, the consequences may be devastating» (Johannessen *et al*. 2001, p. 14). From this viewpoint, we can state that in general, the notion of tacit knowledge can be investigated better in contexts of a holistic nature (see Koskinen 2000, p. 44) and not following approaches that are strongly reductionist, like Fleck's (1979) (Fagan 2009, p. 273).

The emphasis on these elements given by this second interpretative line, unlike those proposed by the KBV, holds firm to the original connotation of tacit knowledge: an approach that identifies in the notion of latent knowledge all those forms of knowledge that cannot be represented in a highly specific way and instead identify an aspect of knowledge that cannot be totally translated in expressive formulae or descriptive objectifications, but whose presence in the cognitive processes strongly conditions the results. We feel that this direction can also tend towards the recuperation of the concept of "expertise" in the epistemological area, that is, making the implicit and explicit areas present in professional competence meet with that unexpressed potential of incorporated knowledge of a biological-structural character to which the theoretical concept of tacit knowledge is referring. Expertise, as part of a wider perimeter represented by tacit knowledge may, in many cases, represent a manifestation of indirect knowledge expressed through concrete practices, while not weakening much its own specialist range, that on the contrary is widely encouraged, as happens in many instances of training in the fields of medicine and clinical education (Engel 2008; Kinchin *et al.* 2008) or in financial training.

5.2.4 – *Models of expertise*

With reference to the traditional conception of expertise that go back to the known distinction of Lundvall's *know-what/know-how* (see § 0.4), we believe that it would be profitable to put into operation a softer neo-humanistic approach (see also § 5.6) to *know-how* that is connoted in a less specialised way, seeing it as self-recognised capacity, matured following examples of previous experience. In this more general form, expertise can be made outside specific contexts of reference of a technical and specialist nature, with the aim that it can be used within a science/society relationship thanks to a more shared and diffused recollocation, that is, seeing it as the possibility of familiarising scientific paradigms on a non specialist basis. Expertise, the value of which is usually determined in relation to other specialists through indicators of an essentially procedural nature, may on the other hand be very instructive in the comunicative praxis of scientific experience, even for lay people. In fact, the wisdom, professional and otherwise, that accompanies the best practices can be considered constitutive not only for the highest levels of knowledge, but also for those that refer to very common operations and of more modest importance. This structural community, which provides for the incorporation of tacit knowledge, also in the form of ordinary knowledge, and not just specialist knowledge, can be considered legitimate on a theoretical level thanks to a more comprehensive view of the workings of the tacit dimension, as shown by cognitive psychology on the level of neuron perception (Engel 1996).

The basic distinction between information (with an explicit character that can be transmitted in discreet units, in bits) and knowledge (comprising the tacit dimension) made by Lundvall, and commonly accepted in studies of the management of knowledge (Johnson *et al*., p. 5; Boisot 1998, pp. 19-20; see § 0.4) – is important not only to describe the concrete procedure of cognitive praxis, but also to define better the roles of the individual agents that operate with complex knowledge. Information, made up of data, is always part of "personal knowledge" (Polanyi 1958), which plays an increasingly important role in decoding other information that requires previous knowledge, proportional and anyway sufficient to interpret it. The relationship between tacit knowledge and expertise can be collocated in the invisible relationship that exists between the new acquired information and the previous one, incorporated in personal experience and that gives it a significant interpretation.

> The scientist who makes a laboratory experiment may get much closer to documenting the process fully and in such a way that others can repeat it with an almost identical outcome. Here it is important to note that scientific research takes place under controlled conditions and that a major objective is to make sure that outcomes are not too dependent on specific personalities and environments. In this case the problem of knowledge transfer is more related to a lack of absorptive capacity in terms lacking institutional support. But even in this case the codification is incomplete in the sense that the personal knowledge of the scientist cannot be fully included in the codified message. Her ability to draw conclusions on the basis of observing complex evolving patterns is something that has been learnt in a direct interaction with more experienced scholars. (Johnson & Lundvall 2001, p. 5)

In fact, in the scientific field, as in the social one, it is easier to decode a description of the world than to manage to understand the ways in which reality is changed and manipulated by the scientist in the context of scientific and applicative practice. The objective of science is not to incorporate knowledge that is not visible in the communication of scientific results. However, the procedural activities at the basis of a new scientific theorizing and that come to form part of a publication can be understood by the scientific community only if they do not trust completely the simple verbal explication, but mobilize the resources that are at the basis of cognitive training.

The problem of recognition on the part of non experts of possible scientific expertise incorporated in the results that science gives society, shows how the concept of tacit knowledge contrasts with the quite widespread idea, involving most scientific divulgation, that it is possible to understand the closed and specialized world of science by observation from outside, seeing its results and applications, or also having a description of its theories of an intuitive type. In these cases, the simple intuitive level, or a simple technical construction of meanings suggested from the outside, that acts on the tacit knowledge of the non expert, is not sufficient to procure results of shared knowledge, since the first level of difficulty encountered by those who are not familiar with science, is a contested familiarity with the specialist dimension.

Many disciplines and researchers have approached the study of expertise from particular perspectives and from diverse traditions. The result is that it is quite difficult to reach an effective, univocal definition for the varied domains of research and the particular contexts in which specialist knowledge is explicated, especially in the field of science. An effective framework of the different ways to understand expertise has been proposed by Garrett *et al.* (2009) and comprises an interrelated set of dimensions that take into account the debates concerning the performance of physical and cognitive abilities available today (see fig. 2); he provides a better structured approach to the distribution of expertise within social contexts that are more or less specialist.

What emerges from this study is that the dimensions of expertise and tacit knowledge may well cross paths, since each considers the other to be a general precondition for a cognitive possibility. Therefore, seeing that the idea in the field of education that "*we can know more than we can tell*" (Polanyi 1966, p. 4 – italics in the text) cannot be used in an explicit way to support the learning of he or she who has to be trained (Kinchin *et al.* 2008), we may hypothesize that much more professional knowledge than what can be explicitly taught emerges from the bottom of tacit knowledge in those areas where the "how" has greater impact, that is regarding the so-called Interface Tools – operative connections whose epistemological nature is «based on training and human-computer interaction literature examining development of user skill in manipulating complex technological systems» (Garrett *et al.* 2009, p. 97).

Another recent model, based on complex descriptors that relates tacit knowledge to expertise is that of Collins & Evans (2007). They present their "Periodic Table of Expertises" that comprise five different levels of expertise each with several typologies. At the lowest level there are the "ubiquitous expertises", linked to diffuse, common acts like the ability to speak in one's mother tongue, the ability to drive or express a political opinion; none of them concern the field of science and technology. This kind of expertise involves the use of a large amount of tacit knowledge, that is «things you just know how to do without being able to explain the rules for how you do them» (Collins & Evans 2007, p. 13). The "dispositions" follow, that is personal qualities like linguistic fluency or analytical capacity.

The most important level is that of "specialist expertises", that in general are constituted by knowledge of those facts that are relevant to solve a cognitive problem (like knowing how to copy a CD) without being fully aware of what it means to do it. This is the knowledge found in practical guides – the so-called "beer mat knowledge" –, that tell us what to do in a certain situation but do not allow us to interact in a positive way or to have any initiative in it or to explain to others *why* it must be done in that way. Also the "Popular understanding of science" belongs to this level, acquired through mass-media and books of scientific divulgation, which pay more attention to the ideas than to the formulae in which they are embodied. It was the fundamental objective of programmes like COPUS (see § 2.2) to increase this. Also the "Primary Source Knowledge" is on this level: knowledge of the primary literature in which scientific knowledge is deposited, but without coming into contact with researchers in the flesh or being part of a research team. This is the knowledge that Kuhn calls "manualistic", that has nothing to do with the science that is actually practiced in research groups; it was also criticized by Latour, who contrasts it with the knowledge in the laboratory (see § 3.4). Knowledge of this kind does not yet have a specialist character and can be learnt almost freely or with the aid of specific support, but generally it does not have any interpretative difficulties; however, it requires the presence of "ubiquitous tacit knowledge". The last two types of knowledge that form part of "specialist expertises" concern knowledge that is no longer "ubiquitous", but a "specialist tacit knowledge": this is "interactional expertise" (the capacity to master the language of certain domains though without any practical competence, as in the case of those who do peer-reviews or scientific journalism) and "contributory expertises", necessary to do an activity in a complete way and that usually are divided into five stages of progressive maturation (novice, advanced beginner, competence, proficiency, and true expertise): the specification of "contributory" means highlighting the ability to innovate or expand the field of specific research, contributing also to the shared culture of tacit knowledge of a specialist type. The "interactional expertise" regarding "contributory expertise" acts as a parasite: although from a qualitative viewpoint it is of a high level, its life is sustained by constant contact with the contributory experts and runs the risk of being rapidly dated when this contact is not kept up. In any case the interactional experts can cover the role of critics and can contribute to the progress of a fixed area of research, acting as facilitators, disseminators and fertilizers. It is important to note the difference between the first three levels of "specialist expertise" and the last two:

> The first three categories of expertise, beer-mat knowledge, public understanding, and primary source knowledge, might be said hardly to enter the category of specialist expertise at all because they do not involve much in the way of mastering the tacit knowledge belonging to the subject matter of the domains; the acquisition of the first three kinds of knowledge (though it depends on ubiquitous expertises), involves reading rather than immersion in the specialist culture. "Enculturation" is the only way to master an expertise which is deeply laden with tacit knowledge because it is only through common practice with others that the rules that cannot be written down can come to be understood. (Collins & Evans 2007, pp. 23-24)

Finally, in the approach of Collins & Evans two further levels are identified: "meta-expertise", consisting in the necessary requisites to make a judgement on what the experts do even if one is not an expert, using either some "external" indicators like their behavior, the coherence of their statements, their social position and so on, or internal indicators that involve a certain familiarity with what one is judging (the music critic does not have the expertise to play, but he is able to understand when a violinist hits a wrong note); and finally, the "meta-criteria" used by those who, completely extraneous to the sector of the expertise, in order to judge experts need external criteria such as their personal credentials, career, recognition and prizes received (a Nobel prize-winner is preferable to an obscure expert from a provincial university, for example).

The framework presented by Collins & Evans is particularly significant in that it enables us to understand the many planes of interaction between tacit knowledge and disciplinary knowledge – or to put it more simply – between formal and informal knowledge; the term "expertise" embraces both aspects of science. In this viewpoint, it is natural to place the themes and the debates that are the subjects of the traditional philosophy of science within "contributory expertise"; in this way it occupies the space of rational and logical argumentation, which also concern the hierarchical levels we described earlier within the "multi-dimensional approach to the scientific practice" (see § 4.5.2). Besides, it is clear that there are diverse types of tacit knowledge: "ubiquitous expertise", that is available to anyone with a minimum of socialization; "specialist expertise", that can be "ubiquitous tacit knowledge" or "specialist tacit knowledge"; and finally there is "meta-expertise", that is used to guide other forms of expertise through the "meta-criteria" of the "Credentials", "Experience" and "Track Record" (Collins & Evans 2007, pp. 45-46).

Besides, it is important to point out the fact that in both the models illustrated above (by Garrett *et al.* and Collins & Evans) the problem of the subject matter is a decisive factor. In fact, it seems clear that in a knowledge-based Society, the role carried out by expertise tends to be increasingly overexposed as the complexity of knowledge, disciplines and practices grows. In brief, we believe that the increasingly accentuated discipline specialism brings the risk of an increasingly high threshold of tacit knowledge and expertise in relation to increasingly complex subject matters. A critical point of the system may be constituted not so much by the rising trend, but by the fact that the tacit knowledge suggested by some highly specialized areas does not permit acceptable training spin-offs in other areas, even in the light of changing economic conditions of the market of knowledge. The knowledge of a subject matter, in the way in which it forms part of a complex web of expertise and tacit knowledge, cannot easily be reconverted into other forms of competence, since the transmission of knowledge would settle within medium level of incorporation both of expertise and tacit knowledge. This would lead to a continual redefinition between the confines of formal and informal knowledge and therefore the limits of disciplinary teaching, the field of which cannot be extended beyond certain specialist limits without then having to resort to the dimension of practice, that cannot be the prerogative of academic circles. A significant indication of awareness of this problem and at the same time an attempt to prepare measures aimed at facing it in certain areas, is the recent document approved by the Department for Innovation, Universities and Skills of the United Kingdom on "informal adult learning" that – though limited to those of a mature, post-school age – proposes a series of measures to reduce the gap between experts and the public, trying to promote, through activities that are different from formal education, the stock of tacit knowledge available from it (see DIUS 2009).

5.2.5 – *Expertise, tacit knowledge, complexity of knowledge*

On the level of knowledge production, or rather in the construction of new competences, research has only now begun to make its first steps in the question of "who learns what", and how learning through experience (*experiential learning*) can be strategic for economic development (see e.g. Kolb 1984, pp. 120-135). In this field, the economists can learn from models and cognitive strategies elaborated by education specialists who have developed, in the most systematic way and on an empirical basis, strategies for lifelong learning (Knust & Hanft 2009; Usher & Edwards 2007) and experiential learning (Moon 2004; Beard & Wilson 2006; Silberman 2007).

Of course, "expert performance", when placed in connection with the question of creativity and problem solving, demands that at the basis there is a high level of expertise, seen as a voluntary path of acquisition of knowledge and practices, so as to have at one's disposal a massive accumulation of data ready to be used to solve a specific problem of a certain sector. This appears to be particularly important for specific branches of science in which high level performance can lead directly to complex studies and the possession of cognitive heritage with a high level of specialization. Even in cases where a direct causality connection between different levels of cognitive ability and operational practices cannot be seen, the fact remains, however, that it should always be considered that the expert has an excess of knowledge to be able to give rise to new practices.

To this regard, it seems important to underline, for the purposes of our study, that improving on a qualitative level the cognitive basis that enables us to link abilities to practices means reasonably and with all probability, making sure that the latter are "forced" to improve. However, this does not take place in the sense of "reproductive expertise", that is in the sense of perfecting a skill, perhaps through hard exercise, without, however, making a creative leap (like the swimmer who, after years of constant training manages to make record performances but only by repeating more and more perfectly an action that has become completely automated) thus going «beyond the expertise as handed down to them» (Weisberg 2006, p. 199).

A large part of cognitive studies do not have a predilection for the approach that links expertise and creativity (Guilford 1950; Frensch & Sternberg 1989; Ward 1995; Simonton 1999), since they are generally considered to be opposing concepts: the former because it is constituted by structured knowledge (Structured Knowledge – StK); and the latter because it is by definition knowledge outside schemata since it is creative (Creative Knowledge – CK). However, we must point out that there is quite a strong relationship between them, because only by virtue of a break between the former (StK) is the passage towards a form of alternative knowledge possible (CK), which would be the result. This way of proceeding – valid for problems concerning quite narrow sectors – does not mean, if made valid as a general schemata, that the break with previous models of knowledge (StK) should lead to an immediate and almost total demolition of the knowledge contained in them. Broad swaths of knowledge on the basis of which the new is built are usually recuperated and transmitted to subsequent generations (Lorenz 2007). In any case, the transition from structured to creative knowledge requires recognition that the problematic situation it caused is the fruit not of "personal failure", due to the limited capacity of the researcher and the insufficient means at his disposal, but is equivalent to an "essential anomaly" that makes a certain paradigm no longer sustainable (Kuhn 2000, p. 27).

Evidently, this means that the relationship between expertise and creativity in the field of discovery cannot be seen either as a complete pouring of the recombined parts of the former into the latter, nor as the absence of the former in the latter. Even when the discovery involves a large part of causality, it is not made "by chance" but always on the basis of a pre-existent one, of "consolidated paradigms" (Kuhn 2000, pp. 26-27), that constitutes its foundation: «knowledge serves as the foundation on which the creative process builds the new» (Weisberg 2006, p. 206). As Kuhn points out:

> the causality through which [discoveries] have emerged would not have been able to happen to a man who was simply looking around him. In mature scientific disciplines, discoveries require very special equipment, both from a conceptual viewpoint and from the instrumental one. […] The consolidated paradigms are therefore often […] prerequisites for discoveries. (Kuhn 2000, pp. 26-27)

The personal interpretation of facts, equally available also to others belonging to same scientific community, must be presented in a completely innovative form. According to these modalities, the terms "expert" and "expertise", preconditions for the realization of creative knowledge on a higher level both on a practical basis (Ericsson & Smith 1991) and a study basis (Weisberg 2006), assume a very high training value (see § 5.3).

On the more typically communicative level, it is just as important that the widest social community is aware that these forms of creativity do not constitute vertices of knowledge whose meaning is generally inaccessible for normal humanity (see § 5.3.1). In the more specific field of the relationship between science and society, it is important that the scientific community itself realizes that increasing scientific familiarity among citizens is not enough to change their opinions of distrust towards so-called cutting-edge research. As efficiently revealed by Gilberto Corbellini, being "science literate" does not necessarily mean "scientifically literate". That is, the possession of a few basic scientific notions does not automatically lead to understanding the way in which science understands natural phenomena (Corbellini 2009, p. 182). From this point of view, the knowledge-based model of society, the attempt to build a model of science not "translated" but "interpreted" in the sense of Kuhn (2000, pp. 56-59), seems to us to be more favorable in order to enable widespread tacit knowledge to meet with expertise, even of high profile. In such a model, we should aim to make the basis of the finalistic aspects and essential ontological questions of scientific research shareable among the community of scientists and the widest possible social context, rather than aiming at a direct translation of the complex and formalized language of science into common language.

With this objective in mind, a more insistent call to the metaphor in scientific communication in a social direction could be very useful. In fact, the distance between presupposed tacit knowledge at the level of "specialist expertise" and that of a lay person can be partially bridged if we find a way to express what cannot be expressed. To this regard, it is more than ever significant to turn to the epistemological positions held by Paul Feyerabend, in the wake of those by Fleck, Kuhn and Polanyi, and the attention that he gave to the history of science and the examination of historical cases as prospective strategies from which to see the progress of science. As he has repeated many times, examples are not "details" to be omitted once the "true explanation" of phenomena has been provided, since those examples "constitute" the explanation of reality (see Feyerabend 1987, p. 279). An understanding of scientific theories both within science and outside it does not require the formulation of a theory of science but rather a shared "participation" in those examples that it proposes as explanations of reality (see also § 2.3).

The possible meeting of "specialist expertise" and the expertise possessed by the wide public can be identified in its most immediate use, that is in the tool of "participation", through the use of figurative language: the metaphor. In fact, the metaphor is both a different way through which it is possible to make people in different cultural contexts and with different experiences understand the same content in an intuitive way. In fact, the powerful use of the imagination allows us to go beyond the use of contents that provide complex and formal forms of knowledge, especially specialist knowledge (see § 2.3.3 and § 5.3 on creativity).

Through metaphors, people can cognitively restructure what they already know in different ways and begin to express what they intuitively know, but that rationally they don't know how to. The apparent non-involvement of science in society can be in part reduced through a "representation" of the former: it is capable of causing a change of viewpoints and alterations of the state in those who know, since rather than highlighting rules and normal procedures, is above all useful in assisting in its scenic and metaphorical representation, that permeates the social dimension, indicating the way in which science is built. The metaphor is capable of merging two diverse areas, that are sometimes distant in experience, into a new cognitive space, which includes a single image or symbol of «two ideas in one phrase» (see Black 1962, p. 38). Establishing a relationship between two elements that appear distant, metaphors can make a cognitive conflict arise, symptom of cognitive restructuring, whose path can be better understood by those who are directly involved in the processes of construction of knowledge.

As in the case of the reflections of Polanyi and Kuhn, the examples are true explanations, they themselves are science. At the social level, the call for tacit knowledge and widespread expertise in a neo-humanist field could operatively constitute an advantage to make it easier to understand the issue of the amalgamation of science and society without giving up either the rigor that this requires, nor yielding to a pseudo-scientification of humanistic culture.

5.3 – The importance of creativity

Last year was declared by the European Commission and Parliament "European Year of Creativity and Innovation" (see EP 2008). The choice to dedicate a year to the subject of creativity and innovation was an important one; as declared by Ján Figel', European Commissioner for education, training and culture, creativity is without doubt the essential quality to find solutions to the economic recession that emerged at the end of 2008. But apart from the recession, creativity brings lasting and constant benefits for the economy, for society, for companies but especially for the individual (Figel', in EC 2009m). The importance of this event consists in its contribution to raising awareness of the importance of non-technological innovation, unlike in the past (Kern 2010), and therefore having brought to light other areas of human knowledge that can make a fundamental contribution to increasing the level of creativity and therefore have a positive influence on innovation in general and on economic growth.

But what does it mean to be creative? And is creativity the prerogative of a few talented people or can we all be creative? And under what conditions can society, schools and companies develop creativity and keep it constant over time?

5.3.1 – *Creativity and the creative person*

For some time now, scholars have maintained that creativity is not the prerogative of a chosen few but that creativity is a faculty that everyone has (Bohm 1998; Peat 2000; Greene 2001; Runco 2004). Therefore, it does not belong to particular individuals who make a name for themselves only in the area of artistic and scientific production, but it is a shared heritage that everyone can have and that is best expressed only if the environment creates the right conditions. The myth of creative thought as a tool available for a selected elite is scotched when creativity is seen as a development tool in any area (from science to economics), and at any level (both individual and collective) (Cocco 2002). It appears to be essential today to be able to recognise, appreciate and stimulate a creative attitude if we want to lead man to find his bearings in the boundless sea of information and enable him to put into operation forms of research, experimentation and active learning (Tuffanelli 1999, p. 50).

