The European Technology Policy:
Propositions for a Multilevel Governance

Muriel FADAIRO
Fadairo@univ-st-etienne.fr

CREUSET-CNRS, Université Jean Monnet de Saint-Etienne, France

Abstract

The aim of this paper is to highlight the relevance of a geographical multilevel technology policy within the European Union. At the present time the European policy of innovation is a "community" policy, in other words it involves a sharing of skills. In this paper we argue that outside the problems that this situation inherently poses, this territorial organisation may be considered as an asset. We use the central concept of technology externalities, taken in its traditional shape and in its renewals, to provide theoretical justifications for a “territorialised technology policy”, that is to say a policy of innovation designed and implemented on several territorial levels. Three levels are here taken into account : regional, national, European.

Keywords *:* European technology policy, knowledge externalities, multilevel governance.

JEL Classification *:* O31, O38.

Preliminary Draft

(April 2009)

1. Introduction

Knowledge diffusion takes a prominent part in the European technology policy. The main texts of the European Commission state its necessity and the European programs, mainly since the third frame program, pay a particular attention to this purpose.

Many arguments for this trend can be found in economic literature. One main result of the Economics of Innovation is indeed that technological knowledge is not only an output of the innovation activity, but that it is also its principal input (Cohen W., Levinthal D. [1989]). In addition, the assumption of a qualitative transformation of technological regimes (Scotchmer S. [1991], Joly P.B. [1992]) emphasises incremental innovations: the new innovative paradigm would be characterised by the improvement, and by the re-use, the re-arrangement of previously known technological skills. Then, innovation essentially depends on the cumulative nature of knowledge production and on skills very strong interdependence. These results justify the focus on knowledge diffusion and on technological spillovers.

The goal of this paper is to highlight the features of technology diffusion justifying a policy of innovation implemented on several territorial levels. In that case, the innovation policy uses and connects the specificities of each territorial level. Within the European Union the “Community”policy of innovation involves a sharing of skills between Regional, National and European levels. Our point here is that outside the problems that this situation inherently poses, this territorial organisation should be considered as an asset.

The article is organised as follows. Section 2 emphasises the bounded feature of technology diffusion. It is based on the results of the empirical studies focussing on an attempt to measure the spatial dimension of knowledge spillovers. By describing the sources, paths and methods of transmission of technology spillovers, this empirical literature helps to specify the conditions whereby the effects of proximity may – or may not - act positively. This section discusses the relevance of multilevel governance to favour technological knowledge diffusion within the European Union. Section 3 highlights the contradictory implications of technology diffusion, which involve compromises in innovation policy. It argues that a territorial organisation of compromise is useful, and draws some orientations for the European context.

2. A multilevel governance to confront the bounded feature of technology diffusion

2.1 The bounded feature of technology diffusion

Knowledge versus information

The assumption that technological knowledge diffusion can be geographically bounded derives from the way technology is defined, and more precisely from the distinction between knowledge and information.

Focussing on learning phenomena, Evolutionary Economics characterises information as a flow of codified data and knowledge as a stock. From this point of view, knowledge involves a non-codified feature and includes the notion of competence: a piece of information becomes knowledge when someone is able to understand it, to combine it with other knowledge, to use it and to stock it. This is why technological knowledge is “localised»: it is the result of a learning process, which is specific for each innovator (Antonelli [1999]). Polanyi [1967] has been the first one to notice that a major part of human knowledge is difficult to explain with words ("tacit knowledge"). The key role of the environment and of the hereditary information within knowledge development is tackled by the concepts of "paradigms" and technological "trajectories" (Dosi [1982]), or in addition by the concepts of " habits " and "routines" (Nelson et Winter [1982]).

When technology is no more defined as information (Arrowian tradition since the main article from 1962) attention is drawn to the difficulties to transfer it. Then the key question is the spreading of technology. Knowledge Economics shows that the means of transmission are depending on the nature of knowledge: generic or specific, degree of codification, degree of complexity, degree of independence (with regard to other categories of knowledge). The more knowledge is specific, tacit, complex, and non-independent, the more informal means of transmission are required (which involves face to face), and the more transmission is related to distance (notably geographical) between agents (Breschi and Malerba [1997]).

This conception of technology taking into account the complexity of diffusion is now part of the mainstream. For instance the theory of endogenous growth is interested in localisation phenomena resulting from technology externalities (Martin and Ottaviano [1999]); empirical studies focussing on the part of spillovers on national growth and productivity highlight sometimes the role of localisation (Caballero and Jaffe, [1993]). For instance it is the case when studies are interested in the part of national and international knowledge externalities (Branstetter [1996], Mohnen [1998]).

