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TECHNOLOGY POLICY AND COOPERATION:
A paradigmatic approach

by

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Abstract
The main objective of the paper is to provide an analytical framework based on evolutionary arguments, explaining the role and rationale of technology policies based on inter-organisation cooperations. We try to combine different arguments developped in the literature in order to define a coherent approach of technology policies : organisational, failure and paradigmatic approaches. We will argue that the role of technological policies and their design are contingent on whether knowledge creation emerges in an existing technological paradigm or will be at the origin of a new one.

In the first part of the paper, we will define two broad kinds of cooperative policy : one (pre-paradigmatic) devoted to create radically new knowledge by exploring new avenues in order to initiate a new technological paradigm and the other (paradigmatic) devoted to create new knowledge by using exploitation mechanisms in order to maintain technological options and variety, inducing innovation and reducing negative lock-in effects. We specify also for each situation the kind of intervention (coordination, institutional structure) compatible with the objective of the policy.
In the second part of the paper, we will illustrate our theoretical arguments by focusing on two types of cooperative programme : one devoted to create a new knowledge base in a pre-paradigmatic phase (the development of a digital switching system in France) and the other more devoted to foster knowledge in existing paradigms (the case of Brite-Euram).

Keywords
knowledge, creation, technological policy, technological paradigm

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INTRODUCTION

The main objective of the paper is to provide an analytical framework based on evolutionary arguments, explaining the role and rational of technology policies. We will focus more particularly on technology policies based on inter-organisation cooperation. The main argumentation is that in a dynamic perspective, the central objective of a technology policy is to foster the competitive performances of the economic actors and systems. The policy has then to stimulate the technological and innovative capabilities of organisations. Stimulating innovation means enhancing learning processes of organisations, generating and coordinating variety within the economic system, influencing the various selection mechanisms in order to create new knowledge. But this is a very general conception of technological change. Innovation is an open ended process that contains a high degree of specificity depending very much on environmental, institutional, technological and economic conditions in which this process evolves. This means that the rational and the design of technology policies should take into account and depend on the context in which innovation takes place. We will argue that the role of technological policies and their design are contingent on whether knowledge creation emerges in an existing technological paradigm or will be at the origin of a new one. In other words, the objective of the technology policy will be to foster either incremental innovations, or radical one. The first kind of objective is more short term oriented and the second one corresponds to a long term perspective.

In the first part of the paper, we will define the specific feature of each situation (pre-paradigmatic or paradigmatic phase) and analyse not only the need of a policy, but also the kind of intervention (coordination, institutional structure) that could be compatible with the needs. We will pay more particularly attention to policies focusing on cooperation between economic actors. In the second part of the paper, we will illustrate our theoretical arguments by focusing on two types of cooperative programme: one devoted to create a new knowledge base in a pre-paradigmatic phase and the other more devoted to foster knowledge in existing paradigms.

I. Objectives and design of technology policies: theoretical foundations

The traditional analysis of technology policy is based on market failure arguments. This approach considers as central the question of the market ability to allocate

appropriate volume of resources in order to create new technologies. Assimilating technology to information induces three reasons of market imperfection: uncertainty, unappropriability and indivisiblity. This inefficiency entails sub-optimal private R&D investments as compared to the social needs and public intervention proves necessary to restore or near the pareto optimality of the economy. The neoclassical foundations allows to justifiy a range of policies such as public support for basic research, financial resource allocation (R&D subsidies, tax reductions), property rights, cooperative agreements by relaxing anti-trust laws, policies designed to maintain competition. Even if policies inducing cooperation may be justified in this framework, the emphasis is put on the amount of monetary tranfer that is necessary to spend in order to generate cooperation rather then on the organisational aspects of the policy (cf. Matt 1996, Llerena & Matt 1999).
In the neoclassical approach, the purpose of the policy maker is to maximize a social welfare function under the constraint that individual agents maximize their private utility function. The policy maker implements incentive schemes that modify the information distribution accross agents and allow a welfare situation near the pareto optimum. It is implicitely considered that the social planner is well informed about the economic situation and is able to intervene efficiently.

In an evolutionary approach, the main concern is no more optimization and equilibrium, but endogenous change, evolution and economic development. The policy question turns to focus on fostering creativity, technological opportunity and market development. The policy maker is no more considered as a fully informed economic agent, having a better understanding of market situation and technological knowledge. On the contrary, he has to learn about the different situations and about the policies he has implemented in order to adapt them in case of inefficiency. The objective of a policy is generally not to reach a predetermined result or technological output, but to improve innovation processes, learning abilities and adaptative behaviours of economic actors and interaction between them. The first part of the paper focuses on those evolutionary arguments that are on the foundation of new ranges of technology policies and especially cooperative policies.

This part will be organized around two phases depending on the importance of novelty that has to be induced (and fostered) by the policy maker. We believe that the need for and the design of a technology policy depends very much of the nature of innovation that is fostered and the state of the art of the existing knowledge used to innovate. Innovation is constrained by the knowledge base and the models of problems resolution imbedded in a technological paradigm. In other words, if the objective of the policy is to create knowledge defining a new technological paradigm (1.1), the efforts to implement are not the same than the ones needed to improve innovation capabilities and technological development processes inside an existing paradigm (1.2).