Creative activity manifests itself in the ability to find new solutions to established problems, but also in providing elaborated *ad hoc* responses to new problems; this highlights the fact that it is «a mental tool that allows the adaptation of a complex, changing organism to an equally complex, changing reality» (Cocco 2002, p. 29). Therefore, creativity is a tool that helps our species to adapt: man has managed to evolve and adapt to his surroundings thanks to the use of creative thought that leaves the schemata of logical-rational thought to find original solutions to problems and challenges. The creative person is he who offers others a different perspective on the world. For example, in the artistic field it is a different way to see reality; or in the case of scientific creativity, a different way to interpret it. In other words, creativity is not limited to the individual sphere but needs co-operation and interaction with other people (Goleman, Ray & Kaufman 1999, p. 28).

The type of cognitive expression usually called creative or divergent has «typical characteristics classified as fluidity, flexibility and associative originality. Fluidity is the ability to produce lots of ideas in a short time; flexibility is the capacity to easily change the categorical register to which the ideas belong; and originality is the ability to produce rare ideas» (Rubini 1999, p. 88). However, for creativity to reach its full potential, some basic elements are essential. First all, an individual should have some experience and the possession of an ability in a specific area; it is a fact that many of us have a particular talent, that is a natural inclination to produce great things in a particular field. Unlike what a romantic approach would have us believe, the work of genius is by no means the fruit of a spontaneous impulse of the soul, of a mind that is not "even tempered", as claimed by Emerson, who asserts that «what has been best done in the world, - the works of genius, - cost nothing. There is no painful effort, but it is the spontaneous flowing of the thought. Shakespeare made his Hamlet as a bird weaves its nest» (Emerson 1870, cap. vii). Actually, it is just the opposite: a solid specialist knowledge that derives from the application of forms of traditional learning is one of the fundamental elements of creativity (Cropley 1978, p. 33).

The other component that supports creativity is passion: it is the intrinsic motivation, the need to do something for the pure pleasure of doing it and not to get something from it. Intelligence alone is not enough to be creative. Clearly, it cannot be excluded from this multiform process because the need to get information from reality always brings moments of decomposition, recomposition, comparison, inference and rational decision; however, the production of new ideas is the effect of fluidity and mental flexibility that is different from mere mental exercise, according to the criteria of logic and inference that have been traditionally attributed to reason. One could maintain there is a "threshold" relationship between intellectual activities and creative activities: a certain level of intelligence is necessary for creativity to show itself; but this threshold value is placed within the limits of normal intellect (de Bono 1992, pp. 41-2). It follows that a very intelligent person is not always very creative and a very creative person may not be very intelligent but may also have average ability.

Many scholars agree in defining creativity as the production of the new. But how does the new emerge? And what is its relationship with the old way of thinking?

Creative thought emerges essentially from the capacity to free oneself from the conceptual limits imposed by old ideas and by the "vertical thinking" (de Bono 1992, pp. 52-6). In the creation of new ideas, an important part is the destruction of the object that belongs to our tradition: «[…] in order to build, nothing is more necessary than to destroy», recognised the philosopher Benedetto Croce, by no means a revolutionary (in Agazzi 1981, p. 284). We have to go back towards the known object and destroy it in order to make a step forward:

> we can understand, therefore, why creation is so difficult; we must destroy the structure and the accepted objects (previously), but we keep this work of destruction under control, within certain limits. We must concede partial disintegration in order to reach a new, and better, integration of the world. […] this is an unpleasant, dangerous task, that causes anxiety. We have to face up to this anxiety if we want to be creative. (Hutten 1976, p. 252).

The great economist Joseph Schumpeter spoke of "creative destruction", referring to the way of operating of capitalism for which no innovation is possible without destroying what existed previously (Schumpeter 1942, pp. 82-85). We can see this phenomenon even more clearly today: «creative destruction, with rapid avances in technology, was a fact of life in the United States in the late 20th century. And by the end of the 20th century, creativity had become the key factor driving the U.S. economy» (Sawyear 2006, p. 281).

However, for creativity to develop, it is essential for people to have many experiences since «the richer the experience of the subject, the more abundant the material that he or she can mentally elaborate and the greater the probability that this re-elaboration will lead to innovative products» (Antonietti 1994, p. 40). This implies that also cultural diversity, the meeting of cultures that brings people into contact with different worlds, stimulates creativity: differences of cultures and diverging viewpoints are a "real tonic" (Goleman, Ray & Kaufman 1999, p. 187).

Indeed, recent studies have confirmed that in regions with great cultural differences, the level of creativity increases. Open regions that are very tolerant towards other cultures tend to attract more people who can manifest their creativity (Florida 2005). Therefore, a careful governance of society should avoid forcing the different cultures that live there together into an artificial synthesis imposed from above; that is, it should not seek a forced "integration" through administrative paths, but let the diverse sensibilities and experiences cross, communicate, converse and possibly form new forms of synthesis that would be able to lead to new perspectives and new visions of the world, thus encouraging creativity and innovation. The search for identity, the obsessive pursuit of it and the struggle against other cultures would inevitably lead to the loss of its richness and would erode the very basis of creative thought. One of the most important achievements of anthropology is the fact that it has highlighted how progress and innovation in the various peoples has been linked to cultural exchange and competitive relationships between people in neighbouring countries (unfortunately, war has been one of the main drives of invention); and vice versa, when a culture has found itself in isolation – because of conscious choices or because of contingent but relevant historical circumstances – a slow but inexorable process began towards decadence and regression, in which the traditional ways of thinking prevailed and innovations – the fruits of creativity – were systematically inhibited. Japan is a case in point: the country already possessed the technology of fire arms, imported in 1500 by two Portuguese adventurers who ended up there; this technology was later developed autonomously, but little by little it was put aside in favour of the winning culture of the Samurai who saw the sword as a status symbol and the most honourable way to fight (also, it was an essential instrument for social power). Since the government was controlled by the Samurai, they first monopolised the construction of arms, then gradually reduced it until they stopped making them altogether. Then, in 1853 cannons were fired in the bay of Tokyo by Commander Perry and the Japanese woke up to the fact that in order to survive as an independent nation, they had to equip themselves with technology and so invest in research and innovation with the results we all know today. This and other examples (China, Tasmania, Easter island etc.) are «well known cases of technological regression in societies that are completed or almost completely isolated» (Diamond 1997, pp. 257-8). Therefore, there is no doubt that imitation, competition and competitiveness of cultures are indispensable for innovation and arousing creativity.

However, it is important that an optimal climate is established, in which competitiveness and cohabitation manage to find the right equilibrium so that competitiveness does not degenerate into destructive hostility and then into a war to annihilate the identity of the other, or that cohabitation is seen in an indifferent, cynical way – a disenchanted view of the world. In the first case, a destructive process is put into operation in which at the end a culture, a faith or a religion wins, that annihilates all others and considers uniformity and "orthodoxy" to be the highest value: this is the destiny towards which countries of the Counter Reformation went, like Spain, which after the "Re-conquest" expelled the Moors and sent away the Jews and cultivated the "*limpieza de sangre*" – pure blood. In the second case, instead, especially in the ruling classes, there is spread of indifference to everything, distrust in collective destinies, the idea that one thing is worth the same as another and therefore every change, every innovation, and every measure of progress is useless without a direction or objective: this was the state of the late Roman Empire which was a reason for the backlash of Christianity, a new faith, in which people believed so strongly that they were prepared to die for it; but it is also the danger towards which the EU could go if it is not able to appreciate the differences and peculiarities of the cultures that it is made up of.

On the contrary, we are convinced that the wealth and strength of Europe consists in the rich cultural tradition, in the diversity of its people, in the existence of stable, prosperous state structures in mutual competition, in the capacity, throughout its history, of establishing antagonistic and often conflicting relationships that, however, have never resulted in the annihilation of diversity (even if sometimes this risk has been run) (Cosandey 2001; Simonton 1999, pp. 204-215). This can be witnessed by the periods of great creativity it has known: Renaissance Italy, fragmented in various competing states, but not yet oppressed by the uniformity of the Counter Reformation; Holland of the 1600s where tolerance and religious cohabitation were widespread and diffuse. When Germany was fragmented in a mosaic of small states, personalities like Mozart, Beethoven, Goethe, Hegel and Schiller offered their genius to the world; when Bismarck unified Germany towards the end of the 19th century, the golden age of the country came to an end. As Gladstone said: «Bismarck made Germany big and the Germans small» (Goleman, Ray & Kaufman 1999, p. 186). For the same reasons, a "great Vienna" could only exist within a multicultural and multinational empire like the Hapsburg one (Janik & Toulmin 1973). We can claim that

> the very foundations of the West (and other civilizations throughout history) are multicultural products, resulting from the international exchange of goods, services, and ideas. To varying degrees, Western cultures draw their philosophical heritage from the Greeks, their religions from the Middle East, their scientific base from the Chinese and Islamic worlds, and their core populations and languages from Europe. (Cowen 2002, p. 6)

It follows that a climate of tolerance but not indifference is necessary for cultures with different values to live together. To support the importance of cultural diversity, Richard Florida has produced a series of data to show how there is a positive correlation between high indices of economic development and social fabric characterised by the presence of tolerance, ability to break convention and mental opening (Florida 2005). In brief, the wealth of poles of development constitutes the existence of great diversity (Cini 2006, p. 281). As Florida says, the areas of development are characterised by a high standard of living, reduced social inequality and the absence of racial discrimination (Florida 2005, p. 7 and *passim*). Therefore, it would appear to be essential to encourage immigration for a society that wants to develop creatively:

> In *The Global Me*, the *Wall Street Journal* reporter Pascal Zachary [Zachary 2000] argues that openness to immigration is the cornerstone of innovation and economic growth. He contends that America's successful economic performance is directly linked to its openness to innovative and energetic people from around the world. (Florida 2005, p. 40)

The European Union is well aware of the importance of cultural diversity for the development of creativity; in fact, both in EP 2008 and in the 2009 *Manifesto for Creativity and Innovation in Europe* by the ambassadors of the year of creativity – including famous intellectuals like Levi-Montalcini, Lundvall, de Bono e Florida – it is stated that it is necessary to open to cultural diversity as a means to favour intercultural communication (see AA.VV. 2009, Action 4).

Another element that leads to creativity is the presence of diverse and varied cultural interests. Florida (2005, p. 41) identified the so-called "bohemian index", «to measure the number of writers, designers, musicians, actors, directors, painters, sculptors, photographers, and dancers in a region». His theory is that many regions that possess a high bohemian index manifest a concentration of high-tech industries, and increase in the population and employment.

To support Florida's theory, an important report came out in 2008 by the United Nations, *Creative economy*, in which the creation of a new "paradigm of development" is stressed

> that links the economy and culture, embracing economic, cultural, technological and social aspects of development at both the macro and micro levels. Central to the new paradigm is the fact that creativity, knowledge and access to information are increasingly recognized as powerful engines driving economic growth and promoting development in a globalizing world. (UN 2008, p. 3)

The "creative economy" is a holistic concept that leads to a decrease in the stress on conventional models and an increase in the focus on a multi-disciplinary one (see also the epistemological support given by us to this approach in ch. 4), that constitutes the interface between economy, culture and technology and concentrates on the importance given to creative services and contents. At the heart of the creative economy there are the creative industries that can be defined «as the cycles of creation, production and distribution of goods and services that use creativity and intellectual capital as primary inputs» (UN 2008, p. 4). In the economy of knowledge, these are the most dynamic industries: in the period 2000-2005, international commerce in goods and creative services recorded an unprecedented average rate of growth of 8.7% annually and the value of world exports represented 3.4% of worldwide trade and commerce.

Even more recent is the study of the importance of culture for creativity carried out by KEA, a research group in Brussels directed by Philippe Kern, which has specialised in the sector of creative industry and the role of culture since 1998 and has often carried out investigations and research commissioned by the EC. In line with its declared mission – «to highlight the contribution of culture and sport to the European project, economic and social development and sustainability […] to promote authenticity, originality, singularity and diversity. Our relevance lies in promoting culture-based creativity and in mainstreaming cultural consideration to irrigate policy fields» (http://www.keanet.eu/mission.html) – this study (see KEA 2009) underlines the importance of culture in general – music, the visual arts, cinema, and poetry – as «a motor of economic and social innovation». This line of thought was also noted in a previous study (see KEA 2006), which indicated that the prevailing idea of the Lisbon Strategy was that growth and employment were essentially linked to investment in high-tech industries like ICT, that is, favoring the development of a "knowledge economy". The importance of the KEA study is that it revealed this absence of consideration of the role of the creative sector not linked to R&S – even if, as we have seen, in more recent times the EC has remedied this deficit – that gave weight to the idea that many people have, that the arts and culture are "ornaments" for human life, rather than essential factors for growth and development; they are only activities providing different forms of "entertainment" and therefore they are marginal in terms of economics or even losing sectors which need state intervention in the same way as health does. Moreover, the KEA stresses that:

> […] how culture promotes European integration and is a key tool to integrate the components of European societies in all their diversity, to forge a sense of belonging as well as to spread democratic and social values. Culture can contribute to "seduce" European citizens to the idea of European integration. (KEA 2006, p. 1)

We think it is particularly interesting how the KEA reports underline the importance of the so-called humanist disciplines, to which we must add – since it has not been sufficiently underlined by the KEA – also those sectors of human sciences like literature, philosophy and the disciplines that come under STS, like in all the other fields not immediately linked to technology and scientific reasoning. To this regard another important fact is that the ambassadors of the year of creativity believe that, together with art, the union of philosophy and science is essential to creativity (AA.VV. 2009, Action 4). If scientific knowledge is to feed its creative vein it should draw on the correct *forma mentis* from those disciplines that stand out in divergent thought.

It is not possible to have an effective policy for innovation and economic growth if this rich heritage that is the storehouse of human culture, the fruit of its secular creativity is put aside:

> Culture-based creativity is a powerful means of overturning norms and conventions with a view to standing out amid intense economic competition.

> Creative people and artists are key because they develop ideas, metaphors and messages which help to drive social networking and experiences. / Apple's success is intrinsically linked to the founder's vision that technology, marketing and sales alone are not sufficient to deliver corporate success. A key factor is to have people who believe very strongly in the values of the company and who identify it with as creators and innovators – the ad campaign "Think different" featuring Picasso, Einstein, Gandhi was described by Steve Jobs as a way for the company to remember who the heroes are and who Apple is. Apple has succeeded to create empathy for technology that other technology companies have failed to provide. The aesthetic of the product range, through innovative design, also yielded success. (KEA 2009, p. 5)

It is not just coincidence that Finland – one of the countries that in recent years has established itself for its greater innovative capacity, scaling the world and European ranks (see § 5.1.2) – has put into operation a progressive change «from technology-driven innovation towards more human-centered innovation» (KEA 2009, p. 9). Therefore, if it is true that industries of high intensity of knowledge surely represent an important engine of development in the society of knowledge, however, we must not think that economic creativity is only their prerogative, that is, a question to be resolved within the productive sector. It is essential to place stress also on the education and training context in which the person is inserted, that forms (together with technical competence and personal skills) one of the fundamental elements for creativity to thrive.

5.3.2 – *Family and school*

The first institution that carries out the task of educating for cultural diversity is the family: it is the first incubator of creativity. The factors that favor the development of creativity can be found in education leading to tolerance, anti-dogmatism, respect for autonomy, freedom to regulate one's own behavior in play and in the development of personal aspirations (Rubini 1999, p. 90). An education that takes account of these aspects forms flexible individuals, who are enterprising, willing to learn, to open themselves to many ways of life and experience, able to easily revise or abandon previous attitudes and opinions and especially have developed a strong sense of self-esteem. On the contrary, people who have been repressed in their creative impulses and have been used to being afraid of their neighbours, are usually insecure and do not have a well-developed sense of self-esteem; it follows that in situations in which their strongly consolidated value representations are questioned, they find it difficult to revise their opinions. For these people, measuring themselves with another orientation is a burden that is difficult to bear. This is why these people, repressed in their creativity, feel anguish in situations of contrast and in some cases suffer from neurotic conflicts (Cropley 1983, pp. 30-31). If the expression of self is cultivated from childhood, people can express it better later on in life in subsequent educational activities, especially at school.

The task of the school is to educate students to both convergent and divergent thought; this can only take place if the teacher shows appreciation of his students, persuading them that they are "people of value", able to realize something in a world that presents enormous difficulties. All too often, however, the inclination to divergence, autonomy and self-sufficiency are valued negatively in the school. Probably this attitude on the part of the teacher depends both on the fact that divergent thought on average takes longer than normal curricular learning, and also on the fact that with regard to these students, teachers feel less important and therefore less gratified (Tuffanelli 1999). But it is often the case that teachers do not have great ability in recognizing truly creative performance (Getzels & Jackson 1962); besides, teachers prefer students whose results are the fruit of convergent thought (bowing to authority, conformism, etc.), rather than students who obtain equally valid results using divergent thought, but who often display behavior that is less easily controlled and who in any case require greater didactic commitment on the part of the teachers, and greater attention to their needs. Besides, the school curriculum has in itself a "convergent" content, based on the "best" right answers to which one must arrive by processes of purely logical thought. Naturally, the right answers and logical thought are important, but what is more important in the present context is to develop that creative capacity, that flexibility and mental opening that allows individuals to face present and future challenges (Cropley 1978, p. 26).

In a survey carried out by the EC in December 2009 on the role of creativity in schools of the 27 European countries, it is stated that the teachers' views on the importance of creativity on curricula objectives vary greatly:

> On average, around half of teachers believe that creativity plays an important role in the curriculum and about a quarter consider that it does not. Moreover, teachers' perception of the role and relevance of creativity in the curriculum varies considerably between countries. […] On average in a EU country, around 53% of the teachers surveyed agree that creativity plays an important role in the curriculum, and 20% are strongly convinced of this. Teachers from Italy, Latvia, and the United Kingdom are particularly convinced of the important role creativity has in their national curricula. Around 75% of teachers in each of these 3 countries share this opinion, i.e. 78% in Italy, 77,5% in Latvia and 73,5% in the United Kingdom. Most notably, a large proportion of teachers from Italy and the United Kingdom strongly support this idea (48% and 47%, respectively). Less than 50% of teachers from Portugal, Spain, Belgium, Slovakia, Slovenia, Germany, Hungary, France and Estonia consider that creativity plays an important role in the curriculum of their national education system. Only a small share of teachers in most of these countries are strongly convinced about the relevance of creativity in their country's curricula. (EC 2009l, p. 16)

This data and the differences existing between the diverse countries of the EU have led to the need to open «a debate regarding the conceptualisation and implementation of creativity in the curriculum, so as to reach a more common understanding and a shared practice within each national context» (*ibid*.).

Another important piece of data that has emerged from this survey concerns the training that teachers have had for the development of their own creativity and consequently in their ability to develop creativity in students:

> On average (EU median value across countries), 40% of teachers in Europe declare to have received training in creativity. The situation however largely varies between countries. In Slovakia (66%), Estonia (65%) and Romania (62%) a notable number of teachers report they have received training in creativity, in contrast with only 14% of teachers in France, 25% in Lithuania, 27% in Hungary, 28% in the United Kingdom and 33% in Spain. […] Innovative pedagogies or methods are better covered by teacher education than creativity. Around 60% of teachers in Europe (EU median) declare that these innovative pedagogies or methods have been covered by their teacher education, compared to 40% who declare creativity has been covered. Again, the situation varies within Europe. In some countries, more than 70% of teachers declare to have received training in innovative pedagogies: Romania (76%), the United Kingdom (74%), Estonia (70%), and Poland (70%). By contrast, around 30% of teachers in Finland (32%), Sweden (34%) and France (34%) declare to have received this type of training. (EC 2009l, p. 18)

It is surprising to discover that countries who have recently entered the EU have for some time developed innovative techniques of training teachers in creativity. We should, therefore, take an example from these "new" nations that have recently appeared in the new capitalist economy but have already recognized the value of creativity in the school. Instead, many EU schools lack courses that are aimed at improving the divergent abilities in both teachers and students.

On the contrary, as we well know from recent Italian experience, in the search for a better monitoring and control in the school, there has been a proliferation of stringent schemes in which "programs, timetables, classes" are bureaucratically fixed, to which is associated the "ritual of lessons-oral tests-marks", which tends to encourage a passive, formal kind of learning, rather than an active, autonomous one (Rubini 1999). As Sternberg remarks (1997), it can also happen that in many educational systems, creativity is encouraged in some moments of life but is placed on a secondary level later on. Thus, in the nursery school, creativity is supported but then, in later stages of education, it is the teacher who decides what the students should do. The risk of this attitude is that children may lose the style of thought that generates creative performance. We must protect children from the killers of creativity – competition, excessive control, limitation of choices, and lack of time. For example, one of the ways to destroy creativity in children is to ask questions with closed answers (true/false type), penalizing those that get them wrong; it would be fitting, on the contrary, to ask also open questions to give space to imagination (see Goleman, Ray & Kaufman 1999, pp. 64-68; Urban 2007).