Empirical results

The "Geography of Innovation"[1] is based on the desire to give empirical foundations to the assumption that knowledge spillovers are territorially bounded, which would explain the pronounced spatial polarisation of innovation activities. This empirical literature focuses on an attempt to measure the spatial dimension of knowledge externalities. Several results are interesting for the science and technology policies, and confirm some current orientations (Fadairo and Massard [2002]).

Econometric studies emphasise the geographic dimension of knowledge externalities from science to industry. The relationship between science and industry is usually studied as the relationship between Universities and private business. Deriving from Jaffe [1989] the first studies focus on the United States and are based on data from the 80's. Here all the studies conclude with the spatial dimension of technology externalities in the science-industry relationship. Studies in more recent periods and other countries have greatly contributed to qualify this initial conclusion (C. Antonelli [1994], R. Paci and S. Usai [2000], L. Bottazzi and G. Peri [2001] for Italy; M. Kenney and R. Florida [1994] for Japan; K. Blind and H. Grupp [1999], M. Beise and H. Stahl [1999] for Germany, C. Autant-Bernard [2001] for France). One main result of this literature is to highlight the geographic feature of spillovers from public research, but also to confirm that the territorial dimension of externalities is varying with the institutional context.

In addition the Geography of innovation confirms that Universities are not the only emitters of externalities. Several analysis focus on inter company spillovers (A. Jaffe, M. Trajtenberg and R. Henderson [1993], B. Verspagen and W. Schoenmakers [2000], D. Audretsch and M. Feldman [1999]). On this point an interesting question for technology policies is to have evidence on whether local knowledge flows are encouraged more by a specialised environment or by a diversified one. The above mentioned literature reveals the driving role of diversity in local innovation. It emphasises the idea that sectorial diversity is favourable to the development of externalities within a concentrated zone whereas sectorial proximity is the basis for the capacity to tap into more distant sources of externalities.

At last, another main result of the Geography of Innovation is to confirm that knowledge diffusion is complex: externalities are not purely local. They are not one-dimensional phenomena because they emanate from a variety of sources. In fact, while being supported by various geographical levels in the United States (counties, metropolitan districts or states), every time the existence of externalities internal to the zone is revealed. When studies compare different geographical scales (C. Autant-Bernard [2001] for France or L. Bottazzi and G. Pieri [2001] for Italy), different levels of diffusion appear, even if the local effects take precedence in certain circumstances.

[1] Term taken from Feldman's work (Geography of innovation) published in 1994, which stands as one of the main reference in this field.

2.2 The relevance of a multilevel governance

Territorial comparative advantages

The local economic system is unique, and the existence of geographic externalities supports the idea whereby certain non-transferable interdependencies characterise the Regions. However these are not static or irreversible; they are subordinate to public action. This is why Regions stand as a key actor in innovation policy. Bearing in mind the principle of subsidiarity, Regional level is adequate to exploit the diversity of local technological connections. The goal here is to exploit regional comparative advantages in technology. For public authorities, this involves bringing together different spheres: various types of industries, diverse types of companies (in particular according to size). Measures encouraging direct inter-industrial contacts stimulate an interchange of the tacit knowledge accumulated inside companies. What is at stake here is the promotion of companies from different fields to get together. By particularly encouraging linkages between high tech sectors and traditional industries, the public authorities can improve the diffusion of generic technologies and the hybridisations, which are sources of innovation. It is interesting to point that stimulating the generation of variety is also one of the main roles assigned to technology policy by J.S. Metcalfe [1994] as well as P. Cohendet and P. Llerena [1997]. Expanding diversity means increasing the number of possible technical options. In short, the role of diversity within innovation is of particular importance today when innovation occurs mainly through recombination.

Experience has revealed the difficulties behind implementing local operational institutional networks generating collective innovation processes. On one side appears the problem of how to articulate these institutional networks - created and maintained by regional institutions - with ad hoc local industrial system. On the other side, setting up transverse cooperations between the local players becomes difficult when the latter do not enjoy organisational proximity. However, intercompany contacts may be stimulated by regional programmes, which support long-term multidisciplinary cooperation projects. Regional intervention level has a key role in encouraging trans-sectoral cooperative structures and more generally meetings on a transverse theme. In addition, the Regional level seems adequate to emphasise the importance of supply-demand relationships in the dynamic of local intersectoral cooperations. There could be a very clear advantage in moving on from policies purely angled towards research and innovation supply, in order to look towards the promotion of local demand.

Territorial absorptive capacity, territorial lock-in

and the connection of Regional, National and European systems of innovation

Enabling firms to exploit the local comparative advantages by way of the promotion of multidisciplinary structures at Regional level is not sufficient. Several arguments explain why it is necessary that Regional and National intervention levels favour the access to knowledge external to the territory, in other words, an opening up to the rest of the world.

