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**COLLECTIVE INVENTION
AND EUROPEAN POLICIES**

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Executive Summary

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1 - Motivation

It is increasingly recognised that the knowledge generated for innovation is not solely a process of intra-organisational conversion, combination, adaptation and extension, but also a process that is collectively organised by industries and other larger domains of inter-firm or government-industry relations. The collective nature of innovation is in the first instance a recognition that the domain of innovation is larger than that of the organisation and that the unit of analysis must therefore be larger as well.

The growing appreciation that it is appropriate to adopt a broader unit of analysis based upon understanding of particular research communities and networks has been augmented by efforts to identify and enumerate the institutional forms of various inter-organisational relations supporting knowledge creation. Thus, technology development agreements in the form of joint ventures, technology exchange agreements and university-industry linkages provide persuasive evidence that collective invention is a rapidly growing component of national innovation systems.

All of this can be characterised as advancement in knowledge about how the innovation process works. It is also about the fact that the innovation process is itself evolving.

There is, nonetheless, a gap in our understanding. The "forms" of collaborative arrangements do not adequately describe their content or process. Moreover, when we return to examine specific organisations in the original innovation studies tradition, we find the firms engaged in collaborative processes that are not implemented within the formal structures of joint ventures or strategic alliances. This suggests that the collaborative invention process is even larger than some of the indicators would suggest. What happens in the process of collective invention is therefore becoming a more pressing issue. Before we can develop broader and more inclusive measurements of the activity and the determinants of its successes, we need to develop deeper empirical knowledge of the varieties and purposes of collective invention. Conceptual advancement and empirical knowledge generation must be developed simultaneously and interactively. This is what we have done in the *Colline* project.

2 - Collective invention as an instrument of the evolution of the public and private sectors

The implications of economic policy on collective invention must be considered in relation to the evolution of both private and public sectors of research and invention. Collective invention can be analysed as an instrument of regulation, allowing both sectors to evolve and to deal with some important issues regarding their transformation.

The accelerated privatisation of the knowledge economy is manifested mainly in a proliferation of private property rights on human activity. This tendency can lead to certain abuses, resulting in

inefficiency traps. In this context of privatisation, collective invention is an important regulation tool for it creates areas for the sharing of knowledge, determines more coherent initial endowments of intellectual property rights and promotes the trading of rights.

The most recent example is the TSC consortium created by ten major pharmaceutical laboratories for producing a human genome map to be placed in the public domain. The consortium is used by firms to produce collective or public data that will be disseminated in the research system, and to work in partnership with academic laboratories (the TSC consortium mobilises several major university genome centres, including the Cold Spring Harbor laboratory).

Faced with the US model of uncontrolled privatisation of knowledge bases, the European experience must be brought to the fore. Incentives to co-operate "in a certain spirit", set up in the context of framework programmes, have led to the creation of an original model: a type of third way, between the undivided domination of the market and the blockage of our systems on relatively outdated public research structures.

Collective invention is also an instrument of mobilisation and transformation of the public research sector (by facilitating its openness towards industry, promoting the evolution of its framework of action and its diffusion mission, and even by orienting the content of its research more towards "use-inspired basic research" and its commercial applications).

Finally, collective invention seems to be a tool for implementing relatively rich action through public policies intended to support knowledge production and limit the negative effects of excessive privatisation. It is also a way of facilitating the transformation of the public research sector (from a mission policy to a diffusion policy) and encouraging the public and private sectors to complement each other more fully.

The *Colline* project is thus at the intersection between two challenges facing European innovation policy. To what extent do collective invention models offer a solution to the "shortcomings" and/or excesses of the market system and public research? Can Europe design its own way in this respect, with the progressive development of an original form of co-ordination based on the collective production of public goods?

Colline tried to answer these questions by examining the tools and mechanisms of collective invention in depth, in the framework of various configurations and in the hope of revealing best practice.

3 - Different forms of collective invention

Collective invention exists in widely diverse and varied forms. Our intention was not to exclude any of these forms *a priori*, for we have found that sometimes powerful mechanisms, used to solve one of the economic problems raised by the production and distribution of knowledge, can be found in relatively informal processes.