We use the notion of "technological paradigms" in the Dosi (1988) sense i.e.:

“A ‘technological paradigm’ defines contextually the needs that are meant to be fulfilled, the scientific principles utilized for the task, the material technology to be used. In other words, a technological paradigm can be defined as a ‘pattern’ of solution of selected technoeconomic problems based on highly selected principles derived from natural sciences, jointly with specific rules aimed to acquire new knowledge and safeguard it, whenever possible, against rapid diffusion to the competitors ” (Dosi, 1988, p.1127 – emphasized by the authors)

1.1. General innovation features and policy implications in a pre-paradigmatic phase of technological development

The Dosi definition emphasizes that technological development and the underlying scientific principles are contextually defined and that a technological paradigm is based on specific knowledge creation rules and selected problems and principles. In other words, the process of knowledge creation will highly depend on the context and on the degree of maturity of knowledge, technological and socio-economic development. In order to capture the contextual and specific nature of technological development and to derive an appropriate policy analysis, we have to distinguish between different paradigmatic phases, each characterized by specific problems and features. In the paper, we will distinguish between a pre-paradigmatic and a paradigmatic phase of technology development.

1.1.1 Innovation in a pre-paradigmatic phase

According to the technological paradigm definition, a pre-paradigmatic phase of a technology development is characterized by a situation of emergence of a new paradigm, in which not only the needs to be fulfilled are not yet defined, but also and mainly a phase in which the scientific principles and the material technology to be used are still to be developed (see also Freeman C., Perez C., 1988; and Willinger M., Zuscovitch E., 1993 on this point). The emerging paradigm means the potential definition (or re-definition) of radically new technological options lying on completly new technical and scientific logics. These radically new technologies may compete with the existing ones. One of the difficulties is then to manage the interfaces between the existing technologies and the new ones.

During this phase of a new knowledge base creation, one may expect the existence of several technological opportunities. In an evolutionary perspective, it also means that first selection mechanisms will take place, and as a consequence a first phase of technological lock-in. In other words, some research avenues and technological options will not be explored and never reveal their full potentialities. The selection mechanisms that take place under very high uncertainty might be somewhat blind and drive the system towards "sub-optimal" solutions.

In the situation of a paradigm shift, radical innovations will take place and a rupture with past products and processes will have to occur. New organisations and infrastructures are then needed, often concerning not only a specific industry or sector but a large part of the economic and social systems. The institutional arrangements will also have to evolve and at the same time, they will constrain and shape the outcome of the process. It appears that in the now classical trade off between exploration and exploitation activities, the exploration one might dominate.

1.1.2 Policy implications: needs and design.

The emergence of a new technological paradigm is a long and complex process and the monitoring of the pre-paradigmatic phase implies both for the policy maker and the firms a long term horizon.

There are multiple ways to understand the rationale for a policy, some of them are obvious, other less:

– the emergence of the paradigm may concern a priori the whole economy and is very often of "public" interest, i.e. incorporating important "externalities";

– high uncertainty induces an important lack of private incentives to innovate, without garanty to recover their initial investments;

– some aspects of the needed scientific area might not exist or might be unsufficiently developed;

– and any progress is constrained by the existence of the required new types of skills, new forms of organisations, new infrastructures and markets.

Even though we consider that the policy maker has also a "bounded" rationality, and has to undergo a learning process, both individual and organisational, there is a need for policy intervention to improve the performance of the system by coping with the technological evolution. The modes of intervention cover a large range of policies, from education to technology policies, from generic R&D expenditures incentives to public procurements. In this paper, we focus our attention on cooperative policies in a pre-paradigmatic phase.

We have already mentioned the importance of the trade-off between exploration and exploitation activities. The policy maker will have to make sure that the exploration activities are conducted by some actors in the system, and if not, to influence by relevent incentives or policy devices the learning processes of some actors. We should notice that, in this case, the policy-maker will have essentially to select a sub-set of actors (firms, research centers, universities…) in such a way to forster their learning capabilities in the given fields. The challenge is, at this stage of the paradigmatic development, more the capacity to select the most appropriate actors able to develop a complex and new research area then to diffuse results.

Another characteristic of the pre-paradigmatic phase is the diversity of alternative experimentations and knowledge development. Spontaneously or not, different research trajectories may be followed, trajectories which, at one point of time, are at different maturity stage. The management of diversity becomes the main question at stake. In particular at this stage of the paradigmatic development, the policy maker might have to intervene in the selection of technological avenues, refraining from too rapid vanishing of some alternatives which have not yet showed their relative "inefficiencies", or favouring interesting long term and risky solutions (cf Cohendet P., Llerena P., 1997). In this pre-paradigmatic phase, the main problem to be solved by the policy maker is to monitor the timing of the selection process in such a way to select at the “ right ” moment an appropriate technological trajectory, compatible with the public interest and limiting the possibilities of negative feed-backs (cf. David 1987, Cowan 1991, Malerba 1996).

The development of research cooperations between different actors (private, public) working together on large and risky research programmes devoted to specific technologies (for instance: Integrated circuits in Japan, Digital Switching Systems in France (see below § II 1), Space in Europe (ESA)…) seems to be an adequate policy tool. First because exploration activities may be more successful in terms of scientific and technological results when different agents cooperate and exchange complementary specialised knowledge bases. Moreover, it is often a necessary condition to pool diverse competences in order to develop a complex technology. Finally, cooperation allows to share risk and uncertainty among different partners.