W. Cohen and D. Levinthal [1989] have emphasised the "two faces of research and development»: as well as the production of new knowledge, the activity of research should correspond to the capture and assimilation of external knowledge, which involves an « absorptive capacity ». To be able to identify and exploit new available knowledge in their environment – in other words to build an absorptive capacity – firms need adequate internal skills and competencies. Widely accepted from a theoretical point of view, this concept has given rise to few empirical works. Defining the absorptive capacity at the aggregate level of geographic zones, C. Autant-Bernard [2000] gives empirical evidence that the research level and its degree of diversity not simply affect the level of externalities captured but also their geographic origin. Having a high and varied level of internal competencies seems vital to tap into remote knowledge sources. From this point of view (territorial absorptive capacity), territories (Regional and National levels) are unequal, in regard to the level of research internal to the zone.

The problem of asymmetry between geographic zones in their capacity to absorb external resources is magnified by the localised[2] character of technology, (for example C. Antonelli [1999]; J.S. Metcalfe [1994]) which involves path dependency. In addition, institutional change is characterised by a phenomenon of inertia, which makes it generally incremental and slow. As a result, the regional and national technological dynamics encompass a risk of lock-in: a firm may find itself trapped with an old technique because the local system is not supplying the right technology. Tight local networks may exclude vital information (B. Carlsson and S. Jacobsson [1997]; E. Ernberg and S. Jacobsson [1997]). The risk of territorial lock-in justifies a public intervention to provide the conditions necessary for the evolution of the system. This requires a systematic promotion of opening up towards the outside (supra territory levels). This point seems crucial in a time of changes and high level of technological uncertainty (B. Johnson [1992]).

At last, the situation today may also be interpreted as the transition to an "economy of networks" through which the pertinent knowledge flows (B.A Lundvall [1998]). Strategic skills are developed in an interactive way, and shared within networks. However access to these networks is not open and free. Among other things, it presupposes the sharing of tacit knowledge, or codified knowledge with codes which are difficult to track down (R. Cowan, D. Foray [1997]; P. Maskell [2001]). The capacity to join these tight networks determines the access to knowledge, today's most strategic resource. The existence of barriers to entering networks in which knowledge is produced and transmitted and more generally the question of access to external knowledge pinpoints a field of intervention for a multi territorial level technology policy.

Three orientations at Regional and National levels can favour the access to external knowledge and avoid territorial lock-in. They support the connection of the Regional, National and European systems of innovation: i) the promotion of learning, ii) the development of communication infrastructures, iii) the access of local firms to the European programmes.

The concept of "a learning economy" (B.A. Lundvall [1998]) synthesises the idea whereby if knowledge is nowadays the most strategic resource, learning constitutes the most important process in economics. As a matter of fact, access to scientific and technological knowledge does not simply presuppose the system has a good "distribution power" (P. David and D. Foray [1994]) – to ensure availability of this input – but also the capacity of firms to absorb external resources, a particularly challenging exercise bearing in mind the current speed of development. What is at stake for Regional and National levels is to develop the means of learning and the capacity to communicate, which are deeply affected by the institutional architecture (B. Carlsson, S. Jacobson [1997]). Such a target presupposes a long-term interventionism. For this reason, we argue that education policy is an integral part of the innovation policy, which goes beyond the quantitative issue of funding. The education system is involved in every level: "*from nurseries to the training of engineers and scientists*" (B. A. Lundvall [1992 p. 302]).

Including public actions in education and training as an integral part of the innovation policy plead in favour of a technology policy in the broadest sense. This long-term interventionism corresponds to setting conditions favourable for innovation, rather than direct targeted intervention. This characteristic recurs in another measure necessary for the capture of external knowledge: the development of communication infrastructures, in all their forms. It is worth making several comments on this point. First of all, it is worth to remind that in the ideal situation defined by P. Dasgupta and P. David [1994], access to new knowledge is broad, fast and free. These features determine a "system's distribution power" and naturally depend on the quality of the communication infrastructures. From this point of view, all actions encouraging the codification of new knowledge constitute the first stage in communications policy. In addition it is necessary to stress the role of diversity in the means of communication. Our last remark concerns the promotion of the new information and communication technologies within access to external knowledge. Even though the geographic dimension still has a meaning – as shown by econometric studies – these technologies considerably weaken the constraints of physical distance. With their diffusion the role of spatial dispersion takes a back seat behind the role of professional communities, which share a code, a language and more generally a culture.