Klaus Urban (2007) made some recommendations to promote creativity in schools:

- Stimulate and create an atmosphere of the creative group, allowing children to talk, think and work without stress and anxiety or without fear of punishment. To this end, a sense of humor makes the school activity more pleasant.

- Avoid pressure of the group and desire for competition but allow and maintain the climate of co-operation and a "competition-together". In fact, placing the students in situations in which either one wins or one loses and in which only one individual can reach the final objective creates anguish among those who do not reach the victory; on the contrary, students should be allowed the time and freedom to progress according to their own rhythms, following their own creativity and subsequently measuring themselves with the group-class
- Do not give procedures or strategies to arrive at solutions too quickly but little by little give them suggestions to stimulate autonomy of thought. Giving the students exact prescriptions on how they should carry out the task leads students to be convinced that every form of originality, every aspect of curiosity, and every new solution are wrong and a waste of time. Very often, this also leads to fear of making mistakes and the criticism that this could trigger, since they do not understand that mistakes and criticism actually represent signs of constructive efforts towards an autonomous solution. One has to show tolerance and appreciation for unusual thoughts, original ideas and creative products. But this must happen also supporting the possible elaboration or realization (in all its implications) of creative ideas, thus making the students aware of possible implications and consequences of solutions.
- Support interests, and perception and acquisition of a wide variety of knowledge and in diverse sectors. Therefore, avoid giving students precise prescriptions about which activities they should undertake; on the contrary, they should be left free to cultivate their own interests and passions.

In line with what has already been said about the importance of a creative culture, artistic education should be considered as an essential element for the development of creativity. In the document produced in 2009 entitled *Design, Creativity and Innovation,* the authors highlighted the value of art education, not only to stimulate creativity but to prevent students from dropping out of school:

> Educators have observed that students develop creative thinking through arts and transfer this capacity to other subjects. Whenever arts are a strong element in the school environment, students tend to achieve higher grades. Moreover drop-out rates and absenteeism are lower [...] Education in arts also helps building specific skills such as goal setting, flexible thinking, tolerance, cooperation, team work, creative problem solving, selfconfidence and motivation, all of them valuable in the business field. (Hollanders & van Cruysen 2009, p. 10)

Also the already mentioned report drawn up in the light of STS goes in the same direction, often expressing the conviction that it is vital not to obstruct – through consolidated and rhetorical narratives, now superseded – «our institutional capacity or willingness to experiment with possible alternatives»; therefore it maintains «that striving to change conventional understandings, and developing more diversified imaginations, both moral and practical, may be the most important initiative to which policy actors and institutions can commit» (Wynne *et al.* 1997, p. 79).

Finally, we should not forget that an important way to prevent creativity from being blocked is *to halt excessive specialisation* that can lead the individual to having a rigid mental attitude, to psycho-sclerosis, also limiting flexibility and opening to changes that today's society is going through. This is particularly important in developing the scholastic and professional curricula in secondary schools and universities: unlike what has happened in many European countries and in particular in Italy, where courses have multiplied that produce rigid professional figures who are already completed, ready to be inserted in the job market, without further refining, it is necessary to aim at the formation of specific, yet flexible competences. We believe that this is one of the points to be insisted on to prevent the rich, multiform cultural education typical of the European school and university system from being lost in pursuit of a premature technical specialisation that would create only limited minds, lacking creative spirit. If it is true what we say – that creativity should be nourished by a rich humanistic culture (a claim also strong supported by the research and reports mentioned before) – then it is vital that the humanistic element of cultural education should not be lost, particularly that which should be given to scientists and technicians. Lorenzo Thione, creator of the search engine Bing which he sold to Micro-soft for 100 million dollars, explained that its innovative character consisted in the fact that it was based on computational linguistics, which is a branch of artificial intelligence dedicated to the understanding of human language on the part of the computer. He adds: «At school, Americans do not do logical analysis which, on the contrary ends up going out of the ears of any Italian student from primary school. And it is logical analysis that is the most important element of computational linguistics» (in *Wired*, nov. 09, p. 57). That logical analysis, which is at the basis of the study of languages like Latin, is gradually disappearing in Italian schools.

5.3.3 – *Companies*

After school education, work training begins, which represents a complex, delicate area. Bendin (1990) underlines that the society of the future will be less and less uniform and stationary and therefore should develop more inclinations and capacity for change. For this it is important to provide students with a new flexibility, educating them to increase their creative capacity so as to enable them to cover the different and changing roles that society may assign to them at the moment of their insertion in productive activity and then over the course of their working lives, more and more subject to work changes and real professional reconversions (Bruscaglioni 1998, p. 10).

People looking for a job or those who want to change their line of work on the one hand have the opportunity to concentrate on "training", taking care of their preparation, keeping up to date and paying attention to new demands; while on the other hand, they can aim at "flexibility", showing that they are willing to change activity, sector or working context depending on the opportunities that are offered (De Carlo 2001). In fact, «companies need people with independent minds, willing to take the risk of speaking and who feel free to respond to change in an imaginative way» (Goleman, Ray & Kaufman 1999, p. 110). But if companies want to have creative people, they should create a company culture that encourages the expression of creativity in a serene climate and be open to innovative ideas and proposals. Mental opening and tolerance of diversity are among the elements that should characterize this company culture. The presence of these elements shows itself also in the acceptance of a sense of humor, in providing places to relax and let the mind wander, away from the work routine. Creativity should be a style of life that leads the creative person to continuously experiment and question the sense of things and possible interventions in them.

On the other hand, creativity is a faculty with no age restrictions: even if the powers of our mind decrease after the age of sixty, nevertheless, an eighty-year-old has the same creative capacity as a thirty-year-old (Osborn 1953). In other words, despite the fact that over time, we lose certain cognitive faculties such as memory, imagination – the faculty that creates – is preserved. For Goleman, Ray & Kaufman (1999, p. 37), «far from declining with age, the creative spirit probably acquires strength and vigor when an old man or woman – who become aware of their own mortality and approaching death – concentrate on what really matters in life». This leads us to the conclusion that company training in creativity should not be limited only to certain age groups or to claim that older workers are no longer able to produce in an original way.

For a company, it is important to enable its employees to experiment freely with creativity. People able to express themselves are happier to carry out their work, in an autonomous, varied way, with levels of participation and responsibility in which they can express their ability; therefore, the presence of a strong intrinsic motivation raises levels of creativity in work (Argyle 1987; Jacques 1970). In fact, those who feel greater involvement in their jobs, and particularly to the task assigned to them, obtain greater creative performance.

In order to realize a creative environment, it is necessary to aim at the development of self-esteem. It is not just important at a scholastic level, as we have seen, but is essential in every moment of life: individuals with a strong sense of inferiority and insecurity tend to be distrustful of everything that comes from the outside, but especially of everything that they themselves produce and therefore their personal intuitions. They prefer to do things which are not very complex, repetitive, not autonomous, excluding therefore every sort of activity in the commercial, handicraft and managerial fields; they do not tend to take their work very seriously, becoming rigid in a narrow mindset in order to protect themselves from the risk that intuition may lead to a distortion of their mental and behavioral schemata (Cavallin 2002). On the contrary, a clear, lucid attitude to every situation, even if it is problematic, leaves a lot of space to creative intuition; humor and intuitive thought have in common the fact that they manage to get out of the linear course of ordered and rational thought with unpredictable and illogical deviations (Ernst 1990). Creativity constitutes an important resource for an individual to be able to realize himself professionally and enrich his competences, getting job satisfaction at the same time.

If individual creativity is the "bricks" with which innovation is built, another element of great importance is flexibility. Being flexible means having an open mentality, having the capacity to make quick decisions, being willing to accept changes and take risks. It consists in possessing the awareness of being able to change; curiosity towards innovation; the capacity for problem finding and problem solving; the desire to learn and improve; and the capacity to assume responsibility and face risks, making the necessary decisions (De Carlo 2002).

To conceive of work in a creative sense and open up to innovations requires "an active search for information", "abilities to redefine problems" and "capacities to produce alternative ideas" to current solutions. Today especially, entrepreneurial ability and innovation are linked to creative capacity; the success of a company mainly depends on the initiative of entrepreneurs who know how to produce innovative ideas, are able to "identify resources" and to "seize the opportunities" of the area in which they operate, assuming the responsibility of risk by investing in their own project. Entrepreneurs, today more than ever before, demand that training activities should have a preparation aimed at creative and innovative development; it is to be hoped that training will become an opportunity for people to know themselves and their own resources better (Dal Corso 2002). In fact, in recent years, training commitment in companies has increased considerably, following the need for everyone who works in a modern productive organization to be highly qualified and to be able to put their creativity to work (Lombardi 1993). A particular task of training then is to promote the development of flexibility understood as

> capacity to activate more articulated organizational behaviors, able to give an answer to modalities that are completely different from situation to situation, to know how to work with style, professionalism, organizational cultures and values that are completely different from their own, to know how to interpret several roles at the same time or in different times. (Civelli & Manara 1997, p. 143)

In this viewpoint

> Training should not be seen as transmission and acquisition of pre-established contents, but rather as a negotiation of meanings, choice of interpretative paths, research and production of innovative solutions to problems, co-operative construction of shared knowledge. (Galliani 2002, p. 2)

As De Carlo maintains (2001), in the society of knowledge, services, and non-material goods, people constitute "the most important added value" of modern companies. Individual responsibility, autonomy, the capacity to interpret creatively one's professional role are therefore factors of fundamental importance and success both for the individual worker (employee or freelance) and for the company. In order to progress and stimulate innovation, financial resources are not sufficient on their own, but the appropriate use of divergent thought that is able to reach solutions and contributions that are difficult to foresee are also required (Cocco 2002).

But what does this often quoted difference between convergent and divergent thought consist of?

Convergent thought grasps a single correct solution, which must be found by systematically applying certain logical processes to a set of information. The correct solution can be established with a sufficient knowledge of the facts and the ability to recognize immanent regularities; when it performs best it is a logical-deductive way of reasoning. Divergent thought is characterized by the fact that lines of reasoning, though starting from what is known, move in several directions and thus generate new and independent ideas. It is not a question of finding a single solution, the right one, but rather arriving at a greater number of diverse inventions (Guilford 1950; Cropley 1983, p. 56).

The use of divergent thought brings many risks, especially when creating a new venture: there is the fear of taking a path that has not been trodden and the fear of not being able to support it economically (Farinelli 1993). However, job creation is not a synonym of improvisation but the result of a good preparation linked to a broadness of vision and interest able to stimulate new enterprise (Carraro 1993). This, therefore, is the importance of investments that can give young entrepreneurs incentives to launch themselves into new activities, especially entrepreneurs on a small scale who have more possibilities of manifesting their creativity. For instance, in Silicon Valley small companies and small divisions of large firms have managed to undertake something new alone without being suffocated by a lot of bureaucracy. An infinite number of secondary products have been produced, all conceived by a group of audacious creative people (Goleman, Ray & Kaufman 1999, p. 129).

In a company, the creative spirit can find many ways to express itself in the workplace. The creation of new products is naturally the most obvious, but there are others – for example devising a system to provide clients with the best services, or operating innovations in management, bringing improvements in the methods of distribution or introducing new ideas to obtain funds. Creative ideas can also be used to strengthen the organization itself, for example increasing the initiative of the workers or their involvement in the company. For instance, one idea (successfully used by a Swedish factory and also by other companies in the USA and in Brazil) is to share all financial information – for example, the flow of money coming in every week – with all employees. The elimination of traditional company secrets helps the employees to understand the bigger reality of the company, thus encouraging them to generate ideas to reduce costs and increase profits (*ib.*, p. 114).

This is an example of how the changes that improve the work environment come from the combined efforts of managers and employees. This takes place since both managers and employees adopt a creative perspective that leads to important changes: workers begin to give value no longer only to the product but also to the process; companies appreciate the fact that that workers learn new things, grow from a personal point of view and express their own intuitions. The organization is conceived no longer as a sort of enormous impersonal machine, but as a complex living organism guided by lively intelligence, needing continual stimulation (*ibidem*). Some companies have highlighted how the elimination of rigid distinctions between the duties of the workers, in order to create an environment in which the individuals are given greater responsibility, leads to greater interest in the company and one's own work and makes each worker both encouraged and motivated to find creative solutions for any problem that arises in the company (*ib.*, p. 126).

An example of creative company approach was that of an important Italian entrepreneur, Adriano Olivetti, who in the 1950s managed to create a new model of a company in which capital and workers could be united in perfect harmony: the construction of large light-filled buildings of metal and glass – help for the families of employees with the setting up of nurseries near the companies, the creation of work islands in which the employee belonged to a group with whom he could interact and so feel an active part of his work (Ochetto 2009).

Another particularly significant example is the "flat" or horizontal type of organization, opposed to the traditional, more rigid model of a vertical type, used by the RAND Corporation (Research AND Development), a research body set up by the government of the United States in the period of the cold war, when the launch of the first soviet Sputnik made them fear that communists would overtake them technologically:

> RAND included a network of several dozen experts from quite different fields and granted them considerable freedom to come up with creative ideas, with only a couple of administrative layers to contend with. Although RAND was project- or goal-oriented, its experts were free to consult each other in fruitful ways. For example, it was at RAND that Herbert Simon and his former student Allen Newell got the idea of designing a computing machine that could prove the theorems of Bertrand Russell and Alfred North Whitehead's *Principia Mathematica*—and hence one that could probably perform any intelligent operation whatsoever. Thus was born the idea of artificial intelligence. Over the years, many leading technologists worked for RAND and at least implicitly imbibed this innovation-stimulating form of organization. A flat, open organizational structure would come to characterize the firms of the future Silicon Valley […]. (Nickles 1999b, p. 118)

Silicon Valley is characterized for refusing the hierarchical model of company organization of the "top-down" type of the age of managerial revolution, that prevailed on the eastern coast of the United States and led to the end of the DEC

(Digital Equipment Corporation), because of its slowness in reacting to market change. Despite its size, and the importance of the companies in it, Silicon Valley tends to minimize hierarchical organization and privileges a way of open communication.

> Managers are still necessary, of course, but they are more accessible to those below them in the company. In terms of creativity, the organizational structure is "flatter" and more flexible than the traditional model and hence more democratic. Superficial symbols of this more democratic arrangement are that everyone, from the top executives down, usually dress casually and have the same access to parking spaces, cafeterias, and rest rooms.
> Silicon Valley fits well into the larger California culture, which is "laid back" and informal ("live and let live") but certainly not lazy: the key people are not only incredibly smart but also intense, hard-working problem solvers. The more imaginative people often grew up as science fiction addicts. They boldly imagine alternative futures but also have a pragmatic sense of what is achievable at a given time. (Nickles 2009b, p. 121)

Besides the structure of an organisation, also the attitudes that pervade all its activities can encourage or obstruct creativity. One of the keys to creativity consists in building a climate of trust and respect, so that people feel quite secure that they can express new ideas without fear of being censured.

Moreover, there is an increasing gap between what many companies consider to be their objective and what an increasing number of people would like to find in their work. The greater that abyss, the more alienated the workers feel. And the more alienated they feel, the less easily they can draw on their creative energy. The unhappy consequence of this state of things is that, in order to encourage their employees, too many companies fall back on a combination of financial incentives (the carrot) and fear (the stick). However, this particular combination has a deadly effect on creativity, compared to when work is done mainly for the pure, simple pleasure that it brings. Besides, we should take note that today more and more people do not go in search of a job that represents simply a source of wealth, status and power, but instead they want a job that – besides ensuring a decent life – offers a meaning and a basis for satisfaction and fulfilment which is suitable to their personality. If a company does not recognise this truth, it will have difficulty finding the best people and also keeping them.

A way to prevent the creation of a rising gap between company conditions and individual needs, that would be beneficial both to companies and to the people who work there, is to promote investment in the development of the interior resources of workers, putting into motion an approach that is in compliance with the "humanistic scenario" (to which we shall return – see § 5.6), especially in highly technological industries. In fact, this solution has been embraced by some far-seeing entrepreneurs who have redefined the objectives of their companies, pushing them beyond mere profit, to making the workplace an opportunity for personal growth. Naturally, this does not mean that a company should not aim at profit, but only that it should broaden its attention and not stay focused on balance sheets to the detriment of the quality of the work itself (Goleman, Ray & Kaufman 1992, p. 156).

Humanising work, opening up to diversity supported by tolerance, and developing flexibility seem to be the essential elements to enable creativity to manifest itself in companies. However, we must not forget that there is also another typology of creativity which companies must take into account: that which develops outside them but manages to interact positively with them.

5.3.4 – *Widespread creativity*

Apart from stimulating creativity in a horizontal way, as we have already seen, companies should let the creativity of the final consumer enter their innovation strategies. In fact, Eric von Hippel (2005) claims that most of the innovation in the realisation of products, especially high technology ones in the ICT and computing sector, derives from the creativity of those who use them, rather than from the company designers. The idea at the basis of von Hippel's analysis is that the approach to the consumer as passive subject is being abandoned. As has happened for some time in the field of art, in which an author or a composer loses the control of his product once it is published, in this way, computer products and also pre-packaged consumer goods undergo the same fate once they are put on the market: consumers are free to modify the product and this may lead to important innovations. Financial analysts, aware of how much creativity is present among the users, have pointed out the need to construct new models of business able to use these creative resources (Nickles 2009b, p. 128).

The vertical model of “command and control”, in which it was the company designers who created the products to be put on the market as finished objects and sold through marketing strategies, imposing them on the passive consumer (according to the “linear model”, that we have criticised – see § 5.1.1), has been put aside by the most innovative companies (those of the American West Coast of Silicon Valley, that have replaced those of the East Coast). In its place, a new form of economics, in which innovation is democratised and shared with the consumer is being implemented: the consumers also become creative producers of the product that they use. The most typical example of this phenomenon is linked to the open source and free software or to the phenomenon of Wikipedia that enables the users/ consumers themselves to change the product in order to adapt it to the use they want to make of it. In this way, the consumer of a product becomes also its creative producer – the *prosumer*.

> In general terms this means the triumph of a democratic theory of innovation over a traditional, “fascist” theory in which an intellectually and culturally superior creative class paternalistically (if that word is not too generous) determines which innovations are good for the masses. The new movements manifest a centrifugal tendency as regards innovative change – a flight from the old centers of power. (Nickles 2009b, p. 105)

In fact, companies that are more attentive and innovative in this field have begun to monitor the innovations produced by the users in order to incorporate them in new production lines. Von Hippel clearly underlines this shift of tendency towards sharing the product:

> Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents. Moreover, individual users do not have to develop everything they need on their own: they can benefit from innovations developed and freely shared by others. (von Hippel 2005, p. 1)

In brief, starting from a finished product, it is possible to generate another, in a system of co-production that never finishes but is continually renewed. At the basis of the need to modify a product, claims von Hippel, there is not only the need to adapt it to one’s own needs, but also the desire to share one’s own innovation with others and consequently contribute to social well-being.

But what need is there for further innovation on the part of prosumers in a global market in which a great quantity of products have invaded the market to satisfy the most varied demands? In effect, the producers tend to follow a strategy of development that aims at satisfying the needs of the widest segment of the market, aiming at maximising sales for restricted types of goods. However, this strategy does not satisfy all those consumers who do not identify with the masses and consequently, they need to adapt and innovate the products (von Hippel 2005, p. 5). Subsequently, this innovation is taken over by the producer who in this way manages to respond better and better to the demands of the user. In fact, through approval surveys, companies always keep open a channel of communication with the consumer, so they can be informed about the destiny of their products.

Obviously, this change in the productive market is difficult for firms with a vertical “command and control” structure to accept. It is difficult to keep count of the infinite varied requests on the part of the consumers, but if companies want to continue to increase their trade, they have no option but to listen to what the customers want and see how they make innovations. Therefore, the proposal put forward by von Hippel consists in abandoning the idea that creativity is found only in companies and in their S&D departments, and that only a few people are in possession of creative capacity, and instead to support the democratization of innovation and widespread creativity, a reservoir that is always full and available, and from which producers and consumers can draw.

These indications have shown us that there is quite a close connection between democracy and innovation: the former is the condition of the latter as it enables a Darwinian process of selection of creative ideas to take place, based on a mechanism of «blind variation and selective retention» (Nickles 2003). Without democracy there can be no selection (creative ideas cannot compete among themselves), and without selection between creative ideas, there can be no innovation. But creativity sees democracy not only in a wide sense (tolerance, measuring oneself with others, hybridisation of cultures etc. and therefore attraction of talent and comparison of ideas), but also in a more typically company sense, with the superseding of the command & control model: «democratising creativity as far as possible is a good way, perhaps the best, to promote innovation» (Nickles 2009b p. 138). And vice versa, innovation and creativity are themselves democratising factors of society, as they make new ideas circulate, make people accustomed to tolerance, push for the abolition of all the positions that cannot rationally justify their authority and so end up contributing to the realisation of that spirit of enlightenment that is at the basis of our civilisation and which we wanted to take up again in this report.