In our examination of the "state of the art", we have distinguished between spontaneous and informal forms of collective invention, on the one hand, and collusive and explicit forms, on the other. The former are rooted in a professional context (network of knowledge sharing or trading between engineers in rival firms or between producers and users) or in a territorial framework (industrial district or "cluster") which exists prior to the creation of the collective. It reveals cases of convergence or complementarity, opportunities for meeting and transaction which lead to the progressive construction of mechanisms of collective invention.

Collusive and explicit forms have the characteristic of creating the framework or at least of "rigidifying" it (in fact we can consider that a framework always exists) enough to reveal contexts of socialisation of knowledge and collective learning, in a concerted and collusive manner. At the same time this helps to control the externalities generated by the innovation (regulating relations between members and non-members, and between privileged users and the "public").

4 - Four forms are studied

We have chosen not to exclude any of these forms. From a pragmatic point of view the areas covered have enabled us to identify four forms. However, this is not in any way an exhaustive list of the phenomenon.

high tech consortia	knowledge trading in producer – user relations
standards setting consortia	informal knowledge sharing between the members of a community

Table 1

Basically, the only phenomena that we exclude are those involving unintentional or non-deliberate collective invention, that is, processes of knowledge dissemination. These phenomena are excluded even if institutional mechanisms explicitly support such processes, as is typically the case with systems of patents, in which provisions for disclosure are a non-deliberate collective invention mechanism. It is likewise the case with the mobility of human resources. All these phenomena produce what are often called "unintentional spillovers" although the use of "unintentional" to describe these mechanisms may be misleading and may rather be understood as "undirected".

Our empirical research therefore focused on high-tech biotechnology and telecommunications consortia. The standards-setting consortium was studied in the case of the building of electronic trading networks in the insurance sector. Knowledge trading in a producer-user relationship was studied in the case of the creation of financial software and in that of the virtual reality industry. Finally, informal knowledge sharing was specifically considered in the case of WEB-page design

and virtual reality. Some of our cases combine several forms, especially knowledge trading and knowledge sharing for the creation of standards.

We see that these four forms are situated at different points on a continuum between extremely formal and extremely informal processes. The consortium is obviously the finest example of a form of collusion, in which a framework or community is created to implement processes of collective invention. At the other extreme, informal knowledge sharing is a spontaneous form. Between the two, the collective production of standards and producer–user relations are forms that have a degree of explicit co-ordination, without the same degree of formalisation as the consortium. Depending on their modes of organisation, which may be vastly different, these two intermediate forms can be situated at varying distances from the two extremes.

5 - Objects of analysis

Collective invention has been the subject of much research. It nevertheless seems to us that *Colline* has constructed an original object of analysis. Although an extensive literature exists on research co-operation, the main aim of such literature is theoretically or empirically to validate the economic rationality of this form of organisation. Game theory, the economics of transaction costs or strategic analysis are all mobilised for that purpose. Few analyses attempt to grasp the processes and procedures through which communities are formed, collective goods produced and the social benefits of the activity enhanced. *Colline* has, by contrast, tried to gain insight into these processes and procedures, i.e. the constituent elements of collective invention. Its work is based on three axes describing the processes and procedures of collective invention:

- **Production of knowledge
(division of labour, technical co-ordination, organisation of resources and knowledge access)**
- **Appropriation and distribution of results
(intellectual property)**
- **Composition of the group (internalisation) and dissemination beyond the group
(externalities)**

- First, *collective invention is a way of producing knowledge, based on the possibilities afforded by the division of labour when a number of entities or agents come together to pursue a particular goal*. This first dimension is that of the "technical" organisation of the circulation and production of knowledge, which uses collective invention as a solution to problems of dispersion and division of knowledge, and of excessive incentives (tragedy of commons). Technical organisation concerns first the distribution of roles, and thus the division of labour, and secondly access to a pool of shared resources. While the former is characteristic of explicit forms such as consortiums (although repeated informal trading can spawn primitive forms of division of labour),

the latter characterises most forms of collective invention, i.e. consortiums but also client-supplier relations and informal exchange between members of the same community.

- Secondly, ***collective invention is a mode of appropriation and distribution of the results of research and innovation, based on the creation of a community.*** This involves problems that are neither simple nor easy to solve. A multitude of possible "rules" can be identified, from the establishment of collective property rights to the maintenance of private rights. This dimension is important in a context of galloping privatisation which is having the effect, among others, of fragmenting the knowledge base and producing monopolies on operation that preclude any subsequent development by a third party. From this perspective, collective invention may be seen as an instrument for producing a more coherent logic for the attribution of property rights, or for providing a framework for trading rights at the lowest cost.