Within the European Union, the existence of a Community technology policy is an undeniable asset for the Regions. The formation of international cooperative structures, driven by the European

---

[2] in all senses of the term including the geographical one.

programmes, gives local businesses the possibility of correcting weak points in their absorptive capacity. It is a means of escaping from the dependency on the local path, to access closed networks and tap into international technological externalities. At the moment and despite the efforts of the European Commission, the proportion of SMEs taking part into the Community programmes remains low. This is a main problem since these firms are characterised by their limited means for internal research, and hence by their inadequate absorptive capacity. Here is a very large field of action for the regional and national innovation policies: to clear away the institutional barriers (national level), to promote the participation of SMEs and more generally of regional firms in the European programmes (regional level). Encouraging advisory activities for SMEs at a regional level in order to allow them to join the Community cooperative structures is justified here. This is a question of teasing out any overlap between the local, national and European systems: the diversity of institutions increases the possibilities for communication and interaction, and hence for innovation. The role of training and codification, put forward in this article, merits again to be emphasised: they represent the conditions necessary to access common languages.

3. A multilevel governance to confront the knowledge dilemma

3.1 Compromise in technology policy

The knowledge dilemma

Favouring technology diffusion - which is necessary at a moment where cumulative innovations take a prominent place – magnifies the knowledge dilemma. This well-known problem concerns the fundamental contradiction between the aim of a widespread diffusion of knowledge, which increases its social value, and on the other hand the aim of increasing the incentives to R&D.

The traditional justification for technology policy focuses on this second point (incentives to innovate). Arrow [1962] establishes this approach, emphasising the specific features of knowledge at the root of the problem of appropriability: the innovator is not rewarded for the social effects of his activity. Such a situation does not urge him on persevering and leads to a socially under-optimal development of R&D. As soon as technological improvements cease to be considered as exogenous, the problems are raised of the R&D results appropriability and of research incentive. This theoretical framework justifies the traditional instruments of technology policy: i) public research substituting completely or partly for the private initiative, ii) R&D financial or fiscal incentives, iii) protection of industrial property. The latter instrument turns towards "closure", i.e. towards the exclusion of the potential beneficiaries to exploit the result of the R&D. This system of exclusion makes it possible to restore research incentive by allowing innovating firms to receive the income associated with knowledge private economic exploitation.

For this reason technology diffusion and incentive to innovate are two contradictory goals of technology policy. None of them can be neglected in the current period where the big industrial groups' participation to basic research holds a more and more important place; whereas before, fundamental research was mainly financed by public funds, which limited the problem of appropriability (Joly [1992]). This is why we argue that technology policy is necessarily a compromise (Fadairo [2001]).

The difficulty confronting the innovation policy to arbitrate between the two contradictory goals is increased by the limited number of available tools: the traditional instruments emphasised by Arrow [1962] within a logic of exclusion (in order to foster research incentive) can be used in a different way to aim a wide diffusion. This is why the compromise shapes, in other words the orientation of the innovation policy towards the degree of technology diffusion do not lie in the set of instruments, but rather in the way they are used. (Cohendet and al. [1999]).

The instruments of the compromise

The patent - main element of the protection of industrial property - is a system of exclusion in that it imposes a technology-related monopoly of industrial and commercial exploitation. From a theoretical point of view, the optimal level of protection is reached when the patent-derived profits balance the R&D private outlays. However, this instrument -traditionally considered as a reward for the inventive activity- can be used to improve the circulation of technical knowledge. Actually, contrary to trading secrecy, the patent has informational properties: the offset to exclusion established by the patent is to accept to codify and to diffuse the patent-related information. This is why *"...to some extent, the most important diffusion policy is probably patent protection..."* (Stoneman and Diederen [1994 p. 920]). Several elements of the patent system can be used to define the compromise, i.e. to determine the circulation degree of technological information (table 1).

Table 1 – Compromise Elements in Patent Policy

TOOLS	MEANS AND / OR IMPLICATIONS
Protection length and extent	the decrease of which reduces the patents power of exclusion
Filing terms and conditions	Facilitating or restricting the patent acquisition: required level of novelty, steps length, filing financial cost; a diffusion policy exploiting patents informative aspect shall support the systematic recourse to this instrument and shall intend to discourage trading secrecy practices, for instance by insuring no protection against industrial spying of unfilled innovations.
System of attribution	The system "first to file" (attribution to the first applicant) that fosters the patent acquisition / the system "first to invent" (attribution to the first innovator) that prolongs the patent acquisition period.
Terms and conditions for the acquisition of licences	For instance, the "licences of dependence" used when a patent brings an improvement to an already-patented innovation, constitute an institutional tool ensuring an interesting compromise between the level of protection required for the incentive and the advantages in terms of knowledge circulation.

Public programs of research also constitute an intrinsically compromise-propitious instrument. The cooperative structures generated by those programs are both inciting and favouring technology diffusion among firms.

Subsidies (or fiscal incentives) merely have an impact on the incentive to R&D. However this instrument can be efficiently combined with a cooperative shape: intellectual property rights (the offset to subsidies is to patent the result of the private R&D), public programs (subsidies combined with public-initiative cooperations), cooperative research (subsidies combined with private-initiative cooperations).