5.4 – The role of the university in the society of knowledge

The development of a human and democratic knowledge society – the main goal of the Lisbon strategy – can only be the fruit of a carefully planned process of investments in sectors like education, in particular university education and research. The EU has often been reminded of the shortcomings in its education systems compared with countries like the USA. It has more than once recognised its mistake in not having invested more in Human Resources, in not having aimed at the creation of updated educational systems to cope with the technological development of the contemporary age, and the construction of virtuous mechanisms of *lifelong learning*, a vital ingredient for a working life that now is longer and more diversified. And we have seen how from a certain moment onwards, the EC has directed its attention on universities (see § 1.2 and EC 2003b), and therefore we must now question where today's university is going, how it can be corrected, what challenges it faces and what tools it can use to face them. It is necessary to understand what must be the specific role of the university within a context in which the EU has stated, in a more decided and clearer way, the aim of creating spaces of International research seen as poles of high level research united in networks of excellence. We also need to be clear about the functions it can carry out in order to create a coherent and efficient ERA and to help the Bologna Process progress towards EC objectives that can no longer be postponed in today's society. In fact, in them, education represents one of the three vertices that form the famous "knowledge triangle", together with innovation and research (see EC 2005c, p. 2; 2006n, p. 10; 2007g, p. 7; 2008m, p. 9; Eurostat 2009c, p. 21).

Education and training have to face many problems in today's society: on the one hand, problems linked to globalisation, rising computerization, population increase and the consequent mass diffusion of literacy skills, the unequal distribution of social wealth, rising multiculturalism, the increasing speed and flexibility of economic and financial markets and especially, the work market; hence the need has arisen to find ways for a sustainable world economy and the construction of a more cohesive society. On the other hand, the structure of the present society of knowledge, seen as the fruit of a high level of incorporated knowledge that characterises every dimension – everything in it has technological, scientific or cognitive weight – has imposed the educational obligation on society to procure adequate tools for the new generation to help them face this new form of complexity and find their bearings in it. For these reasons, a critical rethinking of educational and university systems has become more necessary and we hope that this effort of self-criticism will take the new form of long term investment in the formation of a new kind of capital – human capital (EC 2003c; Florida 2005; OECD 2009). This need is not only on an EC level, but first and foremost on a national level: investments and manoeuvres are urgent in view of EC goals, but always in relation to the strategic aims and requirements of the nations (EC 2003c, p. 4).

5.4.1 – *University potential and problems*

There is now widespread conviction that investing in research and universities is essential for a technologically advanced country, and at the same time it is the only strategic way for economic development and innovation (see Branscomb *et al.* 1999; Weber & Duderstadt 2006): human capital represents the main resource of wealth, while knowledge, in its various dimensions, represents the raw material of that which some have imagined to be an epochal revolution. However, we maintain that the advantage of investment in research and human capital does not lie exclusively and primarily in economic results. There are actually fundamental elements of a modern and civil society that derive directly from increasing knowledge and education even if they do not bring immediate economic benefits: factors such as peace, well-being, democracy, social cohesion, cultural development, and cohabitation of different peoples are some of the elements that, because of conceptual and prejudiced misunderstandings, are too often kept outside university lecture rooms, study courses or even seminar debates in which students may find a way to measure themselves with others and exchange their ideas (Smith *et al.* 2008). The teachers believe it is more correct for them not to get involved in questions of civil or political life, rather than trying to get involved in them in an honest and disinterested way; this is equivalent to an exclusion from academic life of subjects and problems that civil society, on the contrary, feels very urgently. In this way, therefore, university activity does nothing more than sanction that typical attitude of disinterest and detachment from civil life for which it is often reprimanded by today's society. Therefore, we firmly believe that «universities should in some sense return to a role that they played more than a century ago, namely, that of educating students for citizenship in our democratic society» (*ib.*, p. 7).

Secondly, universities have a crucial role since they preserve what for centuries has formed our cultural heritage; tradition and modernity are perfectly preserved in them: in this case, their basic characteristics are resilience and flexibility (see Robbins 2003, pp. 397-406; Weber & Duderstadt 2004, pp. 4, 239). In fact, on the one hand, universities are secular bodies, keeping themselves intact over time; indeed, over the centuries, they have been able to strengthen their role in society. On the other hand, there is no other way to face historical change if not by elaborating, on a basis of pre-existing cultural tradition, that which should serve as new cultural, institutional tools of understanding the real. Naturally, there is not just one single method, one sole model of renewal to face contemporary challenges; but there are elements that represent irreplaceable conquests, which the university culture must never abdicate, including: freedom to do research; freedom to study; freedom to teach; institutional autonomy before other strong powers of society; the ability to teach and select the best in the different areas of research; and the possibility to create transversal abilities and *formae mentis* suitable to understand current complexity. Therefore, we feel that new forms of university adaptation to the epochal innovations of our times are essential in order to find models of equilibrium with the needs and tensions that come from the *stakeholders* of contemporary society. The development of this brief series of potentials is indissolubly linked to the question of bridging the traditional distances that have long characterised the relationship between society and university: the latter is more and more considered today to be a "social institution", called on to take on relatively recent social problems that would not have been thought of in the previous vision of a distant academic world, disinterested in the outside world, such as that described by the old Mertonian model (Etzkowitz 1999, p. 231).

A critical revision of our university systems must first start from what have been identified as contradictions (apparent or otherwise) of the university dimension in the society of knowledge, concerning which we have often felt the need to operate a unilateral and exclusive choice. At the basis of these contradictions, we will try to retrace a dialectic of concepts and a set of potentials that are more complex but not necessarily limiting to one sense rather than to another, so that we can extrapolate some proposals that will contribute to the final policy recommendations.

Democracy is without doubt one of the primary problematic dimensions of university governance. We use this label to mean attitudes like social, cultural, institutional even managerial opening, concerning both the external context and the internal attitude of every university institution. Today there are plenty of occasions in which this attitude seems to conflict with interests towards an economic return, with an almost business-like management of university institutions, imposed, in many ways, by the need for financial support and the increasingly frequent and desirable collaboration between universities and companies. This is particularly evident in American higher education, in which collaboration with companies or the economic exploitation of discoveries, applications, patents or intellectual property are formally and structurally written into the legislation of this dimension. This has given rise to heated debate, in particular regarding the regulation of opening and access to knowledge, to freedom and the intellectual honesty of those who do research, or to the consequences that the applicative orientation of research could have on the future of basic or curiosity-driven research (Hane 1999, pp. 46-50).

Therefore, we must consider in which terms and senses a certain democracy can be developed today within the university, without ignoring the changes and the manifest emergencies of the surrounding society (see Charles 2009).

Now, it seems clear that a society globally seen as guided by knowledge needs mature citizens able to understand its complexity and find their bearings in it; otherwise, we will only build a society of subordinates, individuals who are slaves to the decisions of others and unable to think for themselves. But the maturity understood here implies freedom first of all, in both the negative sense (freedom from need, hunger, wars, constrictions or authoritarianism) and in the positive sense (freedom of expression, thought, the press, study etc.). For these reasons, education, democracy, peace, safety and general well-being represent factors that are closely linked and interdependent, but among them, education is the strategic element on which public international efforts should be concentrated. It is from the universities and in the universities that it is decided which citizens and which societies we will construct for our future. Democracy and ignorance are incompatible; therefore, the university, realising that it has enormous extra-scholastic and extra-academic responsibilities, should be reappraised and supported by national and international institutions.

The universities, on their part, must understand that they are a kind of mirror of the social reality in which they are inserted, and therefore they must do some serious self-criticism if they are to deserve respect and attention. Also teaching and learning come within this responsibility since they are the main tools the university possesses with which to train citizens for democracy, opening their minds and providing them with the necessary tools for civic life as well as for academic disciplines: skills such as analysis and synthesis; the ability to present a subject clearly; to be able to identify alternative solutions; to manage to see things from a different angle; resolve conflicts, or even better avoid them; debate in favour of a thesis and put it into practice; and understand or resolve paradoxes, etc. All these are skills that can, for example, be appreciated in the field of political or professional life, and in everyone's personal life (Huber & Harkavy 2007, p. 63).

5.4.2 – *The European Paradox*

Some of the external pressures on the university world, together with the shortcomings in state financial support that has been felt in the last twenty years both in the European university system and in the American one, have turned into stimulus for competition between universities and institutions: competition to get funds and resources, or to get publicity and to attract students, famous researchers or teachers. At the same time, demand comes from the outside world for professional training that should be increasingly flexible and attentive to the needs of the most advanced sectors; at the same time, pressure comes from politics and the world of business that requires swift and univocal solutions and greater forms of collaboration for the development of innovation, especially concerning the medical and scientific-technological sectors. In all this, the university still has difficulty in finding swift ways to respond to all these forms of pressure, above all since the quality of university education is conditioned by the serious backwardness of the European secondary school system. However, despite the fact that performance levels are often very low, there is some exceptionally high quality scientific production in certain university and scientific centres. Secondly, the problem of funding must be investigated. Total public investment in education in proportion to the GDP in 2000 was on a threshold perfectly on a par with that of other illustrious competitor countries: compared to 4.8% in the USA and 3.6% in Japan, on average the EU spent 4.9% (EC 2003c, p. 9). These values were slightly modified in subsequent years: in 2005 the European education system for all levels of education made a total expenditure of 5% of GDP compared to 4.8% in America and a falling 3.4% in Japan (OECD 2008a, p. 240).

However, the crux of the matter for member states is represented by the still low percentage of private investment in the field of education and professional training: the 0.4% in the EU in 2000, rising slightly to 0.5% in 2005, does not stand up to the 2.2% of the USA in 2000, passing to 2.3% in 2005, and not even to Japan's 1.2% in 2000 which now stands at 1.5% (OECD 2008b, p. 242). The most remarkable difference lies in university education: for each student, the USA spends 2 to 5 times more than European countries (EC 2003c, p. 9). And the American expenditure on higher education, without counting that in R&D, reveals a large amount of investments and support for the university (Guisan 2005, pp. 37-38). However, despite this, the EU is able to produce many more researchers and doctors qualified in science and technology (25.7% of the total graduates in the EU, compared to 21.9% in Japan and 17.2% in the USA). However, among the problems of the European university system we can also find those linked to the development of a career working in research. The percentage of active professional researchers in the population is very low; this means that not everyone who becomes a researcher can progress in his or her career, or because they are lured elsewhere by better professional prospects, or because they get discouraged and abandon professional work completely (EC 2003c, p. 10). This is extremely worrying given the central and irreplaceable role of the European university in the production of research: European universities produce 20% of global research and as much as 80% of basic research; what is more, 34% of researchers worldwide are European (AA.VV. 2004, p. 4; Eu-Ra 2004, v. 1, p. 12).

However, contrary to what it might seem, the data regarding state investment of countries such as the USA, Japan and the EU does not show much variation; what constitutes the real difference is the data concerning private investments: compared with OECD countries that do not belong to the EU (like Canada, New Zealand and Australia), the private resources are scarce and difficult to come by (Eu-Ra 2004, p. 6).

Even more negative is the relationship between the quantity of investments and the results actually obtained, a ratio that has been identified as the "European paradox" since the 1980s (Weber & Duderstadt 2006, p. 162; Weber & Duderstadt 2004, p. 93), or rather, the situation in which the amount of funds and European efforts in R&S, in particular in the scientific sectors and the excellent results of quality of scientific production do not correspond to a proportional rise in terms of economic and commercial innovation. In order to understand why this should be so, we must return to the differences between various kinds of investment. The first root of the problem could lie first of all in the different quota of private investments in tertiary education, that in Europe amounts to 0.2%, a percentage that is negligible and still unchanged today (OECD 2008a, p. 240), while in 2000 in the USA the percentage was 1.2% and has now jumped to 1.9% (Weber & Duderstadt 2004, p. 93; OECD 2008a, *ibid*.). The other roots lie in expenditure in R&S, as we have seen in § 1.1.2. But once again, in these numbers, the really low data regards private investments, while state ones are very similar (Weber & Duderstadt 2004, p. 93; OECD 2008b, pp. 22-23, 26).

In brief, within the American system, the close collaboration between university and business and industry, the rules regarding intellectual property and patenting for the universities who receive federal funds (in particular with the Bayh Dole Act), and even the direct conversion of researchers and scientists into managers of their own companies (see § 0.3.1), have given life to a system of market-oriented and product-oriented research that privileges application focused research. Instead, in Europe, despite the good performances in basic research and scientific production, there is not such an active participation of private stakeholders who could have direct interest in opening new channels of collaboration and implementing new models of innovation. Moreover, since it is convinced that greater support must be given to applicative and market-oriented sectors of research, with its various framework programmes the EU has directed most attention and funds to these sectors, held to be the real tool for reaching the Lisbon objectives, leaving almost exclusively in the hands of the nations the task of supporting basic research which, along with humanistic research, does not have immediate, evident economic return (EC 2004, p. 10).

However, we believe that this political direction is full of risks for the system of European research; in fact,

> the adhesion of governments and International organisations like OCSE and the European Commission to the paradigm that describes science as a privileged means for growth, through its subordination to the dictates of competitiveness, has deeply transformed the relationships between the system of public research, the economic system and the institutions of higher education. Both the research system and the universities are subject to invitations, incentives and pressures to model the order of priorities of their research projects, privileging those that appear to have more evident and immediate economic return. [...] These policies have led to a clear pre-selection of projects in favour of those that can be called applied science or research, together with a marked temporal horizon of research. (Gallino 2007, p. 269)

Rather than economically strengthening specific technological sectors, it would seem more natural if it became the task of collectivity, in this case the European community, to strengthen and protect those assets by definition collective and diffuse: knowledge and culture. If, as sustained by A. Marshall (*Principles of Economics*, 1953), «knowledge is the primary engine of production», then the community and the collective institutions should be the first to protect this engine by supporting basic and curiosity-driven research, and allowing the emergence of innovation and creativity also in sectors and areas not immediately known to be productive. Conversely, the commitment to support innovative projects aimed at production or the support of companies and industries that could invest in applied research could take on national or regional connotations. In brief, it seems that political regulation that is not homogenized but flexible and adaptable to different regional contexts seems absolutely essential for potential and resources to be developed in an adequate, finalised way. In the light of recent econometric analyses, the positive returns that a clear and encouraging investment in higher education could have for regional development are very clear, from an economic point of view among others; this concerns most European countries (apart from some countries in northern Europe who have already undertaken this path) who present a rate of support for the university, in terms of numbers of inhabitants, equivalent to about one third of that in America (Guisan 2005, pp. 43-44).

What constitutes the primary resource of all, human capital, should in our opinion be protected, sustained and given incentives with all means on a level that goes beyond the territory, through certain resources, but also with a clear regulation especially of the whole university system, endowing it with control and transparency systems, shared criteria of efficiency and mutual instruments for international collaboration – such as mobility systems for researchers, but also more uniform systems of recognition of training credits or even an international method valid for assessment of the quality of research and universities (see AUBR Expert Group 2010). It is clear that there are many shortcomings that should be remedied as soon as possible: a job market that is too stifling and unappreciative of research, precarious working conditions, scant prospects for recognition of merit, insufficient institutions of international co-ordination. To this we can add the need for commitment of the part of private individuals to finance that research phase that could produce most adequate resources for the market that are essential in order to remain competitive, perhaps with the aid of local public bodies; otherwise, the fruits of the knowledge produced in Europe will be developed and enjoyed elsewhere. It is therefore imperative for political institutions, first European and secondly national, to revise these conditions and find wide-reaching, long-term solutions.

5.4.3 – *The contradictions of research*

The drives, pressures and innovations that involve the world of research and the university, increasingly conditioned by the needs of the market and competitiveness on a global level, have recently overturned the traditional European university model. In fact, it has been commonly accepted that the Mertonian concept of academic research (see § 3.2), known as *Mode 1*, offers only a partial vision of the complex reality of things. Therefore if it cannot be substituted, it should at least be integrated with further models of development of knowledge, the most important of which is known as *Mode 2*, characterised by a revision of the role of the university in the processes of innovation, since now it is subject to pressing requests for partnership with companies and corporations, and by the remodeling of the so-called "*Triple Helix*", concerning the relationships between the university, the government and industries (see Etzkowitz 2008).

On a theoretical level, these innovations can be defined through the passage of the Mertonian academic model, within which research is closed within a sort of ivory tower, to a new kind of academia, the "Babel tower model" (Kohler & Huber 2006, p. 62), so called because in it, every region, company or existing body has the right to defend its own interests without feeling limited by the classical norms of disinterest and universalism; in this new dimension, universities are authorised to try to get profits from the sale of products and defence of intellectual property; even researchers can become businessmen and begin to get business to exploit their discoveries. If this transition may still seem critical or cause opposing reaction among those who are nostalgic or who want innovation at any cost, however, it represents what has been widely verified in the system of American development.

Moreover, in this dualism of concepts it is possible to see once more the classical alternative among the pure, theoretical, humanistic and social sciences which share the conviction that the mission of the university is to provide citizens with a liberal education, a complete training, that is at the same time civic, as opposed to preferences for the new strong sciences, techno-sciences, which produce an inseparable union of theoretical science and practical application, aimed at the professional and hyper-specialist. Here the dilemma has opened to find the true mission for today's university, to understand which form of research will be able to bring forth true fruits, and what role should professional courses and specialization have in university training (see Readings 1999).

In order to clarify this point, it will be useful to go back to have another brief look at the concept of knowledge (see also § 0.3.2): whether its status is that of public asset or whether or not it should now be understood as a form of private asset to defend and regulate. We believe that there are several elements in favour of a conception of knowledge as "global public asset". First of all – as we have seen – because of its non-rival nature regarding access: one person's access to knowledge is not in conflict with another's access, and nobody is excluded; it is impossible to forbid access to knowledge, though it may have costs. Knowledge may also be considered to be a public asset regarding its consumption, not reserved just for a chosen few, and the possibility for citizens to participate in its creation. Also, it is global in its capacity to move from one place to another on the planet, without nationality and boundaries, universally attainable and considered to be a world heritage (see Gallino 2007, pp. 231, 236-7, 254). In this meaning, therefore, knowledge is still to be considered a global public asset, of a shared, collective, intelligent nature, able to reproduce in open environments so as to permit new and old elements to meet and re-shape (see Cini 2006).

The latter point contributes to highlighting also the central position of the environmental factor for the development of knowledge: it can only reproduce and renew itself within the right environments, and universities are the perfect places as they are poles of attraction for open, creative minds. According to what Richard Florida highlighted in his analyses regarding creativity, universities have to take on the role of attraction and generation of talents. Highly creative individuals are at the same time extremely mobile individuals, that privilege environments rich in stimulus and populated by other creative individuals: «Good people attract good people» (Branscomb, Kodama & Florida 1999, p. 606; Florida 2005, p. 150), therefore, the university should become an instrument to call new, young talent continuously. It is well-known that the USA owes a large part of its excellence in the scientific field to talented foreigners who are attracted there from all parts of the world, thus contributing to the so-called "brain drain":

> the world's top brains end up in America, attracted by the well-functioning, rich scientific and economic institutions there. A high percentage of the academic staff in American universities are originally foreign. More and more often they are from Asia. This is partly because most young Americans no longer consider a career in science and engineering to be 'cool', and also because the USA does not produce enough scientists to cover its needs and so they have to import them from other countries. (Nickles 2009b, p. 117)

On the other hand, within the concept defined *Mode 2* or "post-academic" science (see Ziman 2000), the concept of knowledge as a private asset that can be owned is developed – an asset that can be privatised and exploited for economic ends. Science conceived in this way privileges transdisciplinary forms, is technologically oriented towards application, socially distributed and subject to strong influences of interest and responsibility (see Nowotny, Scott & Gibbons 2003, pp. 179-181). *Mode 2*, therefore, is characterised by the transferring of the productive process of knowledge from the simple, sterile university environment to a reality that is increasingly connected to the outside world: knowledge is seen as being situated, contextualised, co-produced, and the transformations in this direction are considered to be natural and unstoppable. (see Gibbons *et al.* 1994; Jacob & Hellstroem 2000). Within this concept, undesirable though it may be, we foresee that the central position of the university in the process of the production of knowledge will gradually weaken (see Gibbons *et al.* 1994, p. 85).

5.4.4 – *A diverse view of contemporary research*

Now we shall clarify how it may be damaging to see the results of these reflections in an asymmetrical way, accepting the narration that substitutes *Mode 2* for *Mode 1* of research. Rather, it is plausible to think of these two typologies as *ideal typical* narratives where each one tells only one side of a world that is in itself more complex and many-sided than we would like (see Pestre 2003, pp. 245-246). That is, both are seen as two possible visions of research to be conceptualised and to understand in their origins and causes: only if they are seen in this way will they be able to offer cues of pragmatic rethinking for the real problems of the university and research today.

Above all, the idea that universities will soon be supplanted by other institutions of research and industrial laboratories seems improbable. From the statistical data bases that exist today, we can see that scientific publications from universities have by no means diminished, but the number of publications which are the fruit of collaboration between universities and other types of institution (hospital and industrial laboratories etc.) are on the increase. This gives substance to the thesis that the way in which research is carried out is changing, also within the universities, who are increasingly open to collaboration and partnerships, at least in those sectors that have strong and immediate impact on sectors that are not traditionally academic, but this by no means implies that the role of the university in the production of knowledge and scientific research has now come to an end (see Godin & Gingras 2000, pp. 275-277).