- Lastly, ***collective invention produces a new boundary, an original partition between a set of co-ordinated agents and the rest of the world.*** The question of the dissemination of results and thus of the social returns to collective research represent the third aspect of collective invention. This aspect raises the question of the "composition" of the group, that is, the internalisation of knowledge externalities. Is the group composed of all the members of a set (an industry, for example)? – in which case the question of dissemination is less relevant. Or does it consist of a significant part of this set? – in which case collective invention may become an obstacle to the entry of new actors into the industry. Or, lastly, is it limited to a very small number? – in which case the question of the organisation of dissemination beyond the circle is raised. One important issue to be considered here is the elaboration of rules about "rights of entry" for newcomers. Another is the consortium's intention to promote broad use of the invention, as in the case of standards, or to appropriate gains from invention within the consortium. If the latter, it is important to know whether there is a clear 'decision-maker' that can choose to negotiate exchanges with non-consortium members.

Having identified these three axes, an object of analysis emerges: the communities which support collective invention are not all accomplished in the same way, in terms of the following criteria: degree of distribution and collectiveness of the production and circulation of knowledge; degree of distribution of the appropriation of results; and scope and level of organisation of final dissemination. Moreover, these three criteria are not independent of one another and there may be tensions between them. For example, the integration of new partners (composition of the group) may occur at the expense of a change in the collective nature of the production and distribution of knowledge. A balance between these three requirements will then have to be defined. These balances to define are at the centre of our questioning.

We shall now focus primarily on our results relating to three kinds of situation, identified in Table 1. Two situations correspond to relatively formal processes, in which the division of labour is explicitly organised, problems of intellectual property rights explicitly managed and the management of externalities controlled. These situations concern high-tech consortia and formal processes (consortia) of collective production of technical standards. The third type of situation concerns less formal knowledge trading and knowledge sharing processes. Even if the different aspects of collective invention are less organised in such situations, our framework of analysis

remains relevant, especially for observing tensions and contradictions between these three aspects (collective production, attribution of results, and management of externalities).

6 - Results 1 - The fragile equilibrium of European consortia

The consortium naturally offers an appropriate framework for implementing complex forms of division of labour and circulation of data and materials (production of knowledge), for designing sophisticated mechanisms for the attribution of results, and for defining controlled procedures of diffusion towards society. The problem here is the creation of a balance between the composition of the group and the collective production of knowledge. We have identified two models in the particular case of European biotechnology consortia.

In a first model there is little diversity of institutional actors. Consortia are mainly academic, which means that externalities are seldom internalised. On the other hand, the processes of knowledge production and attribution of results are highly collective:

- there is a formal and strong process of organisation of the division of labour;
- the pool of resources (data, tools) is highly collective and resources circulate freely among members of the consortium;
- some consortia have established a regime of collective property. In these consortia, each partner agrees that any patentable result obtained during the project will be the joint property of all partners and that each partner's share will depend on their participation in the work. Because the system of collective property can pose particular management problems, some consortia create an ad hoc institution for managing their collective property.

These consortia are therefore very close to what is seen as a "perfect community", i.e. a community that is strong enough to resist private incentives generated by patent and publication races. They are, however, relatively weak as regards the internalisation of externalities, for industrial partners remain on the outside. That is certainly why the community is so "perfect" in its ability to share knowledge and tools, with little concern for opportunistic behaviour. However, the main economic issue in this type of consortium is the transferability of knowledge to society (to particular classes of users), which is the realisation of a social return of the consortium. This return must come about through explicit "outputs" from the consortium rather than "spillovers" from the processes of knowledge generation occurring within it.

In a second model there is a wider diversity of partners. Industrial partners are integrated into consortia, although at the expense of the collective nature of both the knowledge generation process and the attribution of results. Consortia are characterised by very little sharing of research and by smaller knowledge pools. The results are ultimately appropriated separately by participants. Why is this the case? Industrial companies working within a consortium are reluctant to disclose confidential information. The circulation of data is therefore strictly limited to confined areas, so that rival firms participating in the same consortium work in different sub-

parts of the general project and are never in contact. Finally, private partners cannot release their rights to a collective body. These consortia nevertheless fall into the category of collective invention because there is also some pooling of resources, knowledge sharing, and concerted decisions to organise the division of labour.