The general objective of these large public cooperative R&D programmes is to sustain the competitivity of a specific industry (telecommunication, space, transport, energy…), to guarantee the technological independance of a country by supporting strategic domains and to satisfy major futur social needs (environment, health,…). These general objectives are usually combined with more practical objectives that

defines the concrete outcomes of the programmes (in the case study below (cf. 2.1) the outcome was a unique output: a digital switching system). In this pre-paradigmatic phase, the knowledge base of the new domain is not necessarily well developped, consequently, the cooperative policy might be insufficient and be sustained by the development of some scientific areas in public organisations.
In order to meet the general and practical objectives, the design of the policy or its institutionnal arrangement should be coherent. According to Bach, Furtado & Lambert (1998), the institutionnal arrangement of a policy depends on the distribution of the role of each actor involved in a public programme. They distinguish between different roles:
(i) actors financing the programme;
(ii) designer of R&D that has to be realised and designer of practical objectives in terms of outcome;
(iii) designer of functioning modalities of the programm;
(iv) actors realising the R&D;
(v) manager of the results use modalities;
(vi) actors using the outcomes.
It is difficult to define a priori very precisely the exact distribution of the role, but we will try to give some indications. The State will finance the research programme that will very often induce a large amount of money according to the innovation characteristics (radical innovation, long term perspective, creation of a new knowledge base…). The policy design is “ top-down ”, i.e. the policy maker will define the practical objectives (R&D to be done), the functioning modalities of the programme and the modalities of results use, alone or with a specialised agency or a research organisation which will probably manage the programme. The cooperative research will be done by a limited number of private and/or public actors; the participation of the general management organisation is not excluded. In general, the outcome of this kind of programme will benefit a large part of the society and not only the partners involved and the government agencies.

In the following part, we will underline the specificities in terms of innovation and policy implications in a paradigmatic phase of technological development and analyse the main differences compared to the pre-paradigmatic phase.

1.2 The general features of innovation and the policy implications in a paradigmatic phase of technological development

1.2.1 Innovation in a paradigmatic phase

According to Willinger M. & Zuscovitch E. (1993) it is possible to distinguish between two further phases:
– a phase of auto-organisation where new technological and scientific principles have emerged due to knowledge accumulation;
– a paradigmatic phase where the paradigm is completely established with well-defined models of technical resolutions.
One of the main differences (relevent to our discussion) is that the lock-in phenonema is greater in the second phase than in the first. It implies in particular that the search processes are more specifically focused on a narrower range of alternatives in the latter phase. The knowledge base, on which the research activities are based, is very well defined (the required technological and scientific disciplines are known).
Innovations are more often incremental and constitute an improvement of existing technologies or a development of connex technologies conceived as complementary componants of existing ones. Interactions between users and producers are of specific importance. Innovation depends very much on the existing knowledge base and on the past experiences (cumulative) but remains uncertain. This does not mean that the combination of existing knowledge will not lead to more radical innovations. The accumulation of incremental innovations may lead to major shift of the trajectories. This implies that the policy maker has to be sensitive to this occurrence and might consider this shift as a pre-paradigmatic situation (cf. 1.1).

New knowledge is indeed created but more by exploitation and combination of existing pieces of knowledge than by exploration of new avenues. The knowledge created concerns more a specific sector or a group of sectors, but will probably never affect alone (this means without radical innovations) the whole economy or allow to create a new sector.
Another characteristic to be mentioned, is the relative shorter term perspective, compared to the pre-paradigmatic phase, because both of a more rapid (even though more incremental) technological change, and of a high risk for decreasing returns in a given technological paradigm.
In this phase, one can consider that the diversity of technologies and possible research agendas are reduced as compared to the pre-paradigmatic phase. The nature of technological evolution will rather be influenced by the capacities to exploit and diversify the existing knowledge base than by exploration of new scientific and technological avenues.

1.2.2 Policy implications: needs and design

The main question becomes then: why are technological policies needed and which kind of policies could be implemented ?

It seems that in this phase the policies are oriented towards twofolds objectives:
- to avoid the effects of strong lock-in and to prepare the ground for a potential emergence of a new (or renewed) paradigm;
- to sustain the diffusion processes.

In fact, in the paradigmatic phase, the variety of technological and organisational options might be too reduced through lock-in effects. Both in terms of timing and range, the policy maker should take care of maintaining the possibilities of options widening.

The second path for the policy orientations is to increase the efficiency of the exploitation of existing knowledge base, both in terms of diversity and creation of incrementally expended knowledge. In the purpose, the policy maker has to speed up the diffusion of knowledge between organisations (firms, research institutions, …) and to guarantee the availability of efficient technological infrastructure (technology centers, …). The policy maker should in particular take care of the tranfer of skills or technologies existing in some sectors or regions of the economy and that could be helpfull otherwise, in other parts of the economy. This means an explicit diffusion of knowledge. And as knowledge is disseminated in several organisations in the economy, diffusion has to cross organisational boundaries, and for this reason, incentives for inter-organisational cooperation might be a specific tool both for the impulse of incremental and sector specific innovations and for the diffusion of knowledge across boundaries. In other words, a public R&D cooperative programme should allow the different partners to better exploit the disseminated existing knowledge by a better coordination of their activities (new partners never meet without public intervention, cf. Llerena, Matt 1999). This coordination should ease the diffusion and the creation of knowledge and should allow to keep enough technological and scientific variety in the economy in order to induce innovation and progress.

The general objective of this kind of cooperative policy is to sustain international or university/industry cooperations, to sustain specific groups of organisations such as SMEs or to ease geographical cohesion. The objective is not necessarily to sustain a specific technology in an industry but to support transversely an industry or a group of industries. The practical objectives will very often specify a product, a process or a patent partly publicly funded, marketed or used by a participating firm; or scientific results published by organisations supported by the programme. The practical objectives are in general less ambitious in terms of research and development costs, in terms of economic spin-off towards the society, in terms of individual risks and uncertainty as compared to the pre-paradigmatic objectives. As a consequence, the general design of such policy will differe from the previous one; it becomes bottom-up. The main difference is that the practical objectives and the R&D to be done will be defined by the participating organisations, that are better informed about their needs than is the policy maker. The latter will approve or disapprove the proposal. The public agency or organisation in charge of the management of the programme will probably not participate to the research but will define the functioning modalities. Actors themselves will manage (with the programme assistance) the use of the outcomes that will probably benefit less widely to the society than those of the pre-paradigmatic programmes.