Secondly, the fact that conceptual innovations push the university towards an opening to social needs and consequent responsibilities is most certainly a positive concrete factor. Besides, today it is important to recognize the contextual and situated nature of scientific thought as in any other form of knowledge, since it arises from negotiations of interests and values, is socially and relationally produced, and is in perspective and full of feedback (see. Nowotny, Scott & Gibbons 2001, pp. 47-49 and *passim*) – but this must not become an unlimited concession to extreme constructivism or relativism that would imply a "Rortyan" death of epistemology in favour of a residual "techno-authority" of science, left to carry out a vicarious function, so substituting a disappeared epistemological core (see Nowotny, Scott & Gibbons 2001, pp. 178-199).

Moreover, in the typical narration of *Mode 2* we run the risk of privileging only a "utilitarian" type of approach to science, efficacious and economically productive, market and product-oriented, at the expense of the more theoretical and curiosity-driven aspect of basic research. In this sense, we share the concerns of Luciano Gallino when he states that the current policies of science «do not seem at all fitting to promote science as a public global asset, intermediate and final if not in the restricted, short-term vision proposed by orthodox economics» (Gallino 2007, p. 270). Also regarding the so desired relationships of co-operation and partnership between universities and industries, even more desirable in the revolution that is taking place in contemporary research particularly in Europe, it is not possible to take one clear position or another, to become "apocalyptic or integrated". In the American system there are different university vocations, each with advantages and positive aspects, just as there are different professional vocations for entrepreneurs or local and regional specialization to take into account. For this reason, the opportunity to set up commercial or professional agreements between universities, companies or other kinds of bodies may turn out to be advantageous only on the condition that it is decided following careful assessment of aspirations and advantages on the part of those interested, not in the view of a restricted interest for a few, but of wide interest in the medium- or long-term. Therefore the need remains for clear EU regulation of these forms of partnerships, that allows for the recognition of rights and duties among different countries, that safeguards intellectual property and allow them to get some advantage, but limit the possibility of exploiting it at the expense of the public good (in particular, in areas of absolute importance like medicine and National health, energy, the environment, peace and public safety), and finally that regulates the possible but very dangerous conflicts of interest, so that the university does not lose its function of public institution in favour of the "commons".

Finally, among the various changes that concern the contemporary research system, we have also seen a progressive epistemic shift of disciplinary and methodological boundaries due to the change of the concept of science and research; it seems legitimate that this should happen considering the numerous changes in the current cultural and social reality in which we live, and at the same time justifies the abandonment of a concept of science as systemization, a progressive and linear ordering of knowledge, for a concept of research understood as a challenge of uncertainty, exploration of the unknown, open to new possible directions to be investigated (see MAS proposed by us in ch. 4); moreover, a reality that is increasingly complex and changeable can easily legitimize a phase of revolutionary revision of the epistemological foundations of traditional disciplines. It is even probable that «the increasing complexity and interdisciplinary nature of the problems faced by society will require not only a restructuring of the scientific disciplines, but their further integration with academic disciplines from the humanities, the arts, the social sciences and the professions» (Weber & Duderstadt 2004, p. x). In this sense, it would be logical to direct any reform of the European university system to a reappraisal of frontier research (which is what happens already in the American system), since it symbolically represents a field of open exploration, interdisciplinary or multidisciplinary, lacking pre-fixed boundaries but full of possibilities (see § 5.1).

5.4.5 – *A comparison with the Humboldt model*

Now we will try to reflect on what university model could contain some of the desired advantages for a revision of the role of the university in the society of knowledge. It might come from one of the most important and historical revolutions of the European university: the Humboldt one which was carried out in Germany in the early years of the XIX century (see Humboldt 1970). Between 1809 and 1810, W. von Humboldt worked on the reform of the entire German school system, starting from the elementary school and progressing through the secondary school up to university level. Today's university system and even the system of American university research was inspired by that reform that we believe merits revising in its most essential aspects.

Among these elements, two are most useful for our purposes: first of all, the principle of autonomy of university institutions, and secondly, the union of teaching and research. The first principle of the Humboldt model places at its centre the need for autonomy of the university institutions: this concept means the guarantee of the defense of some elements, in particular the freedom to teach on the part of teachers and the freedom to learn on the part of students (Sanz & Bergan 2006, p. 86), freedom that is threatened today by political influences, market forces, budget constraints, etc. The aim of this call for autonomy is not so much to guarantee freedom to do research in solitude and tranquility, but to maintain that level of autonomy that is required for the free and autonomous management of every university, so as to prevent the administration from being guided exclusively by economic and lobby interests. For this reason, the proposed autonomy should first of all have an economic-financial character in order to allow new knowledge to grow, curiosity-driven research to develop and new and unexpected disciplinary areas to be experimented. Naturally, this would be guaranteed by systems of transparency and responsibility in which every item of expenditure is modified, and after simplifying the processes, the mechanisms of economic management and staff recruitment are controlled.

The second principle, that is one of the features of the Humboldt model that ia a cause for deep reflection, stresses the need to combine research and teaching; however, it risks appearing almost obsolete today; in fact, there have been recent occasions in which the opposite principle of university reform by differentiation has been stated: the principle according to which it is not so much the relationship between the university and the outside world that should be differentiated, but the university model itself, distinguishing in particular between activities aimed at education and those aimed at research (see Nowotny, Scott & Gibbons 2001, pp. 87-90). But differentiating between these two activities would risk going against the whole system. The specific nature of university teaching that makes it stand out in quality and depth from secondary school education, for example, lies in that very union with research, from which taught disciplines often derive and through which they are updated. Rather, sagely combining research and teaching can produce beneficial effects for both activities that those who choose one over the other will never be able to experience (see Maccacaro 2006, p. 67; Vest 2007, p. 8). In fact, thanks to research, teaching finds vigour and innovation, it updates itself and also finds occasions for clarification, competent investigation and involvement that would be unlikely to happen otherwise. Vice versa, from teaching, research can get incentives for the production of new ideas, stimuli for deep understanding but also for the acquisition of non specialist languages, together with attitudes of mental opening and communication towards those who are not specialists. This would cultivate the figure of a scientist who is open to the social, communicative and able to involve non-experts – a topic often mentioned in current debates (Weber & Duderstadt 2004, pp. 66-80).

The reflection on the two-fold task that the university should carry out following the Humboldt example, dedicating itself to research and teaching in equal measure, can find further clarification from a comparison with what happens in the American system. According to the *Carnegie Classification of Institutions of Higher Education*, a classification that analyses all those colleges and universities accredited with conferring various kinds of qualifications (see www.carnegiefoundation.org/classifications/index.asp), there are several kinds of institutes in the country that offer a variety of training opportunities unequalled in the rest of the Western world. However, this great variety of training offer can be placed within a sort of more generic dualistic partition that, according to a more traditional denomination no longer in place since 2005, divides the institutions dedicated to research from those that deal exclusively with teaching: until a few years ago, there was talk of *Research I University*, institutions in which the function of teaching is remodelled in such a way as to give the teachers ample space and resources for research work. In their turn, these universities can be differentiated on the basis of the intensity of commitment and quality of resources in research; so we have Very High Research University (RU/VH), High Research University (RU/H) and finally Doctoral Research University (DRU). They all have in common a complete training offer that starts from the Bachelor Degree and arrives at the PhD. The characteristic that mainly makes them stand out from all other forms of colleges and institutions is that teachers must do research as a large part of their job and they are given the conditions to do so.

In the other universities, most of a teacher's research experience, that should guarantee that his approach to teaching is not merely scholastic, is provided only by PhD training. This enormous difference of institutes and missions finds justification, among other things, in the great variety of requests and possibilities that the citizens can make regarding training and professional choices. This implies that, for example, a student who is not fitted for highly specific or high ranking choices will not take up a position where he could cause a waste of time, energy and resources within universities aimed at high level research, but will be content to choose colleges or other institutions where teachers will pay greater attention to his specific needs and levels of possibility.

Although the proposal to rethink a university reform in terms of diversification of the training offer to make study courses more personalized in relation to the type of student, to teaching requirements and levels of preparation may certainly appear very positive (see Vest 2007, pp. 7-8) – and without doubt necessary in a school system that is always dealing with large numbers – we feel, however, that the proposal to adopt the American model through a simple separation of teaching and research is quite inadequate. First of all, if we balance the advantages and disadvantages caused by separating the two activities, we would easily acknowledge the losses are much greater than the gains: in fact, the separation of teaching and research risks causing devastating effects on the preparation of a university teacher, on his capacity for self-updating and the updating of study programs to propose to his students. Secondly, it is not clear how the simple training experience from a doctorate program could be enough to avoid a merely scholastic approach to the discipline (that for a number of years and occasions is certainly prevalent in the experience of any teacher who does not dedicate himself to professional research).

Among the aspects to be taken into consideration, there is certainly the need to revise and balance more wisely the amount of work of a teacher who dedicates himself to teaching and research over the course of the academic year; but to do this, one could experiment with alternative formulae, like the idea of alternating years of teaching with years of only doing research. Likewise it would be a good idea to revise the teaching system in itself, because of the need to differentiate between the training offer and the possibility of support and teaching assistance. This could happen in different ways: first of all by revising the entry system, for example setting more rigid criteria for entry selection guided not so much by a fixed number of entrants but a minimum performance level required to get in (this could place the student in the psychological condition of knowing that it depends on him). Secondly, another strategy for didactic differentiation could be found through the use of staff or personal tutors whose task is to support students who have some learning difficulties. Differentiating in this way the various universities that all tend to run on the same lines in Europe (also recognised by the EU, see EC 2005c, p. 4; EC 2006, pp. 3-4) could be a way to compete and go in search of different users: moreover, competition is widely recognized within the American school system as one of the strongest factors of acceleration towards achieving excellence (see Vest 2007, p. 9). Naturally, all this implies a totally rethinking of the European university system that could be carried out only where the political institutions prioritize the university system, seen as the nucleus for the development of a society of knowledge and as such should receive the necessary resources but also the tools of transparency and control for their management.

5.4.6 – *What is the mission of today's universities?*

At this point, it is possible to specify the missions that can be hypothesized for the universities in the knowledge society. Historically, the first mission of the university has been the creation of new knowledge through research; the second one was to spread the acquired knowledge through teaching. Today, a third mission can be assigned to the university system: the capacity to "create services" for society by exploiting and capitalizating the knowledge supplied by it, thanks to that academic revolution that some believe would lead to the *Mode 2* of research and the transformation of knowledge into goods and products (see Schuetze 2007, pp. 435-436; Etzkowitz 2008, pp. 27 and fol.). As regards teaching, its central objective is the primary education of the person, of the citizen, in the completion of his attitudes, his interests and his potential. In this direction, the university has first and foremost the task of training individuals to be able to fulfil themselves personally and intellectually, acquiring the ability to successfully occupy any place in society or master any subject with ease. The aim of forming competences and specializations of high quality or in the case of doctoral students, specialist training for research work, should take second place. Besides, if these teaching objectives are to have substantial and long-lasting effect, it will be necessary to revise the communicative paradigms in favour of those models in which the subject who learns and builds the very meanings of his learning is at the centre of the process. Teaching is not finalized at the teacher or the contents; it should concentrate on producing not excellent information, but excellent learning. For this to happen, it must be also research-led or problem-based so as to produce those beneficial effects deriving from the cross-fertilization of teaching and research we have already mentioned (see Weber & Duderstadt 2004, pp. 64-7).

And now we have come to the second mission: the creation of new knowledge through research, of which the university is the main producer in Europe. To this regard, we believe it is important to underline that the research carried out in the university is something specific and different from research carried out elsewhere: perhaps this is the main reason why the university has a role of notable excellence in today's knowledge-based capitalism, also called creative capitalism (see Florida & Cohen 1999, pp. 589-610; Florida 2005, pp. 144-145). In fact, «the shift from industrial capitalism to knowledge-based capitalism makes the university ever more critical as a provider of critical resources such as talent, knowledge, and innovation» (Florida & Cohen 1999, p. 593). In rethinking the current university system, in fact, the process of research development should focus – as we have argued above (see § 5.3) – on creativity and the capacity to continually produce new creative talent: if knowledge and the human capital have to be at the centre of politics fostering innovation and research development, then the university must be considered as the main engine of the economic system. For this purpose it is necessary to pay particular attention to resources for the development of human capital, which must be moulded for research in the widest and most creative sense, keeping as free as possible the diffusion of knowledge thus produced, so that it can self-thrive, instead of focusing on the logics of commerce and companies. At the same time, we must revise the current conditions of the job market, the system of mobility or exchange and that of acknowledgment of merits and rewards. Moreover, the defence of freedom of research must be guaranteed, even in sectors that are not productive immediately, like in the humanities, or in basic research: the advance of knowledge proceeds extremely slowly and seemingly without a prefixed purpose; above all, it proceeds from other knowledge. For this reason, it seems extremely dangerous to leave the subject of intellectual property unregulated, or worse, to allow it to be abused by the exploitation of knowledge as goods to the advantage of a few (see Florida 2005; Boyle 2003).

Having said that, it does not imply (and now we are on the third mission), that the old *Mode 1* of academic research should still be seen as good. Of course, while it is true that in America there has been a multi-linear, anarchic model for some time, economically led by technology-oriented drives, no longer with much distinction between basic research and applied research, Europe cannot merely imitate it or let itself be guided by socio-economic changes in a completely passive way. The recent transformations have forced the university to rethink a new role for itself, but this role must be autonomous, free, and develop from the real needs of every population. There are different strategic roles that the university could cover, connected to each other in various ways, both through partnerships and collaboration like the triple helix one, and adapting themselves to the various conformations of places and vocational disciplines. In any case, we believe (according to what we claimed regarding the creativity in § 5.3 and to research carried out by Florida 2005) that the primary objective of the universities must be the training and attraction of creative minds, open and formed by the union of teaching and research, and therefore should be given the right conditions so they can autonomously give themselves a proper statute and can follow their vocational mission devoted to the freedom and to independence from any power and authority. In conclusion, autonomy, availability of funds, freedom to teach and do research represent some of the fundamental conditions for the development of culture and new thought, the engines for the advance of innovation and economic development; but to be able to realize this, in the knowledge society, universities must continue to successfully cover a primary role, providing the young (and not so young) generations with the necessary tools to face the challenges of contemporary complexity.

5.5 – Not only specialisation: towards a more integrated vision of culture

5.5.1 – *A more comprehensive vision of knowledge*

As we know from the discussion of "tacit knowledge" (see § 5.2), in order to live well within an knowledge economy, in which every object and environment is laden with incorporated knowledge (see § 0.3), it is necessary to acquire certain non encoded general learning skills ("learning to learn", to recognize what we do not know and so on): in an age in which we have to keep up to date, or even anticipate the ceaseless changes, it seems to be very important to be able to master these skills rather than show a specific repertoire of techniques and coded knowledge. These skills, therefore, go beyond the simple updating of technical and explicit knowledge: in fact they enable us to understand or anticipate new things (OECD 2007, p. 25). This strengthens our claim that a creative training, which provides the mind with sufficient flexibility to adapt and to learn new knowledge, is much more important than trying to provide an already "finished product", a person with a pre-set mind and rigidly fixed knowledge and skills that are not easy to update.

However, when speaking of transversal abilities and competences, aimed at "learning to learn", to find one's bearings and acquire tools to face changes, we have to keep in mind the multiform composition of the object that we hastily define as "knowledge": in it there are not only the components which we discussed in § 0.4, but also another fundamental component not directly of a cognitive nature, albeit very important to it: *imagination*, known to all but often underestimated. In fact, it seems that in a concept of science and science policy often guided only by the narrative of objectivity and the evidence of factual data, there is absolutely no consideration for this form of process of the mind that is, however, pervasive and distributed to each individual, and essential also for rational thought, scientific demonstrations and their applications. If we undervalue it in favour of mere "factual data", proved and already established, within the logic or the methodological reflection of science, the consequence will be that the unpredictability of the creative mind, that is always associated with frontier scientific knowledge (see Nickles 2009, 2009c) and represents one of its ways for producing new things, will not be given due consideration (see §§ 5.1, 5.3).

Secondly, in the area of the analysis of various kinds of collective knowledge like science, we need to formulate another distinction between (a) the knowledge that we can define instrumental, that is that body of scientific technical knowledge that allows the concrete development of science and technology their application and practice and that we have included in the explicit or encoded knowledge (see § 5.2), and (b) other forms of definite *reflective* (see Schön 1983; Bourdieu 2004) and *relational* knowledge, that are part of "specialistic expertise" and "meta-expertise", according to the Collins & Evans' classification (1997 – see § 5.2.4). All these forms of knowledge are complementary to each other and the instrumental one may be enriched by an encounter with the other two, becoming more inclusive, sustainable and efficient (see also Wynne *et al.* 2007, p. 63). In particular, "relational knowledge" refers to the need to recognize integrity and independence in others, whose ways of life and thought could diverge from ours to such an extent that we may be tempted to define them irrational, taxing or even threatening for us. On the other hand, with reflective knowledge we mean speaking about implicit assumptions that tacitly form our understanding and interaction. This implies the need to bring to light that series of involuntary and implicit assumptions, incorporated in actions, decisions, styles and objects of life that forge our behavior at every level. Reappraised both by studies of sociology from post-Mertonian science to STS, and by epistemologists who have operated epochal criticisms of the traditional *received* image of science, understood as comprising only rationality, logic, scientific method, specific language, etc. (see §§ 2.1, 3.1-3.4; Coniglione 2008; Coniglione 2009, pp. 9-43; Di Tommasi 2009, pp. 55-71), the "dark side" of science shows that it is no less important than the explicit, rational side: on the one hand, tacit, implicit knowledge, defined also as informal belief or *habitus*; on the other hand, the ideas that are formalised, explicit and instrumental. These two dimensions constantly interact and enrich each other in a process of circular interaction: part of the instrumental knowledge is spread and embedded in the environment, in the objects, and in our very habits, which are slowly modified (see Cerroni 2006, p. 64 and *passim*) and thus foster a more indirect and involuntary way of learning. Over the centuries, the lack of awareness of this variety of cognitive dimensions has provoked that narrative of simplistic and flat science, seen as "factual" and "innocent" knowing, objective and absolute, reliable inasmuch as it is based on "hard data", so losing the multidimensional and stratified structure we have stressed when supporting MAS (see §§ 4.3-4.5; Di Tommasi 2009, § 4). An example of the interaction between these two dimensions of knowledge is provided by the founder of modern economics. Adam Smith, in his masterpiece *The Wealth of Nations*, put forward the theory that many inventions and improvements in machinery are the fruit of the combined effort of two categories of men: "common workmen", on the one hand, and philosophers on the other. The task of the former is to *do* while the others *observe* and *reflect* on what is being done in order to be able, from time to time, to rearrange acquired knowledge in a new way (see Smith 1776, p. 6).

Another element that should be added to the concept of knowledge that we are reconstructing is the reference to values, excluded from the traditional representation of science, for it grants a privilege to the cognitive values. In fact, if the traditional, factual science is characterized by its marked denial of any form of values, emotions or specific ends, now instead, the superseding of the neo-positivist received tradition and a more flexible approach to the concept of truth as "correspondence", has allowed for the recovery of the axiology sphere in a historical-social key. Such considerations are full of implications also for the assessment of scientific-political debates: in fact, there is no such thing as rational decisions perfectly able to calculate costs and advantages, nor absolute experts regarding a problem or a specific area, but each one of us is, time after time, more or less aware of ideologies, interests and interpretations or values that influence our ability for determination and choice (see Di Tommasi 2009, § 1.4).

5.5.2 – *Overcoming hyper-specialization*

In the light of what has been said in the previous §§ – particularly concerning the importance of basic and *curiosity-driven* research and of the paramount role of creativity to nurture new knowledge –, it becomes clearer and clearer how the transition towards an balanced and mature knowledge society should aim at giving incentives to every general aspect of the culture and traditions that structure the human mind so that it can freely create. Moreover the general concept of knowledge proposed so far goes very well together with the epistemological framework based on the open and modeling theories (MAS), we proposed in the previous chapters (see in particular ch. 4), since it stimulates the creation of multiple scientific hypotheses different from each other even within the same area of research. In MAS, creative freedom and the explorative potential of each mind trained for research take a privileged role; furthermore, from the discussion on creativity (see § 5.3) it immediately follows that the current tendency for hyper-specialization of students at a young age, even within a university course of study or research, is counterproductive: the early moulding of young minds to a model of specialist and sectorial knowledge would deprive them of the capacity to acquire tools for reading the global all-comprehensive reality, depriving them of that opening and mental elasticity necessary to be able to "see" something new in a Gestalt way from time to time and create alternative knowledge. The creation of an increasing number of hyper-specialist disciplines and sub-disciplines, among other things, risks in the long run making a fruitful and mutual understanding of work in different disciplinary sectors impossible, which would hinder the advance of knowledge (see Weber & Duderstadt 2004, p. 99; Cini 2006; Bocchi & Ceruti 2007).