The opportunity to use these instruments on several territorial levels broadens the field of action for the innovation policy and relieves it of the dilemma between incentive and diffusion.

3.2 Territorial organisation of compromise

Compromise at the European level

The Community policy of innovation mainly relies on the specific technological R&D programs implementing the frame program. They constitute an especially efficient compromise (M. Fadairo [2001]).

On the one hand, they compose a powerful inciting system by allocating funds to private research. This financial support granted by the European Union is increasing. In addition European programs are dedicated to the pre-competitive field, the first stages of the research step during which the problem of appropriability is particularly high (for instance M. Trajtenberg [1989]). Moreover, the programs leave a privileged place to the generic technologies, characterised by their highly diffusing feature, which involves a problem of appropriability, therefore, a problem of incentive.

On the other hand, the European specific programs have a structuring impact. They establish a wide policy of international cooperation, promoting both the emergence and the stability of international cooperative research structures. The cooperations contribute to foster the circulation of technological knowledge. The spreading of technological knowledge, promoted by the European Union, also stems from the programs opening to the third countries, and from the cooperation with the extra-Community programs.

The National public research programs could be complementary to the European programs. National programs rely on the national specificity's - institutional an cultural - which favour the settling of cooperative structures. It seems adequate that the national level aims at favouring the diversity of technologies. P. David [1986] has pointed the necessity to support the weak technologies, in order to avoid technological lock-in and preserve a wide range of technological options for the future. This aim could be implemented at the National level whereas the Regional and European levels would prolong the results in a more selective way.

Contrary to financial incentives and to the support for cooperative research, the patent system is still not used by the European Community to implement the innovation policy. The patent system at the Community firms' disposal mainly relies on a national basis, which deprives the Community policy of an essential instrument. Actually, the Community scale - the widest one - appears adequate to promote the diffusion of codified technological knowledge. The setting of a Community patent, under consideration since 1975, has been coming up against political difficulties. This problem should be soon resolved with the adoption of the Community patent by the European Union around 2005.

However, the provided conditions defined in 1975 to obtain this patent - the same as required for the grant of a European patent- cause the system to tend towards the protection of major versus cumulative innovations. In addition, the cost of a Community patent – related to the translation regime - and the law enforcement conditions (dispute-settlement procedure) are likely to discourage innovators to resort to this mode of protection, whereas a policy ensuring the circulation of knowledge would require a systematic recourse to this instrument.

The key role of Regional and National levels within the connection science-industry

Within some institutional contexts - like with the French case - the improving of the links between science and industry at Regional and National levels justify a public intervention.

Despite its strategic importance in a "science-based economy", where the links between science and technology are particularly close, this connection risks being inadequate because it is not natural. Universities, which occupy a central place in the generation of knowledge, and industry correspond to two different worlds with specific codes, cultures, reward systems and final objectives. Such a characteristic involves bridging problems between these two spheres.

A second fundamental reason legitimising a public intervention in this field is the need to monitor the conditions of the science and industry getting together. This in effect brings with it the danger of nullifying the advantages of the "open science" (P. Dasgupta and P. David [1994[3]]). The scientific community has traditionally played a key role, not only in the creation of knowledge but also in its widespread diffusion. In this system, the "knowledge dilemma" is resolved by a means of remuneration specific to the university (reputation in the scientific community through publications) which ensures an effective compromise by simultaneously stimulating research and knowledge communication initiatives.

Now, the knowledge dilemma is heightened as soon as there is a tying link between the scientific and industrial domains (P.B. Joly [1992]). Academic research, which generates strong knowledge externalities, was traditionally in the public domain. For this reason the nature of the technological

[3] Pionneer’s work on the opposition between « private technology » and « open science ».

knowledge as public property (K. Arrow [1962]) did not pose a problem. Alongside this, the patent was exclusively used by industry. This incentive system founded on exclusion[4] has shown itself to be adequate bearing in mind the fact that the externalities of the applied research are weak.

At the present time we are witnessing on the one side a growing tendency to protect the knowledge resulting from public research (connected to a new concern to valorise the results of this research), and on the other side the development of externalities resulting from private research (connected with the rise in private funding of R&D activities and the growing involvement of large industrial groups in basic research). This is why the universities are decreasingly the only players in the generation of new knowledge but are more often the heart, the central point of the networks of public actors / private participants in knowledge generation and diffusion. D. Foray and J. Mairesse [2001] argue that such specificity constitutes the very definition of a knowledge-based economy: an economy in which knowledge externalities are more powerful than before. This does not change the nature of the knowledge dilemma, but its degree. This is why "*the institutional compatibility of open knowledge with private incentive structures is one of the most important compatibilities for the future of knowledge-based economies*." (D. Foray and J. Mairesse [2001]).