We can thus differentiate between these two models, in which the main problematic is different in each case.

In the first "purely academic consortium" model, the ultimate problem is one of spin-offs and the transferability of results to industry and users. An important practice here is the building of an industrial platform which includes certain privileged users. In this design, however, the industrial partners do not participate in the consortium's agenda. Another solution is for the industrial platform to become a contracting party within the consortium. This form of quasi-integration aims at strengthening interactions between laboratories and industrial users, who participate at least in the definition of the programmes and the discussion of results, if not in the research itself.

We thus have two different schemas. It immediately becomes apparent that the model of "quasi-integration" is intended to achieve a fragile equilibrium between keeping the collective nature of the process at a very high level, and integrating industry. This is an interesting type of practice.

Another mechanism is absolutely critical in the production of such an equilibrium: partial dissemination of knowledge. This is a remarkable innovation used both to reserve the results for a certain period (which preserves academic institutions' ability to file for patents) and to inform industry immediately about certain interesting results. It is based on the differentiation between effective diffusion of knowledge and the sending out of signals. Signalling has a twofold advantage: the consortium immediately publicises information on its results while maintaining access rights and confidentiality; and, secondly, the firms receive early signals on research underway and can undertake direct negotiation to enter into contractual relationships with the laboratories that own the data.

To sum up, it is clear that a "perfect community" with weak performance in terms of the transferability of knowledge would have no impact on society. That is why such a model has to be equipped with specific mechanisms aimed at promoting knowledge transferability. The combined system of (quasi-integrated) industrial platforms and partial dissemination of knowledge is in this sense valuable.

In the second "industry-academic consortium" model, the question of spin-offs is less relevant. However, the organisation of labour and the attribution of results may be less collective because the condition of participation is the protection of intellectual property rights, even within the consortium. There are various difficulties in pooling data when industry is involved. Partners bring in private materials that they want to exploit with the help of academic partners, without disclosing information on these materials to potential rival companies that are also members of the consortium. Such difficulties are partly overcome through the building of complex systems for circulating data, which are strictly compartmentalised within small teams consisting of only one firm each. The same kind of system is used for the knowledge and data produced during the

collective research activity. The basic principle here is the "controlled" dissemination of data, which can lead to very complex patterns of concentric circles and more gradual processes of dissemination .

The attribution of property rights also raises difficult issues. There are different possibilities:

- Disjoint property rights: in some consortia, while participants agree to exchange research results, they set up a system of separate ownership in which each firm retains control over its confidential material, technical know-how and invention. For example, one consortium is divided into five sub-projects, with one firm only working on each sub-project. Because firms are spread out among separate contracts, they are not forced to grant licenses to their rival partners, as in a typical EC contract. Each firm controls its territory and files patents on the inventions developed within its own sub-project.
- Temporary property rights: the other alternative is to grant participants temporary ownership, lasting for the duration of the research, on fragments of knowledge (e.g. particular chromosomes they receive and decrypt). During that period the participants can publish or patent data concerning their fragments. The right to do so lapses once the research has been completed.

To sum up, although the second type of consortium provides a more explicit set of mechanisms for the industrial use of knowledge (because industry is involved in the actual activity), there is a need for some institutional innovation in order to establish a balance between the collective nature of the process and the protection of private interests. These innovations have to be developed to create such a balance at two critical points: the circulation of data and knowledge during the process, and the attribution of results. Depending on the mechanisms at work at both levels, a continuum can be drawn from the least to the most collective arrangement. Here again, the compromise appears to be difficult to find.

In this respect the European model of collective invention in biotechnology is at a crossroads. The new principles aimed at increasing industry's participation in consortia by reinforcing the protection of intellectual property within the community of partners, are positive and certainly unavoidable. These new principles concern, firstly, limitations to scientific publication (the scientist has to send a copy to his or her industrial partner, who has a period of 60 days to make a "motivated opposition"). Secondly, the academic laboratory needs the authorisation of its initial partner if it wants to continue a research programme with a new partner. These principles should not, however, undermine the collective and multilateral character of such partnerships. A fragile equilibrium could thus be found between the need to provide better protection to private companies within the consortia, and the need to promote strong knowledge communities. There is, however, a risk of these new principles pushing consortia to form far weaker communities which have proved unable to withstand private incentives generated by the patent and publication races. These developments create a paradox. Although the purpose of strengthening intellectual property rights is to increase incentives for the generation of new knowledge, incentives created by strong protection may prove detrimental to knowledge generation and distribution mechanisms.