Besides, we need to note another alarming fact: the increasing lowering of average culture both among the young people who have finished their studies, and among the new generation of citizens who deal with culture (teachers, journalists, artists, etc.), in brief, the drop in the presence of globally trained intellectuals, equipped with acumen and reading tools to be able to understand or settle most problems of modern society.

In our opinion, aiming at the specialization and professionalization of knowledge should come second to a general training. Beginning directly with specialist training would lead to a rise of general ignorance in the education of the young (see Russo 2008, pp. 3-6): the general culture of everyone, both of the masses and of teachers, researchers etc. is little by little becoming flat and amalgamating, and if the traditional conceptual structures become insufficient to understand reality, not even the technical specialists will be able to respond to this cultural crisis. To avoid this, the future specialists need to be equipped above all with a training that is as complete and general as possible, with an all-round education aimed at acquiring skills to manage the current complexity; in brief, the world needs people who are able to become primarily intellectuals, capable of understanding the surrounding reality in all its different aspects – people who manage the problems of their own times and can link them to past events in order to say something new and useful for the future. That is, we need intellectuals able to elaborate new conceptual schemata to find meaning and relationships among the many new disciplines and those traditional ones, although this would be a very long, tiring job (see Russo 2008, pp. 72-75). These are the reasons why in several parts of this volume we insisted on the paramount importance of "human capital" and we will embrace the "humanistic scenario" (see § 5.6).

An example that could guide the revision of the European system in this direction comes directly from the USA in which, for historical reasons, the Bachelor Degree, which is the first step of Higher Education, proposes the possibility of a study course almost entirely aimed at a wide cultural and intellectual training of young students (see Marrucci 2004). The structural shortcomings of the American secondary school system and also of its short duration compared to most European models, for example, explain the need to provide a university preparation of a general type, that is, aimed at the cultural training and civic education of the citizen, usually acquired in the course of the Bachelor Degree of Arts (something similar but slightly more directed to a more specific education takes place in the course of the Bachelor Degree of Science). The proper specialization begins only in a small way in the final year of the Bachelor Degree; after graduation, the students continue with their specialization until it is fully completed with the Masters Degree and the PhD.

Therefore, the European effort to adapt itself to the model of a two-fold training path (basic degree and specialist degree) appears to be significant, but at the moment it is quite insufficient and inadequate: in fact, faced with mass schooling which has led to a lowering of the preparation levels provided by secondary school teaching, there is still the tendency to hyper-specialize in the basic degree course. Therefore, we need to begin to revise the specific mission, duration and typology of basic education in order to be able to reformulate the curricula and possibilities of choice depending on the preparation provided today in the secondary school. In fact, it seems sensible to try to revise the training offer of basic degree course not so much through a proliferation of curricula and specific titles, but thanks to an education in which more space is assured to general humanistic and training disciplines (from mathematics to economics to philosophy), leaving to later years the possibility to gradually introduce students to a precise work choice within more professionally oriented paths. In this way, a young person who does not yet know at what age he will enter the world of work would be able to put off the moment of effective specialization, which seems a good thing today. This can also be justified with the great changes in the job market: many years pass from the moment when a student makes the choice of his study course to when he begins his working life, and in this ample time span, the job market also changes. Therefore, it is likely that a vocational choice made before time could turn out to be useless or wrong and often lead the young person to do a job that has nothing or very little to do with what he has studied.

Keeping this in mind, the choice of too early specialization seems to be completely inadequate for the times and current needs from many viewpoints: both for the epistemological needs linked to the advance of knowledge – an advance that risks becoming more difficult when people are not able to move easily across the borders of the various sub-disciplines; and for the needs of comprehension and adaptation to the complexity of current societies that demand the ability to control areas and find relationships that were unknown before; finally, also for the need to adapt to the changeable and flexible world of work itself, which demands that the growing generations develop the ability to adapt if not to foresee new future scenarios.

5.5.3 – *Towards superseding old dualisms*

Now, within the problems concerning the implementation of a knowledge society, it seems clear that we need to rethink the role of knowledge and its nature in order to help guide us in the choice of the priority mission to assign to cultural and school education. In fact, in the history of culture there are two opposing tendencies. The first is a tendency to conceptual unification, to discipline complementarity and global comprehension; the second, instead, is a tendency to sectorialization and the closure of individual disciplinary compartments that have been gradually formed. In this scenario, it has become necessary to understand which of these two tendencies is most useful today, or which could turn out to be so in the future.

It should first be clarified, however, that if on the one hand the tendency to conceptual unification is the fruit of a need for the individual to understand and adapt himself to the reality surrounding him and the many facets that constitute his environment and influence his life (and this is the fundamental function assured by "tacit knowledge", regarding which see § 5.2), on the other hand, the tendency to sectorialization, simplification and delimitation of an otherwise unlimited and unmanageable field of experiences, appears rather like the fruit not only of a need for clarity and transmission, but also the necessary condition for edifying scientific knowledge (as we have argued in supporting MAS – see § 4.3). The latter aspect in particular represents a need that, linked to the historical development of society and culture, has seen a series of tools prevail over time – writing, text, manuals etc. – that need their own constitution of linearity and rationality, in brief, a disciplinary organization constituted by its own internal logic, lexis, argumentative processes and so on that are gradually handed down and strengthened: that is we have called "encoded knowledge" (in opposition the tacit one). This confers the disciplines with a certain physiognomy of unity and individuality that at the same time separates one from the other. Therefore, if on the one hand disciplinary specialization seems under accusation, on the other hand, it should certainly be given the merit of being the only tool through which in-depth disciplinary study, the science itself, has been achieved (see Martini 2005, pp. 23-29).

What is to be criticized here, or at least placed under carefully scrutiny, is the tendency to justify the closure and absence of exchange among the different kinds of knowledge by the inevitable depth of the disciplinary and specialist studies. It is not so much the specialization of various disciplinary sectors, which is in itself a desirable, profitable element for the increase of knowledge, but rather the closure to interdisciplinary dialogue that is the risk of increasingly advanced specialization, heralding possible negative consequences. But disciplines are exclusively tools, and it is in the use we make of them that the problem arises and a solution can be found: the primary tool through which disciplines arise, grow and are handed down is the path of training, education and research; in this perspective it has already been said how education and the university can take on a fundamental role in avoiding a too early hyper-specialization at an age when the young people are not mature enough for a correct professional course. Here we will try to understand the advantages of a good general and basic training, complete also on different sectorial fronts, which could, in our opinion, also act as a theoretical and epistemological basis to overcome the rift between the "two cultures" and the acquisition of a more complete and rich paradigm of the concept of knowledge (on the concept of knowledge, see also what has been said regarding the knowledge society in § 0.3).

In this light, we believe that a further effort to close the rift between the two cultures is possible, through a synthesis between "propositional knowledge" or explicit, formal knowledge (the so-called *know-that* and *know-why*), and "prescriptive or practical knowledge", i.e. the tacit, implicit and not formalized *know-how* and *know-who* (see § 0.4). Only the reciprocal interaction between these two gives life to "useful knowledge": in fact, the propositional one, applied to the prescriptive one may contribute to changing and improving it; while the prescriptive practical knowledge may provide further feedback to the propositional one to stimulate further reflection. This represents the real engine of the knowledge economy: we should strive to maintain the closest possible links between the diverse typologies of knowledge indicated above, since only the interaction between scientific-academic technological-practical, and humanistic-artistic preparation could represent an effective benefit above all for the formation of adequate human capital, and also for the much feared socio-economic race to innovation.

The proposal for interaction between these levels of knowledge also stresses the importance of overcoming certain dualisms that can only harm the life of research and culture, including the traditional contrast between the "two cultures": between hard and soft sciences, between exact and weak sciences (Snow 2005). Having another look at the terms of this famous debate trying to overcome the antithesis, perhaps only apparent, would lead us to grasp the importance of both specific types of cultures for a formation that offers a holistic synthesis of unequaled depth; this could contribute to raising the level of humanity present in our society or in the knowledge that we put into practice every day in our profession, in the concrete choices of every day, and in the social environment (Sanz & Bergan 2006, p. 89; Charles 2009).

Moreover, it should be noted how this cultural rift does not find an explanation or roots in the biological or human cognitive structure (Snow 2005, p. 59), and that those that appear to be dichotomies rooted in the human structure (like intuition-intellect, right-left hemisphere, reason-feeling, *esprit de geometrie-esprit de finesse*, Apollonian-Dionysiac, etc.) are basically two poles of the same circuit in constant interrelation (see Odifreddi 2005, p. 128). In fact, neither pole could exist if the other was totally eliminated. The risk would be to perpetuate a form of two-dimensional man, or, even worse, a one-dimensional man (see Marcuse 1964) if the culture were deprived of the humanistic side, so hypostatizing the fracture between elements of a same dimension (see Russo 2008).

In our opinion, the real nature of the problem is more academic than ontological or epistemological: in the works of numerous exponents of culture, in fact, this fragmentation has never existed. As long ago as 1964, L. Geymonat expressed his criticism of education programs that were excessively and precociously specialized, risking making young generations lose the general sense of culture (see Snow 2005, p. 9). Future scientists should be educated in humanistic knowledge, philosophical and epistemological reflection, especially where specialization imposes the need for a meta-comprehension that can take place only through a dialogue on these two fronts. In this sense, «philosophical reflection can have an important role in science where and when there is a debate between scientists who are bearers of varying alternatives of discipline language based on different meta-theoretical foundations […]» (Cini 2006, p. 56).

Therefore, a deep understanding of specialist and scientific contents can take place if the students are provided with a background of humanistic contents that leads to the construction of those scientific contents they are studying. Greater interaction between scientific subjects and humanistic subjects seems desirable and would bring benefits as we can see from a simple example taken from the history of science: before Galileo Galilei, the English mathematician and astronomer Thomas Harriot had observed the moon through a telescope, and made a drawing of it that was incomprehensible and completely unrecognizable. On the contrary, the incisions made by Galilei that appeared on the first pages of *Sidereus Nuncius* were very successful due to the fact that he had an excellent artistic and painting culture, typical of Renaissance Italy, and was able to read and represent as plays of light and shadow what for Harriot had only been meaningless blobs. Therefore, it appears evident that the current need is for greater discipline complementarity, greater preparation in the basic cultural sectors and general skills useful in the long term, rather than hyper-specific but reductive knowledge that, very likely, will remain valid only for a few years.

In conclusion, we can state that alongside creativity and innovation, engines for the development of *Homo sapiens* from the invention of the first tools to the creation of art, technology, science and culture, the moment has come to seriously rethink the paradigm of knowledge. For this very reason, it is essential, above all, that the school and the university reassess their meaning and their role. Allowing more complete and rich training spaces, not focused on sectorial disciplines and points of view, giving space to the development of subjectivity, art, humanities and knowledge closely interrelated with life and with the world, will prevent the rising cultural homologation.

However, the role that policy choices will play in this is equally important: in fact, considering the situation of economic disadvantage in which the EU finds itself compared to other countries (the USA, Asia, etc.) it would be desirable to provide incentives for a general, all round training which can unite the diverse aspects of knowledge and science (thereby avoiding too – as we have said – early hyper-specialization that could, over the years, turn out to be damaging), primarily for indigenous students to equip them with those qualities that form a creative and stimulating mind, and the tools and adequate skills to enable them to face the sudden variation of events and scenarios. This would enable the production of local intellectual resources to be exploited later both in the academic field and in companies, and would guarantee national institutions the possibility to make fewer investments, but more shrewd and fertile ones than those that would be needed to compete with foreign universities.

5.6 – Towards an industrial or a humanistic scenario?

As already shown, the western world and particularly Europe, feel the need to invest in R&D principally because of concerns that also in this field they will be overtaken by the emerging countries and thus may lose their superior economic and social position (see § 1.1.2). Underlying this worry there is a conviction that there is a linear relationship between investment in R&D and economic growth (see § 5.1.1). The American and European public have observed over time the delocalisation of the manufacture of many consumer goods, ranging from those with low technology to those that are more technologically advanced such as audiovisual computer equipment and mobile phones, but have, however remained convinced they can maintain their technological supremacy thanks to their continuing *know-how* in the field of design and invention, fostered by the policy of investment in R&D guaranteed by national policies.

This has led to the idea that it is of fundamental importance to continue to invest in R&D and that a decrease in such investment would lead to a decline in economic growth and and would enable emerging countries like India and China to overtake us. Indeed, this was the basis of the Lisbon Strategy promoted by the European Union.

In recent years, however, a new tendency has arisen: that of moving abroad not only assembly and construction work, taking advantage of the low salaries in the emerging countries, but also the supply of services and even the production of knowledge. This process is clearly favoured by the increasing levels of education in the emerging countries, which are now able to offer ever-increasing skills and not just manual labour. Because of this there is now a fear, particularly in the United States, that American technological competitiveness is threatened by the increasing ability of countries like China and India to combine their growing scientific expertise (acquired also thanks to a judicious policy of educating scientists and technicians at American universities) with an enormous work force that can be paid with low cost competitive salaries. As observed by Thomas L. Friedman (2006), as the economy becomes more globalised the world is becoming "flatter" thanks to the increased access to ICT and the growth in technological skills in the rest of the world, thus enabling the delocalisation also of high level technological services and manufacture that were previously considered the prerogative of the industrialised West. As Friedman writes in the *New York Times*,

> in this new era of globalization, so many people now have the communication and innovation tools to compete, connect and collaborate from anywhere. As a result, business rule No. 1 today is: Whatever can be done will be done by someone, somewhere. The only question is whether it will be done by you or to you. In such a world, the way our society flourishes is by being as educated, open and flexible as possible, so more of our people can do whatever can be done first. It matters that Google was invented here. (T.L. Friedman 2006)

This threat can only be met by protectionism or by an intensification of the old strategy: spending more and better on R&D in order to maintain supremacy and keep at bay the threat coming from abroad. This is the line followed by the recommendations included in the report *Rising Above the Gathering Storm*, written by the National Academy of Sciences, a non-profit private enterprise operating upon the authority of the charter granted to it by Congress in 1863, and which has the task of supplying scientific advice to the federal government. It deals with concerns that America is losing its supremacy because of the transfer «not only of manufacturing jobs but also of jobs in administration, finance, engineering, and research» (NAS 2007, p. ix).

Norman R. Augustine, president of the committee that edited the report, declared in the hearing held before Congress, that «America's ability to compete in the years ahead will heavily depend upon its ability to maintain a strong position in the fields of science and engineering» (Augustine 2007). At the time Augustine listed a series of factors casting a worrying shadow over the future of American supremacy. Among the measures proposed, at the top of the list is resolute action to improve the quality of high schools, raising the school-leaving-age to 18 (to the K12 grade) and doubling the funds for research into mathematics, engineering and physics. This type of measure has been applied in the past when American supremacy has been threatened by a danger from outside (it happened in the eighties with threats from Japan, resulting in the Bayh-Dole Act). This is the guiding principle behind the Lisbon strategy and is in general the line followed by most of the countries wishing to develop their economy. The American NSF reports:

> Science and technology are no longer the province of developed nations; they have, in a sense, become "democratized." Governments of many countries have firmly built S&T aspects into their development policies as they vie to make their economies more knowledge- and technology intensive and, thereby, ensure their competitiveness in a globalizing world. These policies include long-term investments in higher education to develop human talent, infrastructure development, support for research and development, attraction of foreign direct investment and technologically advanced multinational firms, and the eventual development of indigenous high-technology capabilities. (NSB 2010, p. 0-19)

However, it has recently been pointed out in Amar Bhidé's important study (2008) that these diagnoses and measures tend to undervalue the complexity of the innovation system and simplistically rely on investment in R&D, particularly at a basic level, to ensure more innovation and hence better economic performance. Innovations come about on various levels and need to be able to interact efficiently: if a step is missing the chain is broken. Therefore, both products and the *know-how* are classified as *high-level*, *mid-level* and *low-level*. As regards products, there is a hierarchy ranging, for example, from microprocessors (*high-level*) to *motherboards* (*mid-level*) and arriving at laptop computers (*low-level*). As far as the *know-how* required for *high-level* products like microprocessors is concerned, there is solid state physics (*high-level*), the design of the integrated circuits (*mid-level*) and finally the management necessary to organise a microprocessor factory in such a way that quality and productivity is maximised (*low-level*). The same can also be said for less technological sectors. Bhidé states that in the light of these considerations, «*innovations that sustain modern prosperity have a variety of forms and are developed and used through a massively multiplayer, multi-*

level, and multiperiod game» (2008, p. 9 – author's italics). Lack of interconnection between the three levels mentioned above or a link missing from the innovation chain explain the occurrence of premature inventions and patents being deposited without having any innovatory impact either on technology or the economy. It would, therefore, be an error to simplistically identify innovatory ability with the number of scientific papers published or patents deposited or to underestimate the increase in the phenomenon of high-level *know-how* crossing borders and becoming available to countries that are not capable of producing it themselves. In Bhidé's opinion it follows that the United States should not fear R&D competition from China and India, since the growth of their research capacity can increase American prosperity – thanks to the exportability of *know-how* – and therefore he contentiously suggests that «the United States embrace the expansion of research capabilities abroad, not devote more resources to maintaining its lead in science and cutting-edge technology» (*ib.*, pp. 11-12). This does not mean he is supporting a decrease in basic research investment but that he is countering the fear of the "techno-nationalists" that the loss of American scientific excellence is due to a lack of investment in the sector (see also Nickles 2009c).

> The techno-nationalist claim that U.S. prosperity requires that the country "maintain its scientific and technological lead" is particularly dubious: the argument fails to recognize that *the development of scientific knowledge or cutting-edge technology is not a zero-sum competition.* The results of scientific research are available at no charge to anyone anywhere in the world. (*Ib.*, p. 13)

To sum up, innovatory ideas have no native country and there are no borders that can prevent them from spreading. It is therefore of no consequence where they come from. On the other hand,

> *the willingness and ability of intermediate producers and individual consumers to take a chance on and effectively use new know-how and products – is at least as important as, if not more important than, its capacity to under take high-level research* […] The richer places are not ahead because they are (or once were) significant developers of breakthrough technologies. Rather, they are wealthier because of their capacity to benefit from innovations that originated elsewhere. (*Ib.*, p. 15).

In fact, unlike Friedman's claims, the world is not "flat" everywhere and in every sector. It is not possible to just look at Bangalore and ignore the context of Indian society; it is not possible to measure the degree of civil and industrial development of a country just by looking at some high-level technological "enclaves", often also physically separated from the rest of the social environment, and merely considering the production of mobile phones and microprocessors or sophisticated software. The lesson to be learned from Bhidé's provocative thesis is that innovation and development are a systemic process requiring a series of factors that must be developed in a harmonic and structured way. In particular the delocalisation of high-level activities does not automatically make possible the delocalisation of mid-level and low-level activities, as these require not only highly specialized research laboratories but also to be structured within a human community whose collective knowledge cannot easily be found or reproduced in every place on the planet. The so-called mid-level innovations are equally important for economic growth. These depend on the general level of creativity and practical ability of the workforce and, as in the emblematic case of Apple with its iPods and iPhones, do not require the use of new technology produced directly by itself but being able to apply and to exploit what is already available with intelligence, simplicity and style. At the end of the day, everything depends on individuals and it is not necessary to be a scientist or a trained engineer to reap this vast harvest of creative and productive work – what is needed is an open mind and the desire to experiment and innovate in the use of technology, not to create it. This means generally improving the quality of human capital and therefore investing not so much (and certainly not exclusively) in advanced research programs as in improving the education, the creativity and general abilities of a country's workforce.

Bhidé's lesson is not so much that it is useless to increase investments in R&D given that patents can be bought from abroad, as the Italian prime minister Berlusconi recently affirmed, as that they are totally useless if they are not connected systemically with the rest of the country's system or if the quality of the human and social capital is not contextually increased. As Castells also points out, the new economy can only work if there are workers who are able to understand the mass of information available, organizing what is useful for businesses and transforming it into suitable knowledge. To a certain extent, they must be capable of self-reprogramming and therefore need an education that gives them not only "skills" but above all "creative capacity" and thus the ability «to evolve with organizations and with the addition of knowledge in society» (Castells 2004b, p. 26). The fact that the workforce must be highly educated and able to take initiatives has important consequences (as we have seen in previous §§) on the education system, during both the formative years and later during subsequent lifelong learning.