Accentuating the interaction between the two spheres of knowledge represented by universities and industry seems now vital. However, in order to perpetuate the interest of the interaction between science and industry, each sphere must retain its own specificities. Among other things, this would signify that the university should not become a service provider at industry's beck and call.

In spite of these main differences between the scientific and the industrial fields, the interaction of these two areas is possible because of the existence of common or complementary objectives on which public intervention can be based. Hence the accumulation of knowledge is an objective common to both the industrial and the scientific fields. Moreover there is an emerging complementarity between the search for technological advance of industry and the search of financial resources at the scientific level.

The objective is to enhance the transformation of scientific results into competitive performances, in other words, to improve the diffusion of the academic knowledge throughout the industrial structures, whilst ensuring that the "open science convention" (Foray [1997]) is not fundamentally challenged. From a general point of view, what is at stake for the public authorities is the implementing of "distribution-orientated institutions" which favour the diffusion of technological knowledge (P. David and D. Foray [1994]) whilst being sure that the level of research incentive is sufficiently high.

The science-industry relationship can take diverse and complementary forms according to the extent of its embodiment: it can be anything from simple transfer to complete cooperation between the two spheres.

[4] As it establishes a monopoly of exploitation.

Apart from publications, specific to the "open science", patent is the most disembodied transfer media between science and industry. For this reason, as seen before, this institutional mechanism is at its most effective when it is operated at the highest territorial level (EU based within the European Union). However, National and Regional authorities have a role to play here. In order to enlarge the stock of technological information available for the firms, the National policy of innovation can limit the costs of search and acquisition: systematic publication of listing concerning existing patents, incentives to knowledge codification and to its diffusion. What is at stake for Regional authorities is to facilitate the access by local companies to the knowledge contained in the patents: information, advice, tax incentives for licence purchasing.

At the Regional level, the heart of public actions to favour interactions between science and industry should rely on the presence of a University. This takes a more embodied form, formal or informal. Informal links like seminars, consultations, visits to laboratories are a good way for opportunities. Formal relationships between science and industry take the form of contractual arrangements with varying durations: funding granted by private companies, research shared between public and industrial laboratories, "hiring" students. The highest degree of transfer embodiment is the creation of incubators by university laboratories ("academic incubators"), which accommodate and support the project carriers before the birth of a company. Promoting the science-industry relationship may also take the form of a support to cooperative/joint research that goes far beyond simple transfer. In this case there is actual integration, for example, by the formation of a common institution, a joint research centre. Thus it seems important that the regional technology policy provides the incentives necessary for the development of a variety of forms of transfer and cooperation between local Universities and industry. In this way, Universities are pushed towards opening up to external players finding the ways in which their research results can be valorised in order to contribute to the regional economic development.

Because of Regional and European actions, the National level appears to be an important intermediate which coordinate the others territorial levels of intervention.

National level is adequate to reduce the problems of institutional incompatibility, which facilitate the relations between University and Industry concerning research. Another aim of national public actions is to favour the emergence in the academic world of an open attitude towards economic environment, favouring the valorisation of the research output, the provision of advice and training to firms. This attitude - which is completely new within some institutional contexts like with the French case - must not take the place of the central mission of University : to create knowledge and ensure it is widely distributed through publications and training.

4. Conclusion

In his 1994 article, J.S. Metcalfe identifies two main profiles in technology policies: i) those which take the possibilities of innovation as given, and thus seek to stimulate innovation by reducing the cost of the R&D activity or by increasing the profitability of private innovation; ii) those which seek to expand these opportunities. The policy of technology diffusion is part of the second perspective. In this point of view, the innovation policy is far more than a support to R&D expenditures or for the direct production of artefacts. Its role is also to put in place and justify the variety of mechanisms that facilitate the capture and assimilation of local, national and international external knowledge.

In this paper we argue that knowledge diffusion - and as a consequence the policy of technology diffusion - is complex for two main reasons. First, parts of spillovers are geographically bounded. The scale of diffusion depends on many institutional factors such as the characteristics of the relationships between local firms, the type of relationship between science and industry at local and national levels, the capacity of absorption. One goal of the diffusion policy is to act on these factors, which appears to be a very complex task. Second, technology diffusion involves a knowledge dilemma. Here again, technology policy appears to be complex because it must establish a good compromise between incentive and diffusion of technological knowledge.

Our point here is that a technology policy implemented on several territorial levels is an asset because this enlarges the possibilities of action. This involves an explicit choice to articulate the different territorial levels of public intervention and to connect the Regional, National and European systems of innovation (table 2).