Compared to the pre-paradigmatic programmes, much more projects will probably be funded, each of them entailing a much lower amount of subsidy (because smaller and less costly).

1.3 Synthesis and limitations

The analysis developped in the previous part underlines the existence of two broad kinds of cooperative public policies: the one devoted to create radically new knowledge by exploring new avenues in order to initiate a new technological paradigm and the other devoted to create new knowledge by using exploitation mechanisms in order to maintain technological options and variety, inducing innovation and progress and reducing negative lock-in effects. The first kind of policy is similar to the mission oriented policies defined by Ergas (1987) (cf. also Foray & Llerena 1997) which are concentrated on the development of a few number of technologies beeing highly strategic for a country or a group of countries. The technological objectives are often defined centrally by a government agency which supervises also the development of technologies. The second kind of policies correspond to diffusion-oriented policies that have for main objective to ease technological change and to diffuse knowledge and innovation in a decentralised way; government agencies play generally a minor role in such policies. Finally, the former policies intend to stimulate the emergence of new technological systems whereas the latter intend to solve “ system failures ” (Metcalf 1998). Our theoretical developments are summerized in table 1 below

	Pre-paradigmatic phase	Paradigmatic phase
Innovation Characteristics	– radical innovation – highly uncertain and risky – creation of a new knowledge base – long term perspective – may benefit the whole society – of public interest – may induce the crea-tion of new organ-isations or infrastru-ctures – existence of a variety of technological options	– incremental innovation – uncertain and risky – existing knowledge base – short term perspective – may benefit a specific sector or a group of sectors – small variety of technological options
Policy Implications	– to sustain exploration activities; to select the appropriate actors able to develop a complex and new technological area – to manage diversity by keeping technological options open as lon as possible in order to avoid too early inef-ficient lock-in effects	– to sustain exploitation activities – to coordinate disse-minated knowledge – to diffuse knowledge and results – to manage lock-in effects by widening the technological options and possibilities
Policy Objectives	– to sustain the technological competitivity of an industry (telecom. space, energy…) – to garantee the techno-logical independance of a country or a group of country (EU) in strategic areas – to satisfay major futur social needs (evironment, health…)	– to sustain interna-tional, national, univer-sity/industry coopera-tions – to sustain specific actors such as SMEs – to ensure geographical cohesion
Cooperative policy design	– top-down designed cooperative policies: technological objectives are centrally defined by a national or international agency (CNET, ESA, NASA…)	– bottom-up designed cooperative policies: technological objectives are defined by the participating organisations

Table 1: Characteristics of innovation phases and policy implications

But policy failures might arise during policy implementation (cf. Malerba, 1996). The governement or the public agencies or organisations in charge of the management of the programme or the definition of the objectives may be incompetent and work in a counter-productive manner. The policy maker may also have a misrepresentation of the sectoral, technological, institutional or economic environment and involve wrong sectors or actors in cooperative programmes. The policy maker may have no vision or inappropiate vision about the future technological opportunities to foster or develop or how to foster them. This failure might be especially crucial in a pre-paradigmatic programme in which one of the objective may be to sustain a specific technology in a defined sector (Digital Switching Systems in Telecommunication, for instance). Finally, governments may fail in coordinating the various actors, sectors and activate the wrong connections. This last failure may also have important negative impacts in cooperative policies.

All these failures may be reduced activating learning processes upon objectives, design and results of previous policy experiences: in any case “ patience is the sure companion to long term success ” (Metcalfe 1998, p. 16).

In the second part of this paper, we will illustrate our theoretical arguments by developing two different kinds of R&D cooperative programmes corresponding respectiveley to a pre-paradigmatic and a paradigmatic programme.

II. Two different types of R&D cooperative programmes: the development of Digital Switching System (DSS) in France and the European Brite-Euram programme.

The French case of the development of the Digital Switching System (DSS) is meant to represent a situation where the policy maker tried to cope with the emergence of a new paradigm (Digital Technologies) and the existence of high uncertainty. The policy maker had to find a variety/selection trade-off.

The second case, considered here, is the EU Brite-Euram programme. It illustrates the case for a policy maker to impact on the learning processes and the coordination accross boundaries of organisations (firms, research institutions, universities…)[3].

2.1 The development of Digital Switching Systems (DSS) in France[4]

In France, especially during the first phase (1958-1974), the development of the DSS was marked by the creation of a "specific organisational device" (cf. Quelin, 1992), with the central role of the CNET, the research laboratory of the French PTT. In 1958, the CNET, after the opening of a new switching department in Lannion, formed an alliance with SOCOTEL, the pool of the French manufacturers for switching equipment (the two French subsidiaries of ITT, CGCT and Le Materiel Telephonique

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[3] This programme tries to cope with what Metcalfe (1998) calls “ system failures ”.

[4] For a more detailled version of the case see Llerena P., Matt M., Trenti S. (1997). This case study was carried out during the TSER project ISE (Innovation Systems in Europe) – CEE-DG XII, November 1997.

(LMT), the French subsidiary of Ericsson, SFTE and the two French manufacturers AIOP and CIT-Alcatel) to research on the new technological paradigm of electronics.

In fact, the policy maker (i.e. the Ministry in charge of the Telecommunication policy; DGT) was interested in the development of a very efficient telecommunication network and in enhancing the competitiveness and the independance of the French telecom industry.