Moreover, it should be noted that Bhidé's vision of *know-how* is partial, in that he limits himself to considering knowledge that is explicit, can be articulated and encoded and is hence transmittable; he claims there are no borders because he is only referring to this type of knowledge. However, as already seen in this report, the knowledge at the origin of an innovation cannot all be considered explicit. *Know-how*, in fact, belongs to the implicit dimension, and given that it is tacit knowledge, it is more difficult to transmit and construct. Knowledge is not merely information and bits, or manuals and lessons given in a classroom – the only type of knowledge Bhidé seems to consider – but also what is learned from apprenticeships, direct contact and practical laboratory work:

> Workers learn more in the coffee room than in the classroom. They discover how to do their jobs through informal learning: talking, observing others, trial-and-error, and simply working with people in the know. Formal learning – classes and workshops – is the source of only 10 to 20 percent of what people learn at work. Corporations overinvest in formal training programs while neglecting natural, simpler informal processes. (Cross 2007, p. 235)

It is, to sum up, society as a whole, the quality of its relationships and the people that interact that ensure the most suitable environment for those mid-level innovations that are fundamental for Bhidé, as

> most of what we learn, we learn from other people-parents, grandparents, aunts, uncles, brothers, sisters, playmates, cousins, Little Leaguers, Scouts, school chums, roommates, teammates, classmates, study groups, coaches, bosses, mentors, colleagues, gossips, co-workers, neighbours, and, eventually, our children. Sometimes we even learn from our teachers. (*Ib.*, p. xiv)

This scenario leads us to what has been called a "post-scientific society" in which the most important thing is that the

> innovation leading to wealth generation and productivity growth will be based principally not on world leadership in fundamental research in the natural sciences and engineering, but on world-leading mastery of the creative powers of, and the basic sciences of, individual human beings, their societies, and their cultures. (Hill 2007)

This does not mean less science and technology or less research but rather a dislocation of the capacity to produce innovations from the laboratories and research institutes organised into big centralised and hyper-financed entities to companies (like Amazon, Google, Cisco and many others at the new technological frontier) that can tap creativity, talent and inventiveness and thus propose new ideas and concepts. This means shifting the focus away from the production of high-level knowledge and towards *mid-level* and *low-level innovations*. In any case, it must be stressed that innovations are always necessary and therefore creativity, flexibility and the conditions that favour the innovatory process are essential.

However, it would be a mistake to think that growth in R&D can take place in this way alone - that creativity by itself is enough or that talent on its own can find the way to innovation and design. Also in this case there is an essential and inevitable tension between big organisations and companies and small and courageous new ventures funded by *venture capital*: creative innovation needs to break the rules and destructure the existing systems in order to come to light but at the same time, if it is not to end up lost in eccentricity and superfluousness, it must be regulated and inserted into efficient managerial systems that can translate it into organisation, products and marketing. This must be done with rules and organising principles with their own cast-iron intrinsic logic. However, the tension always arises again and it is only possible to emerge from the crystallised and centralised systems governing innovation thanks to new bursts of creativity and imagination that again break the equilibrium in favour of new technological horizons.

If these dynamics of an equilibrium that is continually broken and then put back together at a superior level are to take place continuously and uninterruptedly, various conditions are necessary.

Above all there must be a social context (and hence a corresponding social capital) in which it is possible to have both creative freedom (thanks to a climate of tolerance) and an ordered structure in the associated activities, with regulations and laws that are socially recognised and respected. An innovation cannot happen without rules and traditions, but these must not be so oppressive and pervasive that they prevent the expression of creativity. This is the same mechanism that underlies scientific change: the new theory opposes and transforms the old ideas, but at the same time is inserted into a tradition on which it leans and from which it draws material. As Kuhn points out, revolution is not possible without tradition. Innovation and increase in knowledge are as equally threatened by a culture that is blinded by identification and preservation logic, as by a society and a culture that is dominated by scepticism and cognitive nihilism and hence lost in hedonistic dissipation and without principles.

It is in this light that we maintain that the future "knowledge society" must be directed by a "humanistic" vision of scientific and technological development and thus what has been defined a "humanistic scenario" is to be preferred to an "industrial" one, as summarised in the following tables that are a synthesis of what we have claimed until now.

"Industrial" scenario

- greater investment in technology and infrastructures
- scarce capacity to see technology and business creatively
- rise in specialisation and sectorialisation
- disappearance of shared and interdisciplinary knowledge
- rise in unemployment levels
- use of GDP as fundamental indicator of growth
- American model (Silicon Valley)

"Humanist" scenario

- greater investment in "human capital"
- education leading to greater creativity in schools and universities
- superseding of fragmentation and specialist knowledge
- rise in shared and multidisciplinary knowledge
- increase in employment
- going beyond the GDP towards an index of well-being that is not purely economic
- Scandinavian model (Finland)

6. Conclusions: The Recommendations to the European Commission

In this concluding chapter, we aim to summarize the main points of what has been said in the preceding chapters, making particular reference to the theses laid out in chapter 5.

In the light of the descriptive nature of STS, we have come to the conclusion (see § 4.6) that the contribution that they can make to science policy-making consists in providing accurate descriptions of the decisional processes of scientific practice that can act as a basis for a correct and informed activity of regulation and assessment. However, diverse methodological approaches coexist within STS that have a purely descriptive function. Each approach privileges the description of a specific aspect of techno-scientific practice. The sociology of science, for example, explains the decisional processes of techno-science by referring principally to factors of a social nature; the philosophy of science privileges the probative factors as explicative units; and the history of science oscillates between these two approaches (see ch. 3).

Establishing the function of descriptive support for the prescriptive activity of science policy-making as an unequivocal objective for these approaches that are very different from each other, has allowed us to devise and defend a "multidisciplinary" approach to STS – as opposed to the "interdisciplinary" integration of the diverse methodologies that it comprises (see § 4.1). In § 4.2 we have suggested the use of a strategy for the construction of descriptive models that sacrifice "precision" for "realism and "general applicability". This strategy consists in permitting the different approaches of STS to use their own specific descriptive methodologies and therefore to analyze the result of a decisional process (e.g. the choice to follow one given program of research rather than another), introducing different explicative factors (such as the impact of a particular social interest, in the case of sociology of science, or the relevance of a greater empirical cogency, in the case of the philosophy of science). Our multidisciplinary choice was supported by the adoption of a very precise view of science, that goes beyond the limits both of a traditional standard approach of neo-positivist derivation (see § 3.1), and the limits of the post-positivist approach (see § 3.3) and also the postmodernist approach (highlighted in several places, but in particular in § 3.6). We have called this new vision the Modeling Approach to Science (MAS): it is the merging of the Semantic Conception of Theories and the Idealizing Conception of Science (see §§ 4.3-4.5).

Thanks to these theoretical assumptions, we have been able to arrive at a complete framework (inasmuch as this is possible) of the decisional process that we want to describe, since diverse causative factors have been proposed for the determination of the phenomenon investigated. In this way we have obtained a more "realistic" picture (i.e. the complexity) of the decisional situation and the "general" one (in which as many as possible phenomena can be explained).

However, "precise" descriptive models are obtained through a strategy of interdisciplinary "unification" based on the methodological reduction of the discipline content in STS to a single descriptive heuristic. This presents two disadvantages regarding the function of STS in science policy-making. In the first place, mono-methodological descriptive narratives (that is, in the case of STS, fruit of a reductionist interdisciplinary unification of the philosophy, sociology and history of science) use only a specific typology of causative factors to explain the determination of the decisional process investigated and in this way tend to reduce the complexity. This reduction could work to simplify the phenomenon investigated and therefore produce a descriptive narrative that helps the policy-maker, assuming that s/he is not an expert in the scientific practice in question. In actual fact, although the selective reduction of causative factors that explain a phenomenon is a simplifying practice that is scientifically correct, in the case of interdisciplinary unification it is too restrictive (see § 4.4). In the second place, the reductionist mechanism of the interdisciplinary union legitimates the use of too specific technical jargon. The multidisciplinary comparison with other disciplines, on the other hand, leads to a decrease in the technical/specific jargon of each discipline involved in this process, which allows for a communication channel among the different approaches.

On the other hand, as the results of our analysis in ch. 4 show, the construction of descriptive narratives for policy-making seems to favour, at the same time, both descriptive thoroughness and the elimination of technical terms that are typical of STS. These seem to us to be the two fundamental requirements of the contribution that STS can give to science policy-making. Hence our first recommendation:

Recommendation 1

When seeking descriptive narratives of scientific practice to support the prescriptive activities of science policy-making (such as the policies of research funding which require a complete description of factors that can determine expected results, risks, etc.) we suggest privileging those in which the diverse methodological approaches are integrated according to a multidisciplinary logic.

We are well aware that techno-scientific innovation is a key factor of economic growth; there appears to be unanimous consent on this, starting from the report of Vannevar Bush (see § 0.3.1) and it is in line with what the EC has always maintained in its documents and the numerous reports it has commissioned over the last fifteen years (see § 1.2). It follows that understanding the genealogy and the optimization of the innovative process has therefore become one of the fundamental objectives for R&D policies, and a series of models have been proposed to understand these phenomena. In its most elementary version, the "linear model" of techno-scientific innovation (see § 5.1.1), seems to suggest that giving generous grants to basic research, which one presumes produces discoveries and innovative inventions, is enough to guarantee – in linear succession – their application aimed at specific use (which is the function of "applied research" which, ideally at least, stands out from basic research by the fact that it follow specific objectives), the relative experimental development, the consequent industrial production and, finally, their diffusion by means of the market (*science push*). A second variation of the linear model (§ 5.1.2), inverts the sequence by suggesting that it is the market that determines the innovative process (*demand pull*); consequently, a correct R&D policy should adopt strategies aimed at funding from the private sector.

Our analysis, based on the literature of the sector, has shown the defects of the two models, along with their respective strategies for the promotion of innovation. The "European Paradox" (see § 5.4.2) has demonstrated the failure of "science push" strategies. It seems, therefore, that strategies based on "demand pull" could resolve the paradox, for example, planning strategies involving public research and the private sector. However, the implementation of these strategies has detrimental effects that the model cannot foresee, especially the "demand pull" model: placing the market as the main engine of innovation assumes that the needs of general society correspond to the needs of consumers of goods and commercial services; that is, it identifies social well-being with the purchase and consuming power of the citizens/users.

Consequences of this kind help us to understand that, apart from the effective correspondence of the innovation models discussed here with the real process that they attempt to describe, the equation "techno-scientific innovation = economic growth", though generally correct, is not in itself able to guide innovation towards what should be its real objectives, indicated by the EC itself; that is, social well-being, which cannot be reduced to the mere increase and development of goods and commercial services – according to the classic definition of "economic growth". Therefore, the link between the commercialization of techno-scientific practices and the consequent targeting of R&D investment for the increase and production of consumer goods, ends up being too limiting because the long term benefits deriving from research that is curiosity-driven and not aiming at profit, can be received in society in terms of the increase, conservation and improvement of "common goods" and social well-being.

If, as seems to be the intention of the Commission, the regulation policies of R&D must produce as a result both competitive advantage (*alias* economic growth) and also the well-being of society in general (better management and protection of natural resources and public assets in general), then we must critically assess the consequences of the models laid down up to now for the promotion of technological innovation. Hence our second recommendation:

Recommendation 2

We suggest conserving the non-commercial aims of basic research by funding its activities, even if the *linear "science push" model has shown itself to be a failure on the level of increasing financial capital as seen by the "European paradox". In fact, the model is a failure if we consider mere economic growth to be an objective, but the production of techno-scientific innovation is also useful to provide "public" services and goods, besides carrying out the essential function of the conservation, transmission and progressive organization (in the light of new discoveries and inventions) of the heritage of shared knowledge, on which also the private sector can draw for the production of innovation for commercial aims.*

The general objective indicated in this recommendation can be pursued only if a series of strategies are put into operation which we have indicated in the preceding paragraphs and in the research carried out in this project. In particular, we have seen the importance that the universities still have, and their need for public funding (see § 5.4), principally with the aim of creating autonomous institutions in which research can be carried out according to logics that are not immediately subordinate to the needs of the market, since – as Vannevar Bush already understood – new theories can only arise from free research that otherwise would be impeded by a premature assessment of its expediency. As we know from reflection on "frontier research" (Nickles 2009) and from what has emerged from the Finland model (see § 5.1.2), there is no assurance, at the more advanced levels of science, that the results will be guaranteed or that they will be what we expect them to be: if we try to imprison research with processes of assessment or pre-existent methodologies, held to be trustworthy, we will block theoretical innovation, which is quite shocking in itself compared to the methods and procedures that are usually accepted. However, we cannot expect that the risk of this frontier research should be taken on by individuals who are much more motivated by "mid-level" or "low level" technological developments (see § 5.6). This is the reason why we believe that public commitment is still fundamental in the field of R&D, therefore:

Recommendation 3

It is essential for the policy maker to ensure the existence of independent scientific institutions – as the universities traditionally were – able to support themselves economically without having to answer to stakeholders and able to put into operation cognitive strategies that are only "curiosity driven".

Besides, as we have seen, by analyzing the "European Paradox" (see § 5.4.2), the low level of private investment in R&D in Europe is one reason why the EU had addressed more effort and funding towards applied research, within the diverse framework programs, leaving the different nations with the task of supporting basic research that, like research in the humanities, does not product immediate economic spin-offs. We have observed that this strategy is fruitless and dangerous, since we believe that basic research, for the very fact of its high risk and uncertainty, can be better supported by supranational institutions that are not under pressure to respond to needs and problems directly linked to the territory; and that instead, the individual nations may be more suited to supporting applied research as they have better knowledge of the social contexts, the economic, productive and local needs, and the expectations of the population to whom they have to answer politically. Therefore:

Recommendation 4

We suggest that basic research should be given more support on an EC level, inverting the trend that until now has privileged research of an applied nature, and that instead, the individual member states of the EU should be encouraged to invest more in applied research that is linked to the local community. This can take place both through traditional framework programs, and also by increasing and extending the network of scientific community institutions in which scientists from the different countries can participate.

The central position of the role of the universities and the attention to ensure their vitality and autonomy is based on the supposition that they have a general social function that is much more complex and broader than the one that limits them to the sole task of forming the hubs of high basic research, with the correlated illusion that a few centers of excellence are sufficient for this. This would downgrade the rest of the university system to a secondary role, a merely didactic one, and may even reduce the number of universities and consequently the number of students who attend them. This is unrealistic for several reasons. First of all, the diffusion of the universities over the land contributes to a general increase in the quantity and quality of human and social capital, which is essential for those mid-level and low-level innovations which, as we have seen, are vital for technological development and innovation (see § 5.6). It follows that:

Recommendation 5

It is essential for policy makers to ensure that scientific institutions are spread over the country in order to guarantee a general training of high quality, aiming at improving in quantity and quality the human and social capital available in society as a whole.

In the second place, the presence of the universities in the various countries contributes to creating that climate of mental opening and tolerance which we have seen is indispensible for creativity and scientific innovation (see § 5.3.1), representing also a fundamental factor to attract creative talent (see § 5.4.3). Here follows:

Recommendation 6

Policy makers must ensure that the scientific institutions spread over each country are governed in a democratic way, allow the widest freedom of research and have become models of open and tolerant community, with no linguistic, cultural, ethnic or racial barriers, in which success is based on merit and ability, so as to stimulate as much as possible the exchange of ideas, discussion and interaction between different cultures and experiences, primary sources of creativity and innovation.

Finally, the reduction of the universities to the mere transmission of notions of knowledge – all based on encoded knowledge – would reduce that participation in active research and that daily conversation with researchers with *know-how* on which the acquisition of tacit knowledge is based; it would also decrease the ability to possess that expertise that is able to raise the level of the aware participation of citizens in the production of knowledge and democratic decisions that concern the fundamental decisions made by policy makers (see § 5.2). Therefore:

Recommendation 7

Policy makers must prevent an excessive polarization between universities for research and universities for mere post-school training, by trying to revitalize the "Humboldt model" based on the close correlation between research and teaching, which has assured the excellence of European universities and which was the basis of the success of the American university system.

As suggested in the introductory discussion to recommendation 2, we should modify the aims of the innovative process in order to conserve the social function (and not exclusively economic) of research not directed at the market. In fact, the efficiency of the policies of techno-scientific innovation depends on the attainment of social well-being seen as the balance between economic growth and the preservation and improvement, in the sense of their use and diffusion, of "commons" that cannot be privatized. The extensive analysis we carried on the literature concerning guidelines for the construction of a society of knowledge (see ch. 0) has highlighted the fact that this two-fold need is often more heavily weighted towards one or the other. Among the scholars of STS the tendency prevails to privilege the social and democratic objective at the expense of the economic-financial one (see ch. 3, especially §§ 3.5-3.6 and §§ 4.5-4.6). On the contrary, many economists and neo-liberal thinkers, whose judgements seem to reflect the real implementation of the contemporary politics of the industrialized West tend to exclude the public objective and instead pursue the single objective of the continuous growth of production and consumption of commercial goods.

It was especially during our research activity aimed at a comparative study of research policies put into operation by the individual EU nations (and also extra-European nations, above all the US and countries in the Pacific area), that we realized that the efficiency of the politics of research is strongly linked to the macroeconomic order on which the functionality of that institutional order depends. For example, within Europe itself (and we have made particular reference to Finland – see § 5.1.2), models of development in which there is an integration between the European tradition of the Welfare State and industrial models based on macroeconomic orders like LME obtain better results than the mere transformation of solutions of research regulation that have demonstrated their efficiency in nations with macro-institutional orders only based on the free market and on the "light State" (like those put into operation in the US especially in the mid-eastern part of the country).

The model we have indicated as the most suitable for the European tradition – the Scandinavian one – suggests a possible solution to the need, indicated above, to balance the two instances of the descriptive objective aimed at the regulation of R&D institutions. Especially in §§ 1.3 and 5.1 we have tried to show how a costs-benefits analysis of political actions, on the level of R&D institutions, based on the inclusion of environment cost-benefits (therefore on the internalization of costs and benefits relative to the exploitation of natural capital) and on a redefinition of the use of human capital (which will be the subject of the next recommendation) – which in this way are added to factors relevant to the increase of financial and manufacturing capital (that is, privileged factors, in an exclusive way, in the neo-liberal view) – is able to provide a common platform of macroeconomic research as a starting point in order to measure the efficiency of the research policies. In fact, as the "environmentalist turn" we have documented demonstrates (see § 1.3.2), the adoption of a macro-institutional order based on environmental sustainability, that is the balance of the socio-industrial metabolism compared to the natural metabolism of the planet, presents financial advantages for the private sector (think of the energy saving that could be obtained by a better management of use) and also the social sector in terms of a better quality of life and quality of work (think of the advantages in terms of health following the reduction of pollution and for society in general and for the workers in industry). In this way we would obtain a balance between the needs of the private sector and that of society in general which we hoped for in order to give a common objective to the formulation of adequate research policies that are coherent with the ideological background of reference. Hence the next recommendation:

Recommendation 8

In order to balance the need for the accumulation of financial capital by the private sector and the safeguarding and better management of natural and human capital on the part of society in general, the EU should adopt a single platform of macroeconomic reform based on the environmental sustainability of production processes.

We have seen how already in the report of Vannevar Bush, and in particular in that of the Moe Commission who took part in his works, the importance of investing also in human sciences was underlined as a condition for the development of basic research itself in natural and technical sciences (see § 0.3.1). We have also seen how the correct definition of the role of science and technology within the society of knowledge depends as much on the ways in which they are diffused as on the promotion of the humanist content enclosed within them. This can happen through diverse strategies that we have indicated in §§ 2.3-2.4.

From this it follows that a knowledge-based society must seriously take into consideration the fact that being having acquaintance with science, that is, possessing basic scientific notions and knowledge (e.g. the requisites that are dubbed "ubiquitous tacit knowledge" and "meta-expertise" – see § 5.2.4) , does not necessarily mean being science acquainted", that is, in possession of a training that enables one to grasp the specific techno-specialist characteristics typical of scientific production and to contribute creatively to it (dubbed "interaction expertise" and "contributory expertise" – see § 5.2.4). It is necessary to make the public able to receive the cultural meaning of science, by making the humanistic level emerge from it and then inserting it in a general process of training and evolution of human reasoning. Besides, the contents and products of science perceived by society are not always accompanied by an adequate awareness of the procedures (often implied) through which the researchers, in a creative, critical way, accumulate and reconstruct knowledge about nature.

Consequently, a mature European knowledge society can be strengthened through a constant reference to the humanistic and general culture contents of science and also thanks to the reinforcing of that implicit or "tacit" knowledge (see § 5.2), of the meanings of scientific knowledge. To realize both these objectives it is essential to make reference to the common historical tradition of science and of western culture, both of which are at the foundations of European modernity. Under this profile, in the course of our reflections, we have given space to a careful analysis of the tools that are able to create a fruitful exchange between science and society through the use of narrative tools that can create a bridge between scientific culture and the existential needs of a person. The models we have examined have enabled us to underline how the involvement of emotion is of central importance to promote an effective diffusion of scientific thought among citizens. The use of "narrative tools" (from the radio to the press, and from television to the narrative essay) is preferable to the simple scientific divulgation or educational programmes based on a one-way model in which information travels from the scientific community to citizens without taking into consideration their existential and psychological needs (see § 2.3).

Hence the following three recommendations:

Recommendation 9

The spread of scientific culture and appreciation of it, with the consequent overcoming of unease and mistrust towards it, requires not only a generalized divulgation of scientific contents, but also better awareness of the humanistic content within it, and therefore the knowledge of the most vast human and historical context within which science builds itself. With this in mind, we strongly recommend an increase in and support for actions aimed at spreading scientific culture through "narrative" tools (radio, literature, theatre, essays, etc) which can connect scientific knowledge to the citizens' emotions and existential needs.

Recommendation 10

The diffusion of scientific culture and its appreciation on the part of civil society does not come about by the transmission of the contents of science, but requires also the shaping of intellectual habits, tributaries of that "tacit knowledge" that can be provided only by an effective scientific practice that must be implemented within all curricula of tertiary education

Recommendation 11

It is essential that within each specialist training at university level, hybrid areas of knowledge are created in which interaction between disciplines, and especially between the humanistic and scientific ones is possible. This would allow us to reduce the distance between the "two cultures" and would enable each researcher in each field to be in touch with the specialist jargons of others.