7 - Results 2 : The collective production of standards

The collective production of standards is an extremely interesting form of collective invention in so far as it can generate a wide variety of mechanisms and solutions, with respect to both the production of the standard and issues of intellectual property rights and externality. It is a particular case which often concerns a very large number of agents. A "good standard" is essentially a standard that has to concern the largest numbers. But the greater the number of agents, the more the nature of the collective invention is likely to be changed, and the greater the chances of the group breaking up. Communities that are not strong enough may disintegrate, leaving the field open to pure forms of technological competition that lead to the selection of a de facto standard or the proliferation of proprietary standards that are incompatible and not interoperable. Thus, the organisational design of the consortium as well as the management of intellectual property rights matter.

We have documented a type of modular structure that seems to have the same "good properties" as those already highlighted in the case of biotechnology consortia. Compartmentalisation helps to reduce potential tension between the growth of the group (internalisation of externalities) and the demands of collective invention, as regards both the production of the standard and the appropriation of results. Of course, this compartmentalised structure requires "co-ordination mechanisms" to ensure that the global coherence of the project is maintained.

The problem of the appropriation of results is related to the question of the pre-existence of intellectual property rights on technological elements likely to be included in the standard. It arises in situations where the public good (the standard) is produced from partially privatised knowledge bases. The procedure set up for the GSM standard still seems relevant today. Its purpose is to reduce the risk of a loss of investments in the development of the standard, due to property rights not being identified in time. The consortium records "essential" property rights (the rights granted to protect "unavoidable" technologies) by asking members to reveal the fact that they hold such rights. It then grants licences (quasi-free licenses, without territorial limits). Of course, when some members have behaviour that is misleading (non-essential rights are announced or truly essential rights are kept secret) the process can be distorted. Only with a spirit of co-operation is this risk reduced.

Our case studies have enabled us to identify a set of good practice and good properties for the collective production of standards.

The existence of an historical tradition of knowledge sharing and co-operation facilitates collective action and the formation of groups for carrying it out. Such traditions of collective action, crystallised primarily in industrial partnerships, help to produce communities that are sufficiently stable to withstand the expansion of the group and to avoid fragmentation of the project or exclusion of certain members.

But the "organisational design" of the consortium is also important. In this perspective, the *mise en module* of the consortium may prove to be beneficial if accompanied by the establishment of powerful co-ordination mechanisms. Yet the expansion of a consortium can, at certain times,

cause the slowing down of the process and problems reaching consensus. Meta-standard devices (or "lowest common denominator standards" or "standardisation with respect to base characteristics") can, in some cases, allow the modularity of the consortium to function effectively. A meta-standard preserves the advantages of variety and thus allows the agents to maintain some specific features as they enter the standardisation process.

We note, finally, that the choice of collective invention for producing a standard introduces a general tone of co-operation into highly competitive markets. Risks of clashes with private interests are therefore huge and the stated conditions of success (perception of the importance of the standard, little divergence, tradition of knowledge trading) may be insufficient. Proactive policy on essential property rights is often indispensable.

Contrary to the case of high-tech consortia discussed in the preceding section, there is no need for specific rules to attract industry into the standardisation field. The need is rather to find the means to soften the impact between this "tone of co-operation" and powerful private interests that industries naturally take with them into the consortium.

8 - Results 3 : Knowledge sharing and knowledge trading: cases for less formal processes of collective invention

In the case of knowledge trading in supplier-user relationships, we find all three aspects of collective invention: a mode of collective production of knowledge, for example well formalised by the concept of prototyping (users provide feedback on each stage of the incremental development process; confidentiality clauses consolidate the exchange); a problematic of attribution of property rights that are relatively simple but imply compensation mechanisms of the "favoured-first-user" type; and, lastly, a problematic of externality management based primarily on the differentiation between critical and highly competitive knowledge and "semi-public" knowledge. Thus, the same tensions are found here as those listed above.