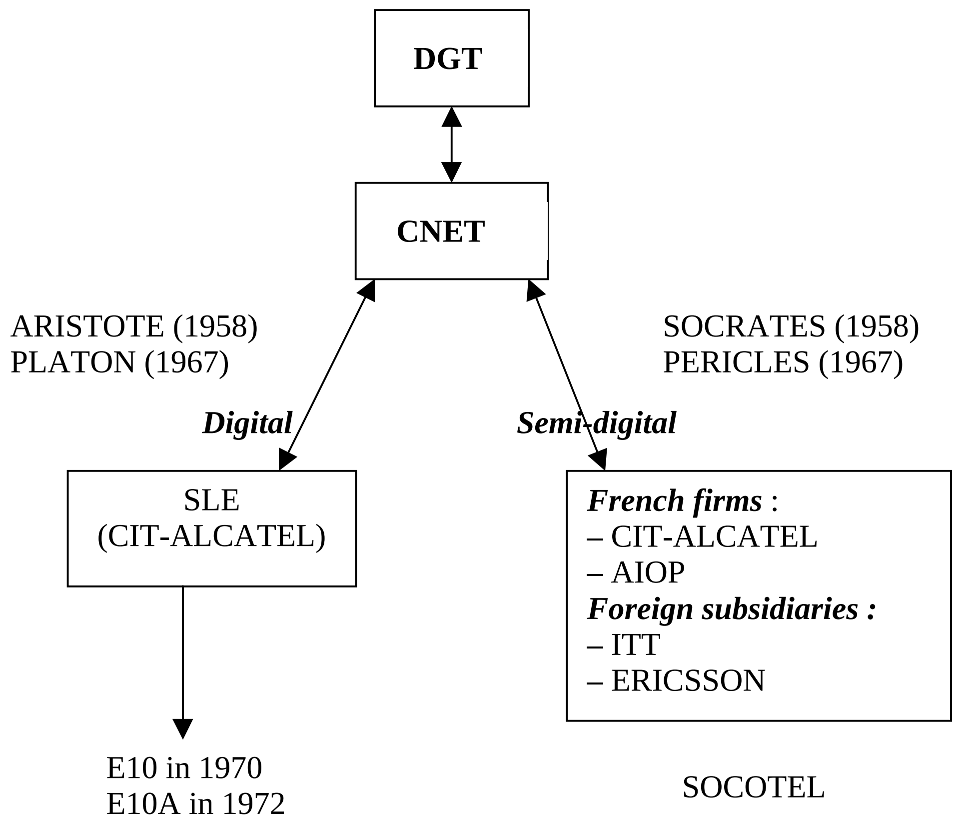

Figure 1: The central role of CNET in the development of the DSS

2.1.1 Two technological trajectories

The government launched two research projects (cf. figure 1) on two different technological trajectories:

- The first one, Socrates, involved the firms of SOCOTEL and the CNET;
- The second one, Aristote, involved only the CNET and Sociéte Lannionnaise d'Electronique (SLE), the new society opened in Lannion by CIT-Alcatel.

The Socrates project aimed at the development of a digital switching system following the space-division trajectory (i.e; semi-digital) while the Aristote choose to start directly on the time-division trajectory (i.e. fully digital).

This division of labour may be explained by two main reasons.

1) On the one hand there was a technological reason with the consideration of the technological advance of manufacturing firms (SOCOTEL) for space-division. Given their bigger experience on the electromechanical paradigm, they were thought to be in a better position to gradually introduce electronic control and managing systems inside a classical cross-bar switch. Conversely, the CNET had accumulated in the past ten years a greater experience on basic research in electronics and data processing;

   The Socrates project can in fact be interpreted as the combination of existing technologies: electronics (applied to limited range of functions) and electromechanical ones. The overall design of the technical system should in particular not be changed in a fundamental way.

2) On the other hand, there was a strategic reason. The bet on the time-division technology was part of the project of building the French independence in this strategic field. It was clear that if the time-division project proved to be successful, the French manufacturing industry would be in a monopolistic position in face of the foreign subsidiaries. In fact, the group of researchers working on Platon (the follower of the programme Aristote on the time-division solution) had the explicit aim to "fastly realise the prototype of totally electronic switch and then to pass immediately to the industrial phase" (Libois, 1983). Thus, the "exclusive" French efforts on the time-division technology could imply the push of ITT and Ericsson outside the market in the case of success of the CNET strategy.

   This second project, Aristote, was based on the expectation of a major technological shift, towards a new technological paradigm, i.e. in particular the definition of a completely new design of the technological artefacts. It consists in favouring a national champion and in asking him to become a potential leader of this technology.

The Platon project led finally to the installation of the first time-division switch worldwide. The Platon prototype, later known as E10, was installed in Lannion in 1970 followed six months later by a new bigger prototype. Between 1970 and 1972, the research continued in Lannion to pass from the prototype phase to the industrial one. In 1972, the E10A was ready to be produced and sold.

During the inauguration of the time-division switch, in 1972, the Ministry of PTT confirmed the importance of the new technology for the modernisation of the French network, announcing that the E10 will cover the 2% of the French switching market for 1973 and the 10% in 1975 (Libois, 1983). Moreover, the sustain to the time-division technique was confirmed in 1973 by the new Ministry of PTT, hoping for a further development of the system, in order to serve also bigger towns (Libois, 1983).

2.1.2 The crucial role of CNET in the coordination mode

The role of the CNET in this first phase is a crucial one. The CNET had during this period two main tasks: the R&D and the control over the equipment. These double functions gave the possibility to interact both with the service supplier (France Telecom) and the manufacturers. It has the advantage of a relative autonomy in front of both. The nature of the CNET was also strongly marked in this period by the presence of a charismatic leader (Pierre Marzin) (P.Griset, 1995). Personal contacts and trust were the main instruments by which CNET developed a dense network of relationships with the industrial side (facilitating the technological transfer), with the political side (accelerating the funding of projects) and with the academic side (strengthening the flows of knowledge and personnel).