This final recommendation allows us to understand the importance that the type of training indicated in it has to encourage the development of democratic participation (see § 2.3): an increasing diffusion of expertise, understood not as simple technical knowledge in certain fields of research, but rather as capacity for the evaluation of the plausibility of scientific discourses, assured by the possession of hybrid and tacit knowledge. Therefore:

Recommendation 12

In fact, it is important to encourage as much as possible a "diffuse expertise" able to promote the increase of democratic participation in decisional processes that are usually the privilege of experts. This can happen only when the scientific culture becomes explicitly part of a shared culture, based not so much on an encyclopedic vision of knowledge but rather on a common concept of reason that sees in logic and in scientific methodology the basis of a shared procedural modality of investigation.

The corollary of what is stated in recommendations 11 and 12 is the idea that the basic task of human sciences is to form a sort of meta-theory, consisting in the study of the methodological foundations of each discipline and that therefore human sciences are able to provide a unitary jargon shared for any multidisciplinary links. In fact, human sciences are the most suited to provide a series of conceptual instruments able to take those subjective processes (creativity, spontaneity, adaptability and using unexpected results) that are impoverished by logical argumentation and the protocol of scientific research, because they are forced to an objectifying simplification of human intervention on the real. In this sense we need to reformulate both school and university curricula favoring a general based education sensitive to multidisciplinary matters: in fact, society transforms too quickly for the capacity of adaptation typical of the school system (compromised by political, bureaucratic and organizational inertia) to foresee the right kind professional path. This is possible only on the condition that the training of researchers avoids becoming hyper-specialized too soon to assure them, during the course of their careers, general knowledge open to theoretical innovation that can be derived only from the capacity of hybridization of specialist languages. It follows that:

Recommendation 13

We recommend avoiding a precocious specialization of competences, both at the school stage and in tertiary education, so as not to block the logical opening of the mind towards universes and worlds that are imagined but still not realized and to aim instead at the training of a flexible mind, able to face ever new problems

What has been said is perfectly in line with the stress placed by the EC on the role of creativity to ensure innovation and development. We have insisted on this theme in §§ 5.3 and 5.5 where we underlined the fact that it is always more expressed in a "diffused" way and not only within organizations institutionally addressed to it. The example of "free software" (see § 5.3.4) is extremely significant to this regard. This means that innovation has the need for comparison, exchange of ideas, interaction between jargons and diverse competences, a climate of tolerance and opening, for which:

Recommendation 14

We recommend increasing the places and the ways of exchange of diverse competences in the specialist field (for example between the hard and soft sectors of science), and also by multiplying the places of interaction beyond R&D departments, since only the meeting of diverse and sometimes divaricating logics can ensure the creativity which is able to produce new cognitive models.

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UN ECE – UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE
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Appendix 1

Acronyms and abbreviations

BA = British Association for the Advancement of Science
CK = Creative Knowledge
CLP = Community Lisbon Programme (see also PCL)
CME = Coordinated Market Economy
COPUS = Committee for the Public Understanding of Science
EC = European Commission
EIS = European Innovation Scoreboard
EPO = European Patent Office
EQF = European Qualifications Framework
ERA = European Research Area (also SER)
EU = European Union
GDP = Gross Domestic Product (also PIL or GNP)
GMO = Genetic Modified Organism
GNH = Gross National Happiness
GNP = Gross National Product (see also PIL or GDP)
HDI = Human Development Index
HPSS = History, Philosophy and Sociology of Science
H&S capital = Human and Social capital
ICT = Information and Communication Technology
ISCED = International Standard Classification of Education (by UNESCO)
K4F = Knowledge for Growth
KBV = Knowledge-based view
KR = Republic of South Korea
LME = Liberal Market Economy
MAS = Modelling Approach to Science
MK = Former Yugoslav Republic of Macedonia
NIS = National Innovation System
NSF = National Science Foundation
OCSE = Organizzazione per la Cooperazione e lo Sviluppo Economico (also OECD)
OECD = Organization for Economic Co-operation and Development (also OCSE)
PCL = Programma Comunitario di Lisbona
PES = Public Engagement with the Science
PIL = Prodotto Interno Lordo (see also GDP)
PIS = Postmodern Interpretation of Science
PSNU = Programma di Sviluppo delle Nazioni Unite
PUS = Public Understanding of Science
R&D = Research and Development
SCOT = Social Construction of Technology
SER= Spazio Europeo della Ricerca (see also ERA)
SII = Summary Innovation Index
SKn = Sociology of Knowledge
SS = Sociology of Science
SSK = Sociology of Scientific Knowledge
StK = Structured Knowledge
S&T = Science and Technology
STS = Science and Technology Studies
USPTO = United States Patent Office
WWF = World Wide Fund for Nature

Appendix 2

FUNDAMENTAL DOCUMENTS AND REPORTS ISSUED BY THE EUROPEAN COMMISSION (OR COMMISSIONED BY IT) CONCERNING "KNOWLEDGE SOCIETY"

(with the indication of the most important non-EC useful and complementary documents)

Official Documents of the European Commission	Reaserches and Reports commissioned by EC and made by indipendent scholars	Other documents, reports and studies of non-EC documents or indipendents reaserchers
1945		
	June *Europeans, Science and Technology* (Report commissioned to INRA e Report International).	**July** Vannevar Bush, *Science the Endless Frontier.*
1977		
October *Science and public opinion.*		
1979		
February *Les attitudes du public europeen face au development scientifique et technique.*		
1985		
		Royal Society, *The Public Understanding of Science.*
1990		
January *Les Europeens, la Science et la Technologie.*		
1996		
December *Green Paper on Innovation*		OECD, *The Knowledge-based economy.*
1997		
		OECD, *National Innovation Systems.*
		OECD, *The Measurement of Scientific and Technological Activities (Oslo Manual).* [see also the 2005 edition].
1998		
25 May *Sorbonne joint declaration.* Joint declaration on harmonisation of the architecture of the European higher education system.		
1999		
19 June *Declaration of Boulogne. Lo spazio europeo dell'istruzione superiore*. Joint declaration of the European Ministers of Education .		OECD, *Information Policy and Performance. A Cross-Country Comparison.*
2000		

18 January *Towards a European Research* – Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. [COM (2000) 6 final].		Unesco, *World conference on science* (Proceedings of the homonymous conference held in Budapest from June 26th to the first of July).
2 February *Communication from the Commission on the precautionary principle*, Bruxelles [COM(2000) 1 final].		
23-24 March European Council, *Presidency Conclusions.*		
20 September *Innovation in a knowledge-drive economy* – Communication from the Council to the and the European Parliament [COM(2000) 567 final].		
4 October *Making a reality of The European Research Area: Guidelines for EU research activities (2002-2006),*[COM(2000) 612 final].		
14 November *Science, society and citizen in Europe*, Commission working document [SEC(2000) 1973].		
16 November *Council Resolution on making a reality of the European area of research and innovation: guidelines for the European Union's Research activities (2002-2006)* [2000/C 374/01].		
2001		
December Eurobarometer, *Europeans, Science and Technology*. See also the 2005 version.		OECD, *OECD Science, Technology and Industry Scoreboard. Towards a Knowledge-Based Economy.*
23-24 March *Realising the Union's potential: consolidating and extending the Lisbon strategy. Contribution of the European Commission to the Spring European Council,* Communication from the Commission [COM(2001) 79)].		
26 June *A mobility strategy for the European Research Area*, Communication from the Commission to the Council and the European Parliament [COM(2001) 331 final].		
5 August *European Governance: a White Paper*, [COM(2001) 428 final/2].		

23 October *Towards an internal market without obstacles. A strategy for providing companies with a consolidated corporate tax base for their EU-wide activities,* [COM(2001) 582 final].		
2002		
15 January *The Lisbon Strategy – Making Change happen*, Communication from the Council to the Spring European Council in Barcelona, [COM(2002) 14 final].	**April 15** de la Fuente – A. Ciccone, *Human capital in a global and knowledge-based economy*, Final Report for the EC.	The International Bank for Europeansfor Reconstruction and development, *Constructing knowledge societies.*
15-16 March *Presidency Conclusions* (Barcelona European Council).		The International Bank for Europeans for Reconstruction and development, *Building Institutions for Markets.*
June *Science and Society – Action Plan.*		**June** *Converging Technologies for Improving Human Performance,* report edited by Mihail C. Roco et al. of the National Science Foundation.
9 August (*Council Decision adopting a specific programme for research, technological development and demonstration: "Integrating and Strengthening the European Research Area,* (2002/834/EC).		
11 September *More research for Europe: Towards 3% of GDP*, [COM(2002) 499 final].	**20 October** *Governance of the European Research Area: The Role of Civil Society*, Final Report, by Henning Banthien, Michael Jaspers and Andreas Renner (with the collaboration of Matthias Adam, Jörg Mayer-Ries and Meike Wulfers), Bensheim – Berlin – Brussels. Commissioned by EC.	**5-7 September** Alberto Amaral-Antonio Magalhaes, *Epidemiology and the Bologna Saga (CHER Annual conference, Vienna).*
20 November *European benchmarks in education and training: follow-up to the Lisbon European Council*, [COM(2002) 629].		**16-18 September** Alberto Amaral, *Institutional identities and isomorphic pressures (IMHE general conference*, Paris*).*
28 November EC, *European Innovation scoreboard.*		
2003		
Towards a Knowledge-based Europe. The European Union and the Information Society, Bruxelles (Issue Paper of the EC).		OECD, *The Sources of Economic Growth in OECD Countries.*
10 January *Investing efficiently in education and training: an imperative for Europe,* [COM(2003) 779 final].		
5 February *The role of the Universities in the Europe of Knowledge*, Communication of the Commission, [COM(2003) 58 final].		

11 March *Innovation policy: updating the Union's approach in the context of the Lisbon strategy* (Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions), [COM(2003) 112 final].		
31 March *Choosing to grow: Knowledge, innovation and jobs in a cohesive society.* Report to the Spring European Council, 21 March 2003 on the Lisbon strategy of economic, social and environmental renewal, [COM(2003) 5 final/2].	**April** A. de la Fuente, *Human Capital in a global and knowledge-based society.* Final Report part II.	
25 May *Building the knowledge society: social and human capital interactions* (working paper of EC).		
27 May *Strengthening the social dimension of the Lisbon strategy: Streamlining open coordination in the field of social protection.* [COM(2003) 261 final].		
6 October *The role of civil society* (proceedings of the conference).		
20 October *The role of civil society* (Final report).		
11 November *Education and Training 2010. The Success of the Lisbon Strategy hinges on urgent reforms,* [COM(2003) 685 final].	**3-4 November** PTS (Institute for Prospective Technological Studies), *ICTs and social capital in knowledge society.*	
2004		
*Converging technologies. Shaping the future of European societies (*a cura di Alfred Nordmann*).* Report commissioned by EC.	Cedepof, *Guidance policies in the knowledge society.*	Transparency International, *Global Corruption Report 2004.*
Innovation management and the Knowledge-driven Economy (edited by the Directorate-General for Enterprise).	Cordis, *Slowdown of transition towards the knowledge-based economy, Key-Figures 2003-2004..*	
January JRC, *ICTs and Social Capital in the Knowledge Society.*		
14 January *Europe and basic research,* [COM(2004) 9 definitivo].		
21 January *Progress towards the common objectives in education and training* (working paper of EC) [SEC (2004) 73].		

11 February *Action Plan: The European agenda for Entrepreneurship,* (COM (2004) 70 final).		
20 February *Delivering Lisbon Reforms for the Enlarged Europe,* [COM(2004) 29 final/2].		
12 March *Building our common future - Policy challenges and budgetary means of the enlarged Union 2007-2013,* [COM(2004) 101 final/3].		
14 July *Financial Perspectives 2007-2013,* [(COM(2004) 487 final].		
November *Facing the challenge. The Lisbon strategy for growth and employment. Report from the High Level Group chaired by Wim Kok.*	**November** Cedefop, *Vocational education and training-key to the future. Lisbon-Copenhagen-Maastricht: mobilising for 2010* (report edited by M. Tessaring e J. J. Wannan).	
19 November *European Innovation scoreboard.*	**November** High-Level Expert Group, *Assuring the future of manufacturing in Europe.*	
Dicember *The financing of higher education in Europe, voll. 1, 2, 3.*	**1 November** *Achieving the Lisbon goal: The contribution of VET* (report edited by Tom Leney and presented to the EC).	
2005		
European Innovation scoreboard .		Observa-Science in Society, *Annuario Scienza e Società 2005.*
Working together for growth and jobs		OECD, *The Measurement of Scientific and Technological Activities (Oslo Manual).* [third edition].
2 February *Working together for growth and jobs. A new start for the Lisbon Strategy,* [COM (2005) 24 final].	**February** High-Level Expert Group, *Frontier Research: The European Challenge.*	Unesco, *Towards Knowledge Societies.*
22 March *Progress towards the Lisbon objectives in education and training* (Commission Staff Working Paper) [SEC (2005) 419].		
22-23 March *Presidency conclusions,* 7619/1/05		
6 April *Implementation Report 2004* [SEC(2005) 474.]		

12 April *Implementing the Community Lisbon Programme: More Research and Innovation - Investing for Growth and Employment: A Common Approach,* [COM (2005) 488 final].		
20 April *Mobilising the brainpower of Europe: enabling universities to make their full contribution to the Lisbon Strategy,* [COM(2005) 152 final].		
5 May *Implementing the Community Lisbon Programme: A policy framework to strengthen EU manufacturing - towards a more integrated approach for industrial policy,* [COM(2005) 474 final].		
June •Eurobarometer, *Europeans, Science and Technology*, commissioned by EC, General Directorate of Research. • Eurobarometer, *Social values,science and technology.*		
1 June *"i2010 – A European Information Society for growth and employment",* [COM(2005) 229 final].		
5 July *Cohesion Policy in Support of Growth and Jobs: Community Strategic Guidelines, 2007-2013,* [COM(2005) 299 final].		
19 July *Stagnation of R&D intensity a major threat to the European knowledge-based economy* [IP/05/968].]		
20 July *Common Actions for Growth and Employment: The Community Lisbon Programme*, [COM (2005) 330 final].		
10 October *Implementing the Community Lisbon Programme: A policy framework to strengthen EU manufacturing - towards amore integrated approach for industrial,* [COM(2005), 474 final].		
20 October *Directive of the European Parliament and of the Council on improving the portability of supplementary pension rights,* [COM(2005) 507 final]._		

25 October • *The Contribution of Taxation and Customs Policies to the Lisbon Strategy,* [COM(2005) 532 final]. • *Implementing the Community Lisbon programme: A strategy for the simplification of the regulatory environment* [COM(2005) 535 final].		
10 November *Implementing the Community Lisbon programme: Modern SME policy for growth and employment,* [COM(2005) 551 final].		
24-25 November *From science and society to science in society* (A European Commission Workshop Directorate-General Research, Governance and Scientific Advice Unit, Brussels, 24–25 November 2005).		
30 November *Modernising education and training: a vital contribution to prosperity and social cohesion in Europe,* [COM (2005) 549 final].		
1 December *Directive of the European Parliament and of the Council on on payment services in the internal market and amending Directives 97/7/EC, 2000/12/EC and 2002/65/EC,* [COM(2005) 603 final].	**December** *The returns to various types of investment in education and training* (edited by the London Economics).	
	9 December *Developing Local learning centers and learning partnerships as part of Member States' targets for reaching the Lisbon goals in the field of education and training* (Report commissioned EC to a group iof experts from the University of Leined, Holland).	
	2006	
Pro Inno Europe, *European innovation scoreboard 2006.*	**January** *Creating an Innovative Europe* (report commissioned by EC to an independent expert group on R&D and innovation after the Hampton Court Summit chaired by Esko Aho)	*Converging Technologies in Society,* report edited by W. Sims Bainbridge e Mihail Roco of National Science Foundation.
25 January *Time to move up a gear*, [COM (2006) 30 final].	*Curricular reform. Part one, two, three, four* (Report commissioned by the General Council of EC for education and culture).	Observa-Science in Society, *Annuario Scienza e società 2006.*

25 January *Time to move up a gear part one* (Commission President Barroso presents Annual Progress Report on Growth and Jobs) [IP/06/71].	*The extent and impact of higher education governance reform across Europe part one, two, three, four* (Final Report commissioned by the General Counsil of EC for education and culture).	The international Bank for reconstruction and development, *Where is the wealth of nations?*
25 January *Time to move up a gear part two.*		
13 February *Implementing the Community Lisbon Programme: Fostering entrepreneurial mindsets through education and learning,* [COM(2006) 33 final].		
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26 April *Implementing the Community Lisbon programme: Social services of general interest in the European Union,* [COM(2006) 177 final].	**26 April** *Efficiency and Europe in european education and training systems* (Report commissioned by EC to the EENEE group).	
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23 October *Community **Lisbon** Programme: Technical Implementation Report 2006*, [SEC(2006) 1379].	**October** KEA, *The economy of culture in Europe.*	
5 December *Horizon 2010. Local and regional authorities for growth and jobs.*		
12 December *Implementing the Renewed Lisbon Strategy for Growth and Jobs: "A year of delivery",* [COM (2006) 816 F-1].		
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4 April • *Green paper. The European Research Area: New Perspectives,* [COM (2007) 161 final]. • *Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation - Implementing the Lisbon agenda* - [COM(2007) 182 final].	**4 April** Lisbon Group, *Open research and innovation policies for Europe – A leap forward!*	
13 April EUA (European University Association), *The Lisbon Declaration.*	**April** K4G (expert group “Knowledge for Growth”), *The EU’s R&D Deficit on Innovation Policy*.	
27 June *Towards Common Principles of Flexicurity: More and better jobs through flexibility and security* [COM(2007) 359 final].	**8 June** K4G,*Universities and Public Research Organisations in the ERA*.	**July** EAPN (European Anti-Poverty Network), *Strengthening the social dimension of the Lisbon Strategy.*
16 August *A contribution to more growth and more and better jobs,* [COM(2007) 474 final].		
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8 October *Starting up a new enterprise quicker and cheaper*, [IP/07/145]. **6 December** *Council Resolution on modernising universities for Europe's competitiveness in aglobal knowledge economy,* [16096/1/07 REV 1]. **11 Dicembre** • *"Member States and Regions delivering the Lisbon strategy for growth and jobs through EU cohesion policy, 2007-2013",* [COM(2007) 798 final]. • *Integrated guidelines for growth and jobs (2008-2010),* [COM(2007) 803 final Parte I]. **13 December** *Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community,* Official Journal of the European Union C 306. **December** • Pro Inno Europe, *Measuring innovation efficiency.* • Pro Inno Europe, *Differences in socio-economic conditions and regulatory environment.*	**October** K4G, *What policies are needed to overcome the EU's R&D deficit?*	**20 December** Jens Arnold et al., *Solow or Lucas? Testing Growth Models Using Panels Data from OECD Countries.*

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		6 February EAPN, *European Europeans strategy should fully take into account the active inclusion approach.*
13-14 March *Presidency conclusions,* [7652/08 CONCL 1].	**13-14 March** European Economic and Social Committee, *The Lisbon Strategy Renewed.*	**March** PWC, *The World in 2050.*
25 April *Resolution,* 2008/C 105/07, *The Strategy for Growth and Jobs — Handling the "Lisbon paradox".*	K4G, *European issues and policy challenges.*	**7 March** Sviluppo Lazio, *La società della conoscenza.*
30 April *Consolidated versions of the Treaty on European Union and the Treaty on the functioning of the European Union,* 6655/1/08 REV 1.		**May** EAPN *Engaging in the Lisbon National Reforms programmes 2008-2010.*

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15 December *Implementation of the Council Recommendation of 2 December 2003 on cancer screening (2003/878/EC),* [COM(2008) 882 final].		**December** Battelle, *Global R&D Funding Forecast.*
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28-29 April *The Bologna process 2020. The European higher education area in the new decade.*	K4G, *How to better diffuse technologies in Europe*	Unesco, *Trends in global higher education: tracking an European revolution (*edited by Philip G Altbach, Liz Reisberg and Laura E Rumbley of the Center for International Higher Education del Boston College).
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24 July *Mainstreaming sustainable development into EU policies: 2009 Review of the European Union Strategy for Sustainable Development*, [COM(2009) 400 final].	**July** ISTAG, *European Challenges and Flagships 2020 and Beyond.*	World Economic Forum, *The global information technology report 2008-2009.*
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2 September *Reviewing Community innovation policy in a changing world*, [COM(2009) 442 final].		World Economic Forum, *Technology Pioneers.*
6 October *A new Lisbon Strategy after 2010* (Paweł Samecki European Commissioner responsible for Regional Policy Speech).		Elinor Ostrom, *A Polycentric Approach for Coping with Climate Change* (Report prepared for the World Development Report 2010).

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November Eurobarometer, *The attitudes of uropeans towards corruption.*	**November** A. Filippetti et al., *Is the innovation performance of country related to their internationalization?*	**12-14 November** PWC (Price Watershouse Coopers), *Rebuilding the Global Economy.*
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