As regards the management of externalities, the "non disclosure agreement" clause is a way for the client to ensure that the development work carried out is not reused by the developer elsewhere, with other clients. There is therefore an explicit blockage of externalities, which is particularly effective when the relationship is bilateral (because the source of any leakage will be easy to determine). But this clause concerns only the most development-specific elements which afford a competitive advantage (the specific pricing model), without including more standard elements that developers are free to reuse for developing other products. In this case, it is essentially the concept of a "favoured first user" that prevails. For the first customer (the one who contributed to the development) the first movers' benefits are substantial (see above) and the dissemination and reuse of standard elements are not considered to be a serious problem. The opposite may even be true in a market where there is an advantage in appearing to be the best and most experienced user of what is likely to become a market standard.

To conclude, the economic opportunities of collective action in the framework of user-developer relations are obvious and considerable. They stem from the invaluable place of the client as an experimenter and tester of products under development. Thus, little needs to be done to encourage these collective invention processes. Developer-client relations, in the field of financial software, nevertheless reveal certain good properties that it would be advisable to formalise and diffuse. These properties favour considerable stability of modes of attribution of intellectual property rights (a stability obtained by means of compensation mechanisms) and modes of managing externalities.

The case of informal knowledge sharing is substantially different. Informal knowledge sharing exploits *ex post* the virtues of a division of labour that it has not explicitly generated, and produces sharing mechanisms based essentially on trust and reciprocity. The establishment and reinforcement of these informal norms (for example in terms of property rights) are determining factors here. On the other hand, informal knowledge trading will not determine explicit mechanisms for the wider dissemination of that knowledge. The main idea is the pooling of resources, without an organised procedure for the attribution of results. The problem with informal knowledge sharing is the creation of a community which transcends the borders of the organisations to which the agents belong. Designers are simultaneously members of a WEB-authoring company and a broader design community. This transcending is then based on the establishment and strengthening of informal norms, which define acceptable practices, especially in terms of intellectual property rights. The whole problem of collective invention lies in this tension between the functioning of the organisations to which the agents formally belong, and the transversal development of a community.

With regard to public policy, the maintenance of relatively relaxed attitudes towards intellectual property seems to be a possible line of action, especially when there are risks of the system tipping towards more aggressive intellectual property rights (as is currently the case in certain segments of the software industry). The protection of common property – that is to say, the public character of the pool of resources – is an important issue. Public political actions may also be envisaged with regard to technologies providing access to the knowledge pool and allowing for the search for relevant information.

9 - Policy implications

Five important policy implications can be drawn from the report.

First, one important postulate of *Colline* is that the process of collective invention cannot be reduced to a few formal structures, and that it is important to recognise that collective invention can in fact be implemented in very informal structures. Hence, an important result is the provision of a framework to capture any form of collective invention and highlight the key tensions and potential conflicts which can occur between the three aspects of collective invention: organization of collective work, attribution of results and property rights, and internalisation of externalities and management of the dissemination of knowledge beyond the boundaries of the

community. *Colline* thus provides a new perspective on collective invention. It highlights the fact that, beyond a variety of forms, policy makers have to deal with similar issues: how to widen a community while allowing it to keep control on innovation; how to integrate rival agents in the same projects without undermining the collective nature of those projects; and how to promote the dissemination of the new knowledge beyond the boundaries of the community? This new perspective extends the scope for exchange, communication and institutional learning among policies with various purposes.

Secondly, collective action in the domain of innovation and technology is a key issue. Our case studies provide many arguments to show that there is a large number of economic opportunities for collective invention – not only in some pre-competitive arenas of scientific research but also in many highly competitive markets. Economists know, however, that collective action can be difficult to initiate. The EU framework programme is a good example of policy instruments which are devoted to this kind of purpose. But such instruments have proved to be inappropriate in certain contexts. When this is the case, and if collective action does not spontaneously emerge, there is clearly a need for other policy instruments. This is for example the case of "virtual reality", in which the generation of interfaces, standards and norms is impeded by the difficulty to initiate collective actions. New instruments are therefore necessary to allow firms to create institutions for solving collective action problems raised by the production of some kinds of goods, resources and knowledge, usually grouped together in the category "industry specific public goods". There is here a class of instruments which have not yet received the attention of policy makers – for example the so called self-organised investment committee – and a domain of valuable interactions between economists and policy makers.