A crucial aspect of the organisation of the technological development was the not-exclusive character of the organisation with the involvement of all the suppliers acting on the French market and the division of labour between the different members of SOCOTEL. One of the characteristic of the division of labour in the two series of projects was the possibility of interaction and cross-fertilisation between the two groups, given the presence of CNET researchers in both projects. For example, the experience of the manufacturers about the reliability of the switch drove towards the adoption in the Socrates prototype of a particular principle: the "load sharing" (“partage de charge“) i.e. the simultaneous use of two (or more) parallel computerS for the control of the switch. This principle was later used in the design of the architecture of the Platon.

It is possible to interpret the role of CNET in both projects as the “manager“ of technological diversity. It was able to get the most exhaustive informations and knowledge possible about the two possible technological trajectories: the semi-digital and the digital one. It was in particular also able to organize some cross fertilisation of the projects. It had also during the process a great influence on the technological choices made by the policy maker.

Basically two trajectories were possible and the policy maker had the corresponding targets and tools:

- the combinatory trajectory (semi-digital Switching System): the differents agreements (mainly SOCOTEL and CNET) was the potential tool which might guarantee in case of success of this “incremental“ solution the maximum diffusion of this technical solution (in SOCOTEL all producers of equipements were involved);
- the “radical“ trajectory (D.S.S.): in this case, the national “champion“, with the scientific resources of the CNET, was able to develop the technology and to secure the maximum return on it through at least a temporary monopole.

It appears that the behaviour of the policy maker during this period was to maintain the option open and to benefit from the increasing informations and knowledge about the options, before to induce a specific choice. Inter-organisational agreements were in both case the used tool to obtain the results; i.e. to maintain the choice set open as long as needed to make a “ better-informed ” choice.

2.2 An example of cooperative R&D policy in a paradigmatic phase of technological development: the case of Brite-Euram.

By developping this second example, we would like to emphasize the positive effects of a coordination policy on the various learning processes of economic actors behaving in a defined technological paradigm. The objective of this policy is not as the previous one (2.1) to select between alternative projects and to create a new knowledge base, but to use the existing knowledge base in order to foster and improve some processes in the economy. Helping actors to coordinate themselves more efficiently, i.e. inducing cooperation between agents who would not have cooperate spontaneously, generates incremental technological development and improves the learning ability of various organisations. We will show that the way agents are coordinated influences the performance of the innovation process induced by the policy maker.

2.2.1 A brief presentation of Brite-Euram

Brite-Euram I[5] is an R&D programme funded by the EU and was created in 1989 from the merger of Brite (1985-1989) devoted to the development of new technologies and materials in traditional industrial sectors and Euram (1986-1989) devoted to the development of new materials. The European Community mentionnes three main objectives concerning this kind of policy:
– to increase the competitivity of the european industry ;

[5] Brite-euram I was followed up by Brite-Euram II (1992-1995) and Brite-Euram III (1996-1999).

– to enhance the economic and social cohesion of Europe;
– to promote scientific, technological and economic integration of the european industry.
These objectives underline the necessity to foster european industry by enhancing the scientific and technological knowledge base. There is no explicit intention to create a new knowledge base in order to open a new technological paradigm. Rather, public intervention is justified by the need for a better diffusion of knowledge between innovative organisations and also between different national systems of innovation. In other words, these policies should allow to decrease the limits inhibiting coordination of existing diversity in order to impulse variety and to avoid negative lock-in phenomena inside a paradigm. One of the objective is to stimulate cooperation between actors who had no incentives to collaborate spontaneoulsy because of existing barriers. The creation of such a collaboration network should allow to better exploit the knowledge of the different participating organisations but also to enhance their exploitation abilities. Complementary to the main objectives cited above, the EU mentionnes other targets:
– to increase the use of high technologies by SME;
– to increase the participation of SME in R&D programmes by developping links between other companies and promote a better management of resources;
– to ensure dissemination and exploitation of results and knowledge;
– to foster and diversify engineering and scientific education needed by the european industry.
These objectives confirm that the policy is more devoted to a better exploitation of diversity and diffusion of knowledge than to the exploration and creation of a new knowledge base.

The next part will focuse on how coordination of existing diversity may lead to the generation of new technologies, new links, new internal organisation modifications and increase the learning ability of partners.

2.2.2 Economic impacts of Brite-Euram on the european industry

The results we will present are stemming from several evaluation studies realized by the BETA since 1991. These studies are based on a specific methodology developped by BETA to quantifiy direct and indirect effects generated by organisations participating to publicly financed R&D programmes. This approach does not allow to define precisely the impacts and diffusion process of a public programme in all the economy. The analysis is limited to the evaluation of effects generated inside organisations and evaluates only partially the creation of wealth. The results underline more the existence of a phenomena than a global measurement of innovation.

Very briefly, direct effects are economic effects directly linked to the objective of the research contract signed by the different partners of an agreement. For instance, if the objective is to create a new poduct, the sales (measured in terms of added value) of the latter are considered as a direct effect.

Indirect effects are those impacts not explicitly related to the objective of the research project. They correspond to new knowledge, skill learned during the project and applied to other activities of the participating organisation that were not involved in the project. We have divided these indirect effects into four categories:

– technological effects that concern internal technology transfers from the project to other activities of the partner. These transfers may concern a product, a process, a service, new technological competences or knowledge;

– commercial effects take into account the increase of economic activity (sales of new products, services, new research contracts) that do not integrate technological innovation generated by the project. They concern the creation of a new network and the utilisation of it in order to increase the economic activity or the use of a reputation effect acquired during the participation to Brite-Euram;

– organisation effects appear when the experience acquired allows the actor to modify its internal organisation and/or to apply new working methods;

– work factor effects concern the impact of the project on the human capital of the contractant. It measures the increase of innovating skills of the company, in other words the fact that the company is able after the project to answer more complex technological problems than before.