Table 2

Policy of technology diffusion implemented on three territorial levels within the EU; Some propositions

TARGETS	MEANS
Regional	
To exploit the regional comparative advantage within technology i.e. the diversity of local technological connections.	Bringing together different types of local firms and industries: to support long term multidisciplinary cooperation projects, meetings on a transverse theme, local supply-demand relationships in the dynamic of intersectorial cooperations.
To develop the regional absorptive capacity and the entering to national and international networks.	Promotion of learning (notably to support the access to common international technological languages). Development of communication infrastructures. To support the participation of local firms (notably SME's) to the EC programs. To favour the access of local firms to patents (information, advice, tax incentives for licence purchasing) To rely on the presence of a local University and promote embodied interactions within regional industries, formal (contractual arrangements) and informal (seminars, consultations, visits to laboratories).
National	
To coordinate the three territorial levels of intervention	To reduce the problems of institutional incompatibility, notably : to promote the connection of regional, national, and European public research programs.
To exploit the national technological comparative advantages.	Sectorial research programs based on national specificities (institutional and cultural).
To favour the access of firms to external knowledge.	National education and training policy, development of communication infrastructures, access to patents (systematic publishing of lists), fiscal incentives to private R&D.
To support the "open science" and favour the emergence of a wide range of technological options.	Promotion of Universities and research centre (to enable a part of independence in relation to industry) ; to support weak technologies.
European	
Widespread diffusion of technological knowledge and compromise with the incentives problems on a large scale.	European research programs, cooperations with third countries and with the extra-community programs. Community intellectual property rights, notably community patent.

References

Antonelli, C. (1994), "Technological Districts Localized Spillovers and Productivity Growth. The Italian Evidence on Technological Externalities in the Core Regions", *International Review of Applied Economics*, pp.18-30.

Antonelli, C. (1999), "The Evolution of the Industrial Organisation of the Production of Knowledge ", *Cambridge Journal of Economics*, 23, pp. 243-260.

Arrow K. (1962), "Economic Welfare and the Allocation of Ressources for Invention". in *The Rate and Direction of Inventive Activity : Economic and Social Factors*, R. Nelson, NBER, Princeton University Press : 164-181.

Audretsch D.-B., Feldman M.-PP. (1999), " Innovation in cities : science-based diversity, specialization and localized competition ", *European Economic Review*, vol 43, pp. 409-429.

Autant-Bernard C. (2000), *Geographie de l'innovation et externalités locales de connaissances. Une étude sur données françaises*, Thèse pour le doctorat en sciences économiques, Université Jean Monnet St-Etienne.

Autant-Bernard C. (2001), « Science and knowledge flows : Evidence from the French case », *Research Policy*, vol. 30, n°7, août, p. 1069-1078.

Beise M., Stahl H. (1999), "Public research and industrial innovations in Germany", *Research Policy*, n°28, p. 397-422.

Blind K., Grupp H. (1999), "Interdependencies between the science and technology infrastructure and innovation activities in German regions : empirical findings and policy consequences", *Research Policy*, n°28, p.451-468.

Boston, Dordrecht, London, 35-51.

Bottazzi L., Peri G. (2001), « Innovation ans spillovers in regions : evidence from european patent data », *Third Congress on Proximity*, Paris, 13 et 14 decembre.

Branstetter, L. (1996), "Are Knowledge Spillovers International or Intranational in Scope ? Microeconometric Evidence from the US and Japan", *Working Paper 5800*, NBER, October.

Breschi, S., Malerba,. F. (1997) "Sectoral Innovation Systems : Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries", in : De la Mothe J. (Eds), *Systems of Innovation. Technologies, Institutions and Organizations*.

Caballero, R., Jaffe, A. (1993), "How High are the Giant's Shoulders ? An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth", *NBER Macroeconomic Annual*, pp. 15-75.

Carlsson, B., Jacobsson, S. (1997), "Diversity creation and technological systems: a technology policy perspective", In Edquist, C., *Systems of innovation*, Pinter, London and Washington, 266-294.

Cohen W., Levinthal D. (1989), "Innovations and Learning : The Two Faces of R-D", *The Economic Journal*, 99, Septembre, pp. 569-596.

Cohendet P., Foray D., Guellec D., Mairesse J. (1999), "La gestion publique des externalités positives de recherche", in Foray D., Mairesse J., *Innovations et Performances*, Ecole des Hautes Etudes en Sciences Sociales, pp. 366-383.

Cohendet, P., Llerena, P. (1997), "Learning, technical change and public policy: how to create and exploit diversity", In Edquist, C., *Systems of innovation*, Pinter, London and Washington, 223-241.

Cowan, R., Foray, D. (1997), "The economics of codification and the diffusion of knowledge", *Industrial and corporate change*, 6, 595-622.