A third implication concerns the tension between the uniformity of intellectual property regimes at the level of the European RTD consortia, and the variety of knowledge creation tasks – as described in our case studies. A "single rule" may be inconsistent with the diversity of situations. It is however clear from our case studies that the uniformity of intellectual property regimes mainly characterises the general conditions of intellectual property and confidentiality – that is to say, the legal infrastructure for cooperation and networks – while there is ample leeway for devising specific practices and rules under those general conditions. The general framework includes the definition of various classes of knowledge and legal status of participants; the attribution of property rights to those who have produced the knowledge; the sharing of knowledge under reciprocity rules among the participants; and the granting of non-exclusive access rights to non participants. Those conditions express a certain policy orientation in favour of knowledge dissemination and exploitation. But this general framework also includes the possibility of devising specific contractual agreements (the so called "consortium agreement") in order to allow participants collectively to generate *ad hoc* modes of circulation of data and knowledge and of intellectual property rights attribution. It is, moreover, in the "spirit" of the actions of the DG XII scientific officers to leave networks with extensive leeway for finding original modes of regulation, and this principle of a complementary design of institutional practices and norms is now formally recognised in the rules of the 5th Framework Programme. Thus, there is most often more than one solution to deal with problems of data circulation, attribution of property rights or dissemination of knowledge beyond the boundaries of the network. The important policy question now is what kind of practices – as elaborated within one

particular context – could fit into a large class of activities? This leads us to another fundamental implication.

Colline has identified and documented practices and rules dealing with the issues of attributing property rights, organising access to a pool of resources and knowledge, and managing the dissemination of knowledge beyond the boundaries of the community. Thus, high-tech consortia are areas of high levels of institutional creativity where the actors have to devise rules for sharing and appropriating knowledge. These rules are used to manage the multiple tensions between individual priorities and collective invention, members and non members, academic participants and industrial partners. We have documented an abundant production of rules and institutional innovations. The reason for such creativity is the somewhat unusual context of collective invention in some of the fields investigated. Moreover, two specifically "European constraints" necessitate creativity in the design of consortium agreements for supplementing European standard contracts:

- the absence of a grace period implying the need for deferred or partial access;
- the thrust towards knowledge sharing (produced by the European standard contract) which implies the need for reinforcing individual protection.

These local arrangements are mainly produced by researchers. Very frequently such rules and practices emerge spontaneously from the search by participants for "better organisations". Some are merely guidelines; others appear as appendices to the contract. For lawyers, guidelines and local rules are private arrangements between actors, organised under the principles of "self-discipline of a professional partnership". These rules express a tendency towards the decentralisation of economic regulation. In this respect, they serve as experiments that can be influential in the development of persistent patterns of inter-organisational behaviour. That means that some of these rules are now codified and replicated in various contexts. But most of them, while performing very well, remain local, largely uncodified and therefore very difficult to transfer and generalise to other contexts. There is, thus, a risk of under-performance in institutional learning. This first point therefore suggests a need for more in-depth institutional experiments. "Institutional experiments" does not necessarily mean search for and diffusion of "best practices". It can mean, instead, processes of institutional learning through which actors and participants in various contexts are informed about original practices developed in other contexts, and are encouraged to test them, at least intellectually.

A fifth implication deals with the fact that the collective invention model – under its particular organisational form, the consortium – has been chosen by Europe as a crucial coordination mechanism to reinforce competitive advantages in some fields of high technology (and in particular in biotechnology). Now, an important policy question is to know whether the consortium remains the appropriate and efficient schema as research advances towards the discovery of new knowledge (a new molecule), when patents races are likely to occur. While the value of collective invention seems to be indisputable during the first phases of basic research (when the pay offs are essentially informational, the question remains open for the latter phase of the process.

The case of the international breast cancer consortium is interesting: participants have effectively shared resources and data to narrow down the gene research field (enabling them to target their own work better so as to remain in the race, and excluding groups not participating in the

consortium). But the field of breast cancer genetics was so competitive that once the area to investigate had been defined, strategic knowledge was kept secret while each group negotiated with industrial firms and a patents race started within the consortium itself. The analogy with minerals prospection or deep-sea fishing is obvious. With the sharing of "geographic" information between a few agents, a first selection can be made among the groups, before the real competition starts.

Should we conclude here that the constraints of collective invention and assignment of collective property rights can slow down the process while racing has the potential to accelerate it? This cannot be taken for granted, for gene hunting has the potential to impede the cumulative production of knowledge. Genes would have been discovered earlier if all non-disclosed information had been diffused and shared among the participants.

It is, however, obvious that there is no constant best form of coordination during the whole process of research, development and innovation. We might think, instead, in terms of finding a best policy flux, an optimised path and rate of movement between promoting forms of organisation that support the collective production of public goods at some stages, and forms of market coordination that can support the acceleration of research at some further stages.