As it is not the purpose of this part of the paper, we will not expose the quantification method (cf. BETA 1995). Some results will be given in terms of ratios which represent the total amount of effect (direct or indirect) measured by BETA / EU funding. If the ratio equals X, it means that for a subsidy of one ECU, the organisation or group of organisations generated X ECU during the quantification period taken into account.

In the following part, we will present two different kinds of diversity coordination and their impact in terms of economic effects, i.e. creation of new knowledge, competences and learning ability. What we would like to emphasize is that a better coordination of existing diversity inside Europe is helpful in the economy and allows to generate new diversity. The two types of coordination are:

– coordination of different kinds of research knowledge;

– coordination of different types of organisations.

a) Coordination of diversity in terms of research knowledge

In a sample of 50 consortia (i.e. 176 different organisations), we analyze the performance of the agreements by investigating whether the involvment of one partner in fundamental research has an impact on the effects of the other partners. Among the 50 projects, five consortia do not associate fundamental research to the rest of the innovation process. It seems that the Brite-Euram programme have selected and induced mainly research projects including a diversity in terms of research. The analysis of projects involving or not fundamental research underlines the following results:

– the performances of the 19 participants included in the five consortia without diversity of research are far less successful both for direct and indirect effects as shown in the following table. This result confirms the assumption that coordinating diversity in an agreement contains a high learning potential (cf. Johnson and Lundvall 1992). The presence of knowledge diversity increases the probability to create new knowledge by recombinig the existing one.

Parameters	Partners associated with fundamental research	Partners not associated with fundamental research
Number of consortia	**45**	**5**
Number of participants	157	19
Total direct effects in MECU 91	505	17.5
Ratio direct effetcs/EU funding	**14.8**	**3.3**
Total indirect effects in MECU 91	149.7	11.1
Ratio indirect effetcs/EU funding	**4.4**	**2.1**
Technological	50.5%	8.9%
Commercial	10.2%	11.6%
Organisational and method	12.2%	3.1%
Human factor	27.2%	76.3%

Table 2: the importance of fundamental research

– the nature of the indirect effects (i.e. the nature of learning) is completely different from one group to the other. The group containing diversity (fundamental research) generates a large amount of technological transfers (50.5%), while the second group generates mostly effects on human factor. This means that the knowledge acquired by

this second group has not yet find any applications, but could be used in a near future if needed.
It is to be noted that these results are consistant with the conception of innovation as an interactive process. Fundamental research cannot be dissociated from the rest of the process if innovation (radical or incremental) has to succeed.

b) Coordination of diversity in terms of organisations

In this part, we will analyse the creation of knowledge inside an agreement when it involves on the one side industrial and research organisations and on the other side users and producers of the technology.

The first result underlines the importance to associate in a group of cooperating agents universities with industrial partners. The presence of a university (or a fundamental research institution such as Max Planck, CNRS, etc.) in a consrtium has a positive action on the generation of economic effects. The positive effect is especially efficient for direct effects but can also be observed for indirect effects. The influence of universities is also observed for the research centers but to a lesser extent. The table below shows that in a consortium without diversity in terms of organisations (i.e. containing only firms or firms and research centers) the generation of direct and indirect effects is nearly divided by two as compared to consortia involving diversity. This phenomena has to related to the concept of learning by interacting developped by Lundvall (1988). According to Lundvall, interactions between agents allow the creation of new knowledge by the combination of existing one and a certain degree of diversity is necessary to reach an efficient process of learning and creation. This concept has been applied by the author in user-producer interactions, which constitutes the second result we will focuse on.

Parameters	Firms with universities	Firms without universities	Firms and RC* with universities	Firms and RC without universities
Number of partners	49	64	60	86
Total direct effects in MECU 91 **Ratio direct effects/EU funding**	312.1 **24.4**	209.5 **13.0**	312.2 **20.4**	210.4 **10.3**
Total indirect effects MECU 91 **Ratio indirect effects/EU funding**	63.3 **5.0**	43.1 **2.7**	69.3 **4.5**	55.7 **2.7**

* RC means research centers

Table 3: The role of universities

The second point is to check if the association of a user and a producer of the technology inside a consortium has a positive effect in terms of learning as compared, on the one side to users or producers working alone and on the other side to integrated firms being simultaneously user and producer of the technology. For the purpose of the analysis we have divided the participating organisations into three groups:

– integrated firms being at the same time a user and producer of the technology;
– cooperation between users, producers and integrated firms;
– independant users and producers, i.e. those who are not associated in a project.

Parameters	Integrated Users-Producers	Associated Users and Producers	Non Associated Users or Producers
Number of contractants	26	74	25
Total direct effects in MECU 91	289.1	189.5	37.3
Ratio direct effects/EU funding	**40.2**	**10.7**	**5.4**
Total indirect effects MECU 91	58.7	67.3	15.3
Ratio indirect effects/EU funding	**8.2**	**3.8**	**2.2**

Table 4: User-Producer coordination

The table 4 shows that a consortium effect exists on associated firms comparatively to non associated users or producers: the user-producer relation generates twice more direct effects (and slightly less than twice more indirect effects) than users or producers working alone. Here again, the combination of complementary and diverse skills and knowledge generates positive results inside a consortium. Moreover, the EU seems to favorise these kind of combinations as for the 99 non integrated users or producers in our sample, 74 were associated in an agreement and only 25 belong to projects involving only producers or users. We have to notice that the economic performance of the associated users and producers does not reach the efficiency of the integrated population.