Dasgupta, P., David, P. (1994), "Towards a new economics of science", Research Policy, 23, 487-521.

David P. (1986), "Narrow windows, blind giants and angry orphans : the dynamics of systems rivalries and dilemmas of technology policy ", *Conference on Innovation Diffusion*, Venise.

David P., Foray D. (1994), Accessing and expanding the science and technology knowledge-base: a framework for interpreting available quantitative measures, OCDE-DSTI-CSPT.

Dosi, J. (1982) "Technological Paradigms and Technological Trajectories", *Research Policy*, North Holland, Vol. 11, 147-162.

Endogeneous Growth", *European Economic Review*, 43, pp. 281-302.

Ernberg, E., Jacobsson, S. (1997), "Technological discontinuities and incumbents performance: an analytical framework", In Edquist, C., *Systems of innovation*, Pinter, London and Washington, 318-341.

Fadairo M., Massard N. (2002), « The Geography of Innovation : Challenges to Technology Policy within Regions », EUNIP Conference, december, Turku, Finland.

Fadairo, M. (2001), "Technology externalities and compromise in innovation policy; the European Union case", In Feldman M., Massard N., *Institutions and systems in the geography of innovation*, Kluwer Academic Publishers, Boston, Dordrecht, London, 293-308.

Feldman M. P. (1994), *The geography of innovation*, Economics of Science, Technology and Innovation, vol 2, Kluwer Academic Publishers, Dordrecht, Boston, London, p.155.

Foray, D. (1997), « Generation And Distribution Of Technological Knowledge : Incentives, Norms And

Foray, D., Mairesse, J. (2001), "The knowledge dilemma and the geography of innovation", In Feldman M., Massard N., *Institutions and systems in the geography of innovation*, Kluwer Academic Publishers, Boston, Dordrecht, London, 35-54.

Institutions », In Edquist C., *Systems Of Innovation*, Pinter, London And Washington, 64-85.

Jaffe A.B. (1989), " Real effects of academic research ", *The American Economic Review*, vol. 79, n° 5, décembre, p. 957-970.

Jaffe A.B., Trajtenberg M., Henderson R. (1993), " Geographic localization of knowledge spillovers as evidenced by patent citations ", *The Quaterly Journal of Economics*, août, p. 577-598.

Johnson, B. (1992), "Towards a new approach to national systems of innovation", In B.-A. Lundvall, *National systems of innovation,* Pinter, London and New York, 23-44.

Joly, P.-B. (1992), "Le rôle des externalités dans les systèmes d'innovation" (The role of externalities within systems of innovation), *Revue Economique*, No. 4, July, 785-796.

Kenney M., Florida R. (1994), "The organisation and geography of japanese R&D : results from a survey of japanese electronics and biotechnology firms", *Research Policy*, n°23, p.305-323.

Lundval, B.-A. (1998), "The learning economy: challenges to economic theory and policy", In Nielsen, K., Johnson, B., *Institutions and Economic Change*, Edward Elgar, 33-54.

Lundvall B-A. (1992), *National Systems of Innovation*, Pinter.

Martin, P., Ottaviano, G. (1999), "Growing Locations : Industry Location in a Model of

Maskell, P. (2001) "Future challenges and institutional preconditions for regional development policy", in Feldman, M., Massard, N., *Institutions and systems in the geography of innovation,* Kluwer Academic

Metcalfe, J.S. (1994), "Evolutionary economics and technology policy", *The Economic Journal,* 104, July, 931-944.

Mohnen, P. (1998), "International R&D Spillovers and Economic Growth", UNU Project Meeting on Information Technology and Economic Development, 12-13 Juin.

Nelson, R., Winter, S. (1982) *An Evolutionary Theory of Economic Change*, Belknap Press of Havard University Press, Cambridge Mass & London.

Paci R., Usai S. (2000), "Externalities, knowledge spillovers and the spatial distribution of innovation", *CRENOS Working Paper*, Mars,p. 28.

Polanyi, M. (1967) *The Tacit Dimension*, Garden City, Doubleday Anchor.

Scotchmer, S. (1991). "Standing on the Shoulders of Giants : Cumulative Research and the Patent Law". *Journal of Economic Perspectives*, Vol 5, n°1: 29-41.

Stoneman, P., and P. Diederen (1994). "Technology Diffusion and Public Policy". *The Economic Journal*, n° 104: 918-929.

Trajtenberg, M. (1989). "The Welfare Analysis of Product Innovations, with an Application to Computed Tomography Scanners". *Journal of Political Economy*, Vol 97, n°2: 444-479.

Verspagen B., Schoenmakers W. (2000) "The spatial dimension of knowledge spillovers in Europe : evidence from firm Patenting Data", *Working Paper*, Avril, P.18.