These consortium-related issues immediately lead us to a last issue which is the need for evaluating the impact of the evolution of EU policy in terms of intellectual property, as described in section 6 of this summary. The extent to which the number of industrial partners is increasing as a result of the establishment of new rules (aimed at providing a better protection of intellectual property within the consortium); and the way in which these changes affect the "quality" of collective invention, are some of the issues that warrant further research in a second *Colline*.

Appendix: Content of the Final Report

Abstract

Chapter I – Background and Objectives of the project

I.1 – What is “collective invention”?

I.1.1 – Towards definition

I.1.2 – An “original” form of co-ordination providing particular mechanisms to the production and appropriation of knowledge

I.1.3 – Economic rationality of collective invention

I.1.3-a - Efficiency analysis of collective invention

I.1.3-b - Creation of areas of trading and sharing of knowledge

I.1.3-c - Summary : economic opportunities for collective production of knowledge

I.2 – Different forms of collective invention : at what point is our empirical investigation ?

I.2.1 – Collusive and spontaneous forms

I.2.2 – Four forms are studied

I.3 – Objects of analysis

I.3.1 – The three axes of collective invention

I.3.2 – Respective problematics of the different forms

I.3.3 – Tools and mechanisms for reconciling the three axes

I.4 – Implications of economic policy with regard to collective invention in Europe

I.4.1 – Collective invention as an instrument of the evolution of the public and private sectors

I.4.2 – A way of transforming and mobilizing the public sector

I.4.3 – A political and research tool for transforming systems

Chapter II : Observation of best practice and good properties

II.1 – The fragile equilibrium of European consortia

II.1.1 - Two generic models

II.1.1-a – Model A : Issues of industrial transferability of knowledge

II.1.1-b – Model B : How to produce a strong community with heterogeneous actors?

II.1.2 - In search for best practice

II.1.3 - A challenge for European policy

II.1.4 - Institutional creativity

II.2 – The collective production of standards

II.2.1 – Initiating collective action with some chance of success

II.2.2 – Internalizing externalities without slowing down the process or losing control

II.2.3 – Organization of work and collective production

II.2.4 – Problem of attribution and appropriation of results

II.2.5 – Best practice and public policy

II.3 – Knowledge sharing and knowledge trading: cases for less formal processes of collective invention

II.3.1 - User-producer knowledge trading

II.3.2 - New industries and the formation of a knowledge pool

Chapter III : Policy implications

References

- Annexes :**
- List of *Colline* Working Papers
 - List of other outputs from the project

Appendix: List of *Colline* Working Papers

Colline WP 01:

“ The sharing of knowledge in collective, spontaneous or collusive forms of invention ”,
authors: Maurice Cassier and Dominique Foray, April 1999

Colline WP 02:

“ The Economics of high tech consortia : case studies in biomedical research ”,
authors: Maurice Cassier and Dominique Foray, April 1999

Colline WP 03:

“ Public knowledge, private property and the economics of high tech consortia ”,
authors: Maurice Cassier and Dominique Foray, May 1999

Colline WP 04:

“ The collective invention of the World Wide Web ”,
author : Paul Windrum, December 1998

Colline WP 05:

“ Collective invention in virtual reality ”,
author : Peter Swann, April 1999

Colline WP 06:

“ Network, noise and navigation ”,
authors : Paul Windrum and Peter Swann, January 1999

Colline WP 07:

“ The role of standards for collective invention in network technologies ”,
authors: Peter Swann and Paul Windrum, April 1999

Colline WP 08:

“ Collective invention activities in the telecommunication sector ”,
authors : Alessandra Lanza and Cristiano Antonelli, November 1998

Colline WP 09:

“ Software in Finance ”,
authors : Andreas Crede and Edward Steinmueller, April 1999

Colline WP 10:

“Software in Insurance”,
author: Gordon Rae, June 1999

Colline WP 11

“The creation of industry-specific public goods”
authors: Dominique Foray and Morris Teubal, September 1999

Colline WP 12

“The Policy Implications of Collective Invention : the Minutes of the Panel discussion concluding Colline ”

author: Serge Petit, December 1999

Colline WP 13

“Collective Invention and European Policies – Executive Summary”
authors: Dominique Foray and Edward Steinmueller, December 1999