CONCLUSION

In this paper, we underline theoretically and empirically the policy rationale for two broad kind of cooperative policies. The first kind of cooperative policy aims at creating a new paradigm based on radically new knowledge in order to explore new research avenues. One of the challenge of the policy maker is to sustain exploration activities among the selected partners who should be able to develop in a cooperative way a complex and new technological area. The other challenge is to manage diversity in order to avoid too early inefficient lock-in effects. This kind of policy are usually concentrated on the development of a few numbers of technologies that are considered as highly strategic for a country. The organisation of such programmes is generally very centralised in the sense that the technological objectives are defined by the government or by a government agency which supervises the development of the technologies. We illustrated this policy by the French case of the Digital Switching System development, where the policy maker had to find a variety/selection trade-off. In this case, we highlight the central coordination role played by the CNET.

The second kind of cooperative policy aims at creating new knowledge and at enhancing learning abilities by using exploitation mechanisms in order to maintain technological options and variety in a paradigmatic phase of technological development. The main challenges for the policy maker are to sustain exploitation by a better coordination of disseminated knowledge, to diffuse knowledge and technological results in the economy and to manage lock-in effects by widening the technological options and possibilities. These policies are compared to the others more diffusion oriented and organised in a decentralised way. The research or technological objectives are generally defined by the economic actors and selected by the manager of the programme, who does not participate to the realisation of the objectives. To illustrate this kind of policy we considered the EU Brite-Euram programmes and we showed how this programme impacts on learning processes. More precisely we underline the positive effects of diversity coordination on the creation of new knowledge, competences and learning abilities.

References

Bach L., Conde-Molist Nuria, Ledoux M.J., Matt M., Schaeffer V. (1995): “ Evaluation of the economic effects of Brite-Euram programmes on the European industry ”, Scientometrics, Vol. 34, n°3, pp.325-349

Bach L, Furtado A., Lambert G. (1998): “ Variété des programmes de RD, variété des méthodes d’évaluation: quelques enseignements tirés de l’application de la méthode du BETA à différents programmes de RD ”, workshop avaliçao de programas tecnologicos e instituiçoes de P&D, DPCT, Instituto de Geociencas, UNICAMP, Campinas.

BETA (1995): “ Evaluation and analysis of the technological transfers generated by the programmes EURAM, BRITE and BRITE-EURAM ”, final report, CEE-DG XII, March 1995.

Cohendet P., Llerena P. (1997): “ Learning, technical change and public policy: how to create and exploit diversity“, in “Systems of Innovation: Technologies, Institutions and Organisations ”, Edquist C. (ed), Pinter, London, 1997, chap. 10, pp. 223-241

Cowan R. (1991): “ Rendements croissants d’adoption et politique technologique ”, in De Bandt J. and Foray D., l’évaluation économique de la recherche et du changement technique, Edition CNRS, pp. 381-398.

David P.A. (1987): “ Some new standards for the economics of standardization in the information age ”, in Dasgupta P. & Stoneman P. (eds) Economic Policy and Technological Performance, CUP.

Dosi G. (1988): “ Sources, procedures, and microeconomic effects of innovation ”, Journal of Econmic Literature, Vol.XXVI, September 1988, pp. 1120-1171

Ergas H. (1987): “ The importance of technology policy ”, in Dasgupta P. and Stoneman P. (eds), Economic Policy and Technological Performance, CUP.

Freeman C., Perez C. (1988): “ Structural crises of adjustment: business cycles and investment behaviour ”, in “ Technical Change and Economic Theory ”, Dosi G. and alii (eds), Pinter, London, 1988, pp.38-66.

Foray D., Llerena P. (1996): “ Information structure and coordination in technology policy: a theoretical model and two case studies ”, Journal of Evolutionary Economics, Vol. 6, N°2, pp. 157-174.

Griset P. (1995): “ Innover comment? Innover pourquoi? cinquante ans de recherche au CENT ”, Les cahiers - Télécommunications, Histoire et Société, n°2, France Telecom.

Johnson B., Lundvall B.A. (1992): “ Closing the institutional gap ”, Revue d’Economie Industrielle, Numéro Special, n°59, pp. 111-131.

Lundvall B.A. (1988): “ Innovation as an interactive process: from user-producer interaction to the national system of innovation ”, in Dosi et alii (eds), Technical Change and Economic Theory, Pinter Publisher, pp. 349-369.

Matt M. (1996): “ Politiques technologiques et accords de coopération en R&D: théorie et application à des programmes européens ”, PhD Dissertation, University Louis Pasteur, Strasbourg.

Libois L.J. (1983): “ Genèse et croissance des télécommunications“, Paris, Masson.

Llerena P., Matt M. (1999): “ Inter-organisation collaborations: the theories and their policy implications ”, in The Organisation of Scientific and Technological Research in Europe, A. Gambardella and F. Malerba (eds), Cambridge University Press, (to be published)

Llerena P., Matt M., Trenti S. (1997): “ Government Technological Procurement: the case of Digital Switching Systems in France ”, mimeo, intermediary report for TSER project ISE (Innovation Systems in Europe), CEE- DG XII, november 1997.

Malerba (1996): “ Public policy in industrial dynamics: an evolutionary perspective ”, TSER-ISE, Milan, December 1996.

Metcalfe J.S. (1998): “ Innovation as a policy problem: new perspectives and old on the division of labour in the innovation process ”, presented at the conference SMEs and Innovation policy: networks, collaboration and institutional design, november 1998, Robinson College, Cambridge.

Quelin B. (1992): “ Trajectoires technologiques et diffusion de l’innovation: l’exemple des équipements en télécommunication ”, Revue d’Economie Industrielle, n°59.

Willinger M., Zuscovitch E. (1993): “ Efficience, irréversibilités et constitution des technologies ”, Revue d’Economie Industrielle, vol.65, pp.2-22.

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The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation

- Competence building and inter-firm dynamics

- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the resource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human resources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

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There